German Economic Review 6(3): 395–414

Education, Work and Wages in the UK

Paul Bingley
Århus University

Yu Zhu
University of Kent

Ian Walker
University of Warwick

Abstract. *This paper is concerned with the relationship between education, wages and working behaviour. The work is partly motivated by the sharp distinction in the literature between the returns to education and the effect of wages on labour supply. Education is the investment that cumulates in the form of human capital while labour supply is the utilization rate of that stock. Yet, variation in education is usually the basis for identifying labour supply models – education is assumed to determine wages but not affect labour supply. Moreover, it is commonly assumed that the private rate of return to education can be found from the schooling coefficient in a log-wage equation. Yet, the costs of education are largely independent of its subsequent utilization but the benefits will be higher the greater the utilization rate. Thus the returns will depend on how intensively that capital is utilized and we would expect that those who intend to work least to also invest least in human capital. Indeed, the net (of tax liabilities and welfare entitlements) return to education will be a complex function of labour supply and budget constraint considerations.*

Here we attempt to model the relationship between wages, work, education and the tax/welfare system allowing for the endogeneity of education as well for the correlations between the unobservable components of wages and working behaviour. We use the estimates to simulate the effect of a new UK policy designed to increase education for children from low-income households.

JEL classification: *I*38, *J*22, *R*31.

Keywords: Welfare programmes; labour supply; returns to education.

1. INTRODUCTION

This paper is concerned with the relationship between education, wages and working behaviour. In a lifecycle model we would expect tastes for leisure to affect education decisions because labour supply at a point in time is the utilization rate of human capital. Those with a low taste for leisure should choose to invest in more education because they would plan to use the resulting human capital more intensively when they joined the labour force.[1]

This argument has traditionally been ignored in both the literature on the returns to education[2] and the literature on the wage elasticity of labour supply. In the returns to education literature it is commonly assumed that the private rate of return to education can be found from the schooling coefficient in a log-wage equation. While the costs of education are essentially independent of its subsequent utilization, the benefits of that human capital investment will be higher the greater is its utilization rate and so the return to education will depend on how intensively individuals work in later life.[3] The literature on the wage elasticity of labour supply commonly assumes that education can be used to identify the hours of work equation: that is, one can legitimately exclude education from this labour supply equation.[4] Yet, if preferences for work affect education decisions earlier in life then this common identification strategy becomes invalid because the residual in the hours of work equation would be correlated with the wage.

A related consideration is that the system of taxes and welfare may affect the acquisition of human capital. Traditionally, it has been argued that taxes leave the returns to education unaffected since they affect opportunity costs and subsequent wage gains by the same amount and so the tax rate cancels out. However, this argument depends on the tax being proportional and, in practice, the tax system may be progressive and the system of welfare payments may be 'means-tested' against income. Indeed, in-work welfare programmes are becoming increasingly popular[5] and may act as a wage subsidy that reduces the net costs of on-the-job general training. The

1. The argument assumes that education affects productivity in paid market work but it does not affect domestic productivity. This is a common assumption although one that has been argued may not apply in the context of LDCs where maternal education may, for example, enhance aspects of child quality.
2. Polachek (2004) is a notable recent exception where it is argued explicitly that rises in female participation rates induce a narrowing of the gender pay gap through higher expected returns to education, and supporting evidence is provided from ten countries. The theoretical argument for how human capital investment patterns relate to the presence of intermittent labour force participation is most clearly made in Weiss and Gronau (1981). See also Blinder and Weiss (1976), Heckman (1976) and Altonji and Blank (1999).
3. Indeed, there is even little evidence that tests for the possibility of selectivity into work on the estimated returns to education conditional on working.
4. See, for example, the survey by Blundell and MaCurdy (1999).
5. The earliest such programme was Family Income Supplement in the UK which dates from 1971 while the Earned Income Tax Credit in the US dates from 1975.

implication is that the net (of tax liabilities and welfare entitlements) return to education will be a complex function of labour supply preference and budget constraint considerations. One aspect of this is the effect of education on labour market participation – an issue that has attracted relatively little attention in the literature despite its apparent importance.

Finally, we are concerned about the arguments usually used to justify education subsidies. In the context of higher education the justification is usually in terms of credit market constraints or externalities. In fact, there is very limited support for the significance of either of these arguments in the empirical literature. The credit constraint literature is reviewed in Carneiro and Heckman (2002) who argue strongly that the strong correlation that exists between education and parental income is most likely due to the strong correlations between income across the lifecycle and between early deprivation and intellectual development.[6] However, a standard second-best argument for subsidizing education can be made that does not rely on externalities or market failure. That is, if education and labour supply are jointly determined then a distortionary tax, especially a progressive one, that reduces labour supply might be offset by a subsidy that increases education. Trostel (1993) makes the theoretical case for this but does not produce any evidence, and Heckman *et al*. (1998) provide simulations of the general-equilibrium effects of taxes and tuition subsidies on skill formation and find that these are much smaller than the partial-equilibrium effects suggested by econometric models.

This is an area where we need more research and here we attempt to model the relationship between wages, work and education incorporating the tax/welfare system and allowing for the possible correlation between the unobservable component of wages and working behaviour arising from the endogenous determination of education. We provide evidence based on an analysis of UK data and use the resulting estimates to analyse the effects of a new policy that aims to improve post-compulsory schooling participation rates for children from low-income households.

The UK has an early school-leaving problem in the sense that a high proportion of individuals in the population will have left school at the earliest possible opportunity. Indeed, although the higher education participation rate has increased dramatically over the last ten years and there have been considerable efforts to increase the examination performance of children at the age of 16, this has not been reflected in a substantial increase in post-compulsory participation and there is still a significant minority that leave school at the age of 16 with minimal formal qualifications. Moreover, the proportion of children from low parental income backgrounds who participate in higher education has fallen despite the large overall increase in participation. The problem is regarded as acute and the present government is

6. The externality literature is reviewed in Sianesi and van Reenan (2003) who find little supporting evidence.

introducing payments to children from poor backgrounds to stay on at school beyond 16 (Educational Maintenance Allowances, or EMAs)[7] and is changing the structure of higher education tuition fees and student loans to favour children from low-income backgrounds.

We use the estimates to simulate the net private returns to education, and hence the financial returns to the government, through greater taxes and lower welfare expenditure, from encouraging greater education participation. We also simulate the effect of an EMA-induced increase in education and hence on net incomes and tax revenue net of welfare payments.

Section 2 outlines the theoretical case for labour supply and education being jointly determined in a simple lifecycle model. Section 3 describes the dataset. Section 4 discusses identification. Section 5 presents the estimates which are applied in Section 6 to simulate the effects of an EMA. Finally, Section 7 concludes.

2. THEORY

The basic intuition of the idea that education affects labour supply can be shown in a two-period model with no uncertainty.[8] Individuals are assumed to be endowed with one unit of time per period, t, which is allocated among three alternatives: working, h, schooling, s, and leisure, l. Thus the time constraint is $1 \equiv h_t + s_t + l_t$, $t = 1, 2$. Time allocated to schooling in the first period[9] produces human capital, H, which increases earnings from working in the second period. Thus the wage rate, w, in the second period is given by $w_2 = H(s_1)w_1$, where $H(0) \equiv 1$. Human capital production is assumed to be governed by a simple isoelastic function $H(s) = \phi s^{\sigma} + 1$, $1 > \sigma > 0$, where $\phi > 0$ reflects learning ability, and σ measures the returns to scale in producing human capital. Individuals can save or borrow at rate r in the first period and the initial financial endowment is given as e and so the budget constraint is $(1 + r)e + (1 + r)w_1h_1 + w_2h_2 = (1 + r)c_1 + c_2$, where c is consumption.

Utility is a function of consumption and leisure in each period. Human capital produced in the first period is assumed to increase the productivity of leisure in the second period. Thus the utility function is $U = U[c_1, c_2/(1 + \rho), h_1, v(H) \cdot h_2/(1 + \rho)]$, where $v(1) \equiv 1$ and ρ is the rate of pure time preference. $v(H)$ is assumed to be a simple isoelastic function $v(H) = H^{\alpha}$, where $1 \geq \alpha \geq 0$ and α measures the leisure-productivity returns to human capital. Most

7. This follows their successful piloting in a number of areas. See Ashworth *et al.* (2002) for detailed evaluation.
8. This section draws heavily on earlier work in Trostel and Walker (2004) where many further details can be found.
9. Think of the first period as not just the schooling age, but as the entire first half of economic life. Full-time schooling ends long before middle age. Similarly, the second period in this model is not just the working age but also includes retirement which is one of the ways that work can vary in the second period.

modelling of human capital ignores its potential impact on the productivity of leisure time (i.e. $\alpha = 0$ and $v(H) \equiv 1$), but there are a few exceptions. In particular, beginning with Heckman (1976), human capital has sometimes been assumed to affect the productivity of leisure in the same proportion that it affects the productivity of work (i.e. $\alpha = 1$ and $v(H) \equiv H$). This 'neutral' specification of human capital, however, may be no less restrictive than the usual specification. In other words, neither of the special cases used in the literature appears particularly likely. It does seem likely that human capital will affect the productivity of leisure time to some extent. Indeed, the extent that human capital affects the productivity of leisure is crucial for the interaction between human capital and hours of work. Thus a general specification is assumed here. The equilibrium relationship between education and future hours of work can be derived from the first-order conditions of the individual's optimization problem. Specifically, maximizing utility by choosing c_1, c_2, s_1, h_1 and h_2 (s_2 is zero and ignored) subject to the time and budget constraints yields first-order conditions that can be combined to reveal the equilibrium relationship between education and work:

$$s = [\sigma\phi(h_2(1-\alpha)+\alpha)/(1+r)]^{1/(1-\sigma)}$$

This equation reveals that the relationship between education and future work is weakly positive. Unless human capital from education affects the productivity of leisure time and the productivity of work time proportionately (i.e. $\alpha = 1$), there is a positive relationship between education and work. Moreover, this relationship is independent of preferences about work, consumption and discounting since heterogeneity in preferences will simply result in individuals choosing different points along the equilibrium education–work locus.

3. DATA

A major motivation for our work is that hours of work (and participation) and education are jointly determined. The empirical labour supply literature has not explicitly acknowledged this possibility so we begin by establishing that there is some correlation. The data from the UK Family Resources Survey data (pooled over all of the available years, 1994/95–2000/01) were selected to be couples (married or cohabiting) in households without other non-dependent adults, where the male partner is aged 25–64 and the female aged 25–59, neither are self-employed, and there is at least one dependent child present in the household.

The FRS is the dataset of choice for the econometric modelling of UK labour supply since it has been developed by the UK Department for Work and Pensions for policy analysis purposes. It contains the age at which individuals complete their full-time education and so can also be used to conduct simple analysis of wages and education. As is quite common, the

Table 1 Labour market status (%)

	Mother's status			
Father's status	Non-participant	Part-time	Full-time	Total
Non-participant	6.11	1.46	1.31	8.88
Participant	25.14	37.33	28.65	91.12
Total	31.25	38.79	29.96	100.00

hourly wage rate is not observed in the data and is constructed by dividing (normal weekly) earnings by (normal weekly) hours.

The selected dataset consists of 28,572 households and the breakdown of labour market status is given in Table 1. This shows that male participation is high and that, conditional on having a non-participating male partner, female non-participation is disproportionately likely. Thus, there is a 6% core of 'workless' households. Conditional on having a working male partner there is a large proportion of part-time working mothers in the UK.[10]

4. METHODOLOGY

Modelling labour supply choices in the face of complex budget constraints has proved to be problematic for researchers and a popular compromise in the literature has been to adopt a discrete-choice methodology where individuals are assumed to choose between a small number of discrete alternatives. We follow Blundell and MaCurdy (1999) who do static labour supply modelling in the presence of non-convexities by discretizing the hours distribution. Modelling labour supply behaviour in the context of non-convex budget constraints gives rise to a number of empirical difficulties, as summarized in Blundell and MaCurdy (1999). Essentially, the choice model is simplified to be discrete choice in order to make it empirically tractable.

Our analysis is confined to married couples and we model labour supply choice for women among three discrete alternatives (broadly described here as non-participation, part-time and full-time) while we assume that male labour supply is either full-time or non-participation.[11] The probabilities of being at each position are functions of income at that position relative to incomes at all other positions so these models estimate the effect of income levels (at each choice) on the probabilities of being at each and every choice.

Invariably, labour supply modelling has assumed that education is exogenous. In contrast the literature on the returns to education has paid a

10. Further details of the data can be found in an Appendix to this paper available at http://go.warwick.ac.uk/iwalker
11. This classification seems appropriate given the negligible proportion of men working part-time and is a compromise between capturing the details of the tax and benefit system and maintaining empirical tractability.

great deal of attention to the potential endogeneity of education in determining wages (see Card, 1999, for example). Our modelling of education is reduced-form but we allow for correlations between education and unobservables in our wage equations and labour market choices. Thus, the paper aims to introduce education directly into labour supply behaviour and allow agents to act in a theory-consistent way in the presence of non-convex budget constraints due to taxes and transfers.

We are interested in modelling the labour supply of married couples and assume a unitary model of household consensus behaviour (see Chiappori, 1992, for the alternative, collective, approach). Labour supply choices are limited to that between a small number of discrete alternatives: non-work, part-time or full-time work for women, and non-work or full-time work for men. No hours substitution is allowed within each of the 6 (2∗3) household alternatives.[12]

Multinomial choice problems are most often estimated through multinomial logit (less often multinomial probit) by making appropriate stochastic assumptions. Here we assume joint normality and hence estimate a multinomial probit. This is because of the natural way selection and endogeneity can be introduced via multivariate normality. The small number of alternatives we consider make the problem numerically tractable. Furthermore, following Hausman and Wise (1978), we allow for taste heterogeneity via random parameters on income.[13]

So far we have defined a state-of-the-art (as defined by Blundell and MaCurdy, 1999) labour supply model, appropriate for the analysis of behavioural responses to tax reforms. This can simply be formalized as follows for the labour supply equation:

$$U_j^\star - U_k^\star = g(Y_j - Y_k)\psi X^H \beta_{jk} + E^m \alpha_{jk}^m + E^f \alpha_{jk}^f + (\varepsilon_j + \varepsilon_k)$$

where j and k denote combinations of household labour supply alternatives, $U_k^\star$ is unobservable utility in state k, $g(\cdot)$ is some function of income differences between states (in this case linear), ψ is an associated coefficient vector with mean ψ and variance $(1 + \bar{\psi})$, X^H is a vector of state-invariant explanatory variables, β_{jk} is an associated vector of coefficients for the comparison between alternatives j and k, E^m is education for the male, α_{jk}^m is an associated vector of coefficients for the comparison between alternatives j and k, the similar education and coefficient vector for females is superscripted f, and $\varepsilon_j - \varepsilon_k$ is a normally distributed composite error term.

12. Hoynes (1996) further allows 'approximation error' within each alternative. We do not pursue this, in lieu of added complexity elsewhere.
13. Recent generalizations of the multinomial logit allow heterogeneity by including mixing terms which are normally distributed (see MacFadden and Train, 2000) or of unspecified distribution (Hoynes, 1996). While these approaches are arguably more general than that presented here, their extension to endogenous right-hand-side variables is not obvious.

The assumption that the income coefficient is a random parameter is common in labour supply analysis where models based on additive errors have been shown to be inferior to random preference models. Here we combine random preferences with an additive error term.

For the wage equations we assume that $W^s = X^s_W \beta^s_W + \varepsilon^s_W$, where W^s denotes the log wage for each spouse $s = m, f$, X^s_W is a vector of explanatory variables including education, β^s_W is an associated vector of coefficients and ε_W is a random error term.

The novelty of the paper is to extend this conventional model of wages and labour supply to allow for education to be potentially endogenous so we add to our system of labour supply and wage equations, education equations for husband and wife, $E^s = X^s_E \beta^s_E + \varepsilon^s_E$, where E^s denotes the level of education, measured as the age left full-time education, for each spouse, X^s_E is a vector of explanatory variables, β^s_E is an associated vector of coefficients and ε_E a random error term.

Thus, we have a six-equation model: education, wages and working behaviour for both men and women where wages and education are treated as continuous, and labour supplies are treated as (six possible) discrete choices. We allow education to be correlated with unobservables in both wages and working behaviour. In addition to allowing for a correlation between the education equation and the residuals in the wage equations, we also expect individuals with a greater than average attachment to the labour market to have more education than average and so we allow for a correlation between the education equation and the labour supply model.

5. IDENTIFICATION AND ESTIMATES

The main empirical difficulty in all labour supply modelling, is addressing the endogeneity of the gross wage. Mostly, hard-to-justify exclusion restrictions are imposed, and wages (which are missing for non-workers) are predicted from a reduced-form first-stage regression (see MaCurdy *et al.*, 1990, for a critique). Education is often included as a wage determinant but assumed not to affect hours preferences. This is an assumption we test and reject. In practice, we estimate the wage and labour supply equations jointly and missing wages for both men and women are integrated out. While normality alone would be sufficient for identification, it would not, of course, be convincing.[14]

In the absence of valid exclusion restrictions, we would have to rely on the joint normality of the error terms of the wage and hours equations, together with non-linearities in the tax and benefit system to identify the effect of net wages on labour supply. The wage equations are used to construct the net

14. See Puhani (2000) for a review of the importance of normality in selection models more generally.

income variables that enter the labour supply model. The wage predictions are used to compute gross incomes at each discrete hours point and a complex tax and welfare routine is applied to compute corresponding net incomes.[15] One significant advantage of using data pooled over a long period of time is that, in addition to deriving identification from the non-linearities in the relationship between W and Y at a point in time we can also exploit variation in the structure of taxes and transfers over time. For example, the data span a period when the 'standard' marginal rate of tax fell from 30% to 22%. Indeed, strictly speaking, there is no need for exclusion restrictions between the wage and hours equations: the non-linearity of the tax and benefit system is enough to break the simple link between potential net incomes and wages. This argument was used to support the identification in Blundell *et al*. (1998).

Non-parametric identification requires excluded instruments in the education equation: determinants of education, which are not also determinants of wages and hours of work. Here, identification is achieved through (in addition to non-linearities and changes in taxes and transfers over time) plausible exclusion restrictions. Our instruments for the education of husbands and wives in their respective wage and hours equations are (quadratic) functions of the age difference between mother and oldest child and between father and oldest child. This is based on the presumption that the age at first birth reflects unobserved heterogeneity. The literature on the effects of early childbirth suggests that women who have their children early may have found staying on in education more difficult than those women who had their children later in life.[16] There is a great deal of evidence that teenage motherhood is associated with low educational achievement.[17] It is, of course, possible that early motherhood has an independent effect on wages – perhaps through common family effects. It is also possible that young mothers have different attitudes to paid labour market work and there is a well-developed literature that suggests that fertility and labour supply are jointly determined.

Given the reduced-form nature of our model, the validity of these exclusion restrictions are ultimately empirical questions and two different tests for the validity of our education instruments appear supportive. First, an over-identification (likelihood-ratio) test shows that both age-difference

15. Our treatment of taxes and transfers computes income tax, national insurance contributions (i.e. social security), Housing Benefit (income supplements for low income/high housing cost households), Council Tax Benefit (which reduces the liability of low-income households to local taxes), Income Support (the main out-of-work welfare programme in the UK) and Family Credit (the main in-work welfare programme in the UK).
16. We appeal to assortative mating to justify using fathers and child age difference as an exclusion restriction for husband's education.
17. Chevalier and Viitanen (2003) and Goodman *et al*. (2004) produce evidence for the UK that teen motherhood has significant adverse consequences for education but not on wages conditional on education.

instruments can be excluded from both the labour supply and the wage equations so they are valid to be used as instruments and not controls. Second, a likelihood-ratio test against the exogenous education model suggests the instruments have sufficient explanatory power.[18] Moreover, the assumption of exogenous fertility is quite standard practice in much of the labour supply literature. The results of the model with endogenous education are given in Table 2.[19] The age difference variable measures the age of first birth so we find that the longer that children are postponed the higher is education.[20] This effect is statistically significant and, as in Chevalier and Viitanen (2003), substantial in size – mothers who postpone childbirth by one year have around 0.45 years additional education. The log-wage equations are conventional with large ethnic differences, lower wages for cohabiters (compared to married), some strong regional effects, and (gross) rates of return to education of around 9% for men and 10% for women. These high estimated returns are consistent with the view that the UK has an early school-leaving problem:[21] many able children, lacking the confidence and/or resources to progress further in school and higher education, leave school early despite their ability to continue.

In the labour supply equations, non-participation (NP) is the omitted labour market state so that a positive estimated coefficient on a variable in the labour supply model suggests that such a variable is associated with a preference for non-participation compared to that state. Thus, the positive coefficients on ethnic origin (non-white) suggests that non-white men have a stronger preference for non-participation than do white men, and non-white women have a stronger preference for NP relative to PT (but weaker reference for FT) than do white women. The education coefficients suggest that more educated men have a weaker preference for FT compared to NP, while for women they have a stronger preference for FT and weaker for PT. This also supports our idea that education and labour supply are jointly determined

18. The log-likelihood of the restricted, exogenous education model is 782,399 compared to 782,477 for our preferred model with our exclusion restrictions imposed and allowing education to be endogenous. This amounts to a chi-squared of 156 which, with 12 restrictions, has a *p*-value of 1.00 and amounts to a rejection of exogeneity. Moreover, when we drop our exclusion restrictions by including the age difference in all equations we find that the log likelihood rises only to 782,450 giving a chi-squared of 6 and, with 10 restrictions, a *p*-value of only 0.18. Although, strictly speaking, this amounts to a rejection of the exclusion restrictions, with such a large dataset it is surprising to get a *p*-value that is below unity and we regard this as a powerful result (see Arellano *et al.*, 1999, on this point).
19. The results presented here are for the model with a random coefficient on income in the labour supply model – $(1+\bar{\psi})$ in our description above – but this is not significantly different from unity.
20. Note that we are ignoring children who have died and children who have left home. However, this is irrelevant since we are not making any structural inferences from this variable – the education equations are strictly reduced-form so that all that matters is that this variable is correlated with education.
21. It is also consistent with evidence in Harmon *et al.* (2003) which uses a variety of UK datasets and a variety of instruments to show IV returns of around 10% and higher.

Table 2 Married and cohabiting couples: labour supply, education and wages. Maximum-likelihood model estimates and standard errors

	Education/10				Log wage				Labour supply					
Variable	Male		Female		Male		Female		Male: FT → NP		Female: PT → NP		Female: FT → NP	
intercept	1.0755	*0.0365*	0.9787	*0.0301*	−1.7396	*0.1743*	−2.8144	*0.2038*	1.7194	*0.2520*	−1.4411	*0.2650*	3.6268	*0.9927*
unearned income/100									0.4550	*0.2210*	0.5392	*0.0181*	1.1385	*0.0377*
income difference/100									−0.4790	*0.0541*	−2.3954	*0.0542*	−2.3954	*0.0542*
education/10					0.8872	*0.1261*	1.0048	*0.1331*	−0.8180	*0.0531*	0.6775	*0.0734*	−0.5681	*0.2006*
age difference/10	0.3144	*0.0212*	0.4533	*0.0184*										
(age difference ^2)/100	−0.0322	*0.0032*	−0.0535	*0.0031*										
ethnic origin	0.1098	*0.0049*	0.0280	*0.0042*	−0.5267	*0.0206*	−0.1962	*0.0263*	0.8025	*0.0410*	1.1686	*0.0553*	−0.8484	*0.1567*
cohabiting	−0.0586	*0.0077*	−0.0437	*0.0062*	−0.1448	*0.0165*	0.0154	*0.0208*	0.6041	*0.0345*	0.4030	*0.0384*	−0.3230	*0.1292*
# kids 0–4	0.0181	*0.0030*	0.0247	*0.0025*	−0.0086	*0.0083*	0.0875	*0.0110*	0.2018	*0.0204*	0.3232	*0.0278*	2.5521	*0.1286*
# kids 5–10	0.0206	*0.0025*	0.0258	*0.0022*	−0.0313	*0.0059*	−0.0653	*0.0078*	0.2693	*0.0154*	−0.0505	*0.0199*	1.5181	*0.0907*
# kids 11–15	0.0155	*0.0035*	0.0263	*0.0031*	−0.0454	*0.0073*	−0.0818	*0.0091*	0.2743	*0.0195*	−0.1933	*0.0199*	0.2182	*0.0678*
# kids 16–18	0.0603	*0.0062*	0.0643	*0.0054*	0.0151	*0.0108*	−0.0326	*0.0151*	−0.0271	*0.0373*	−0.1484	*0.0377*	−0.4422	*0.1085*
age/10	0.0657	*0.0224*	0.0201	*0.0191*	1.1941	*0.0558*	1.4674	*0.0715*	−1.4465	*0.1210*	−0.2498	*0.1402*	−2.7859	*0.5086*
(age^2)/100	−0.0181	*0.0027*	−0.0165	*0.0024*	−0.1325	*0.0068*	−0.1757	*0.0094*	0.1794	*0.0152*	0.0506	*0.0192*	0.4359	*0.0681*
North	−0.0380	*0.0098*	−0.0287	*0.0087*	−0.0676	*0.0226*	−0.1003	*0.0270*	0.3555	*0.0573*	0.1547	*0.0619*	0.5014	*0.1971*
Yorkshire	−0.0207	*0.0078*	−0.0093	*0.0067*	−0.0622	*0.0188*	−0.1025	*0.0223*	0.1257	*0.0507*	−0.3822	*0.0519*	0.3940	*0.1675*
East Midlands	−0.0147	*0.0081*	−0.0046	*0.0068*	−0.0308	*0.0185*	−0.1165	*0.0239*	−0.0512	*0.0566*	−0.0973	*0.0525*	0.5766	*0.1679*
West Midlands	−0.0311	*0.0080*	−0.0042	*0.0065*	−0.0045	*0.0183*	−0.0378	*0.0220*	−0.0440	*0.0519*	0.1014	*0.0515*	0.1978	*0.1592*
East Anglia	−0.0063	*0.0098*	0.0172	*0.0083*	0.0119	*0.0208*	−0.1255	*0.0275*	−0.4800	*0.0984*	0.2851	*0.0673*	1.2915	*0.2282*
Greater London	0.0595	*0.0069*	0.0605	*0.0058*	0.1522	*0.0190*	0.1176	*0.0237*	0.2989	*0.0511*	0.6149	*0.0602*	1.1357	*0.1745*
South East	0.0349	*0.0063*	0.0309	*0.0054*	0.1719	*0.0154*	−0.0126	*0.0185*	0.0671	*0.0449*	−0.0343	*0.0455*	0.2493	*0.1396*
South West	0.0078	*0.0078*	0.0216	*0.0066*	−0.0526	*0.0178*	−0.0922	*0.0216*	−0.1637	*0.0622*	−0.0514	*0.0536*	1.7123	*0.1928*
Wales	−0.0075	*0.0099*	0.0088	*0.0088*	−0.1376	*0.0220*	−0.1327	*0.0272*	0.4836	*0.0609*	−0.0965	*0.0613*	0.7352	*0.2062*
Scotland	0.0054	*0.0077*	0.0182	*0.0067*	−0.0101	*0.0180*	−0.0409	*0.0225*	0.0195	*0.0545*	0.1016	*0.0536*	1.2153	*0.1740*

(Continued)

Table 2 Continued

	Education/10				Log wage				Labour supply					
Variable	Male		Female		Male		Female		Male: FT → NP		Female: PT → NP		Female: FT → NP	
1994	−0.0190	*0.0057*	−0.0173	*0.0048*	−0.0249	*0.0146*	0.0037	*0.0180*	0.3331	*0.0409*	0.3398	*0.0426*	1.1682	*0.1374*
1995	−0.0203	*0.0058*	−0.0183	*0.0050*	−0.0356	*0.0141*	0.0129	*0.0172*	0.2687	*0.0414*	0.3017	*0.0411*	1.0266	*0.1325*
1996	−0.0132	*0.0058*	−0.0065	*0.0048*	−0.0222	*0.0137*	0.0690	*0.0171*	0.1736	*0.0422*	0.1926	*0.0417*	0.1654	*0.1319*
1997	−0.0106	*0.0060*	−0.0086	*0.0050*	−0.0497	*0.0137*	−0.0079	*0.0178*	0.1322	*0.0431*	0.1572	*0.0410*	0.3019	*0.1321*
1998	−0.0010	*0.0059*	0.0047	*0.0049*	−0.0993	*0.0126*	−0.0466	*0.0159*	0.0203	*0.0462*	−0.0136	*0.0429*	−0.0014	*0.1351*
2000	0.0067	*0.0060*	0.0113	*0.0050*	0.0062	*0.0134*	−0.0201	*0.0159*	−0.1342	*0.0493*	−0.0317	*0.0428*	−0.0412	*0.1357*
Covariance														
Sigma	0.2390	*0.0014*	0.2005	*0.0010*	0.5151	*0.0019*	0.5166	*0.0024*					6.8512	*0.1571*
Male: FT → NP	0.0550	*0.0140*	0.1420	*0.0110*	−0.3100	*0.0940*	0.1290	*0.0420*			−0.1284	*0.0201*	−0.2369	*0.0195*
Female: PT → NP	0.0950	*0.0140*	0.1820	*0.0110*	−0.2140	*0.0950*	0.0280	*0.0440*					−0.6473	*0.1458*
Female: FT → NP	−0.0970	*0.0100*	−0.0800	*0.0080*	0.3040	*0.0950*	0.0660	*0.0370*						
Male: education			0.6190	*0.0058*	−0.0580	*0.0059*	0.0585	*0.0332*						
Female: education					0.0680	*0.0305*	−0.0280	*0.0053*						
Male: wage							0.1176	*0.0098*						

Notes: FRS 1994/95–2000/01 married or cohabiting couples with children 0–15, father aged 16–64, mother aged 16–59. Monetary units are March 2001 GBP. Wages are top-coded at the 99.5% level. Variables are scaled for estimation as indicated. Age difference is that between the person and the oldest child in the household. Reference categories are North West, 1999 and non-white ethnic origin. For calculating potential incomes Male FT is defined at 44 hours/week, Female PT at 18, FT at 38.

and that the latter is the utilization rate of the former so we would expect a positive correlation. The estimated covariances are also generally supportive of the motivation for the work: we find that there is a significant correlation between (PT and FT) labour supply unobservable preferences and education that casts doubt on the traditional identification assumption in labour supply models. Thus, for example, men who have stronger than average preferences for work have higher than average levels of education. The economic variables have the correct signs throughout – higher unearned income is associated with a higher probability of NP relative to alternatives for both men and women; and for a given unearned income, the higher is the income difference between states (i.e. the slope of the budget constraint) the greater is the chance of choosing the higher-income state.

The multinomial nature of the labour supply model makes it difficult to understand the implications of budget constraints for the probabilities of being in each state. Thus in Table 3 we present some simple simulations of how the baseline probabilities are affected if every individual in the sample had £10 added to their net income in each state in turn. In each case these effects are consistent with economic theory. In the case of the model with endogenous labour supply we find that adding £10 to NP income for women raises the NP probability from 0.3 to 0.35 with a 0.04 fall in PT and a 0.01 fall in FT; raising PT income by £10 raises the PT probability by 0.04 (i.e. from 40% to 44%) with a 0.03 fall in NP and a 0.01 fall in FT; and raising FT income by £10 raises the FT probability by close to 0.02 (i.e. from 30% to 32%). These are relatively large effects from relatively modest changes in net incomes. Men, as usual, are a great deal less sensitive and exhibit backward-bending labour supply behaviour: raising NP income by £10 reduces the FT probability by 0.003 (i.e. from 91.5% to 91.2%).[22]

Our results have important implications for both the labour supply and returns to education literatures. The usual exclusion restriction in labour supply modelling, that education determines wages but not labour supply conditional on wages, is shown to be strongly rejected. Moreover, we find that unobservable determinants of labour supply (preferences) do indeed affect education and wages. The implication of this is that there are important selection effects from using samples of workers only[23] and it is surprising that so little attention has traditionally been given to this sample selection issue in the context of female wage equations.

These results are potentially important for policy. Our finding that education and labour supply are jointly determined implies that a second-best case for subsidizing education can be made if high marginal tax rates

22. The corresponding simulations using the model with exogenous education show very similar effects for women but suggest even more inelastic responses by men.
23. We leave the extension to separate FT and PT wages equations to a later date. In earlier work in a model with exogenous education (for example, Bingley and Walker, 1997) we found important selection effects in PT and FT wage equations.

Table 3 Simulated effects of budget constraint changes to labour supply (% expected in each state)

	Women			Men	
	NP	PT	FT	NP	FT
Baseline	30.3	39.7	30.0	8.5	91.5
Baseline + £10					
NP	5.4	− 4.2	− 1.2	0.3	− 0.3
PT	− 3.2	4.3	− 1.1	–	–
FT	− 0.6	− 1.0	1.7	− 0.3	0.3

cause significant work disincentives.[24] Indeed, since marginal tax rates are high on the rich (through the progressivity of the tax system) and the poor (through the effect of means-tested welfare payments and tax credits) one might argue that there should be subsidies available for both the rich and the poor. The tax deductibility of certain savings vehicles offers a way for rich parents to reduce the net cost of education for their children but since welfare recipients save little in such vehicles a means-tested education subsidy may be the most efficient policy – as well as having potentially desirable effects on inequality.

Analysing the implications of the results require that the labour supply effects be computed. Thus, to illustrate the results we analyse the effects of adding an additional year of schooling to the whole population. This raises the gross wages of husbands and wives and this has direct consequences for the budget constraint, via the tax/welfare system, and hence has labour supply consequences. Table 4 shows the effects obtained from simulating the effects of the change in the levels of education for the labour supplies of each couple in the sample (we uprated all of the data to April 1999 by reflating the data by price and earnings indices) and averaging. These calculations allow for the effects of education to impact on labour supply probabilities directly, and indirectly through the effect of education on wages and hence on net incomes at each labour supply point. That is, the figures in Table 4 allow for the impact of the tax and welfare system.[25] Because the empirical model and the budget constraints are non-linear we cannot simply simulate some typical household. Rather we add one year of education to each wife in the data and we find that this has an effect, on average, of reducing female non-participation by more than 3%, while adding two years has around double the effect. Adding one year to all husbands' education levels increases wives' NP probability by about 3% (because we treat husbands' earnings as unearned

24. See Blundell *et al.* (1998) for some UK evidence on the impact of taxation on labour supply that exploits the reductions in marginal tax rates that have occurred over time.
25. We use the same very detailed code used in estimation to capture the tax and welfare rules.

Table 4 Simulated effects of additional education (% in expected state and changes)

Education years +		Female labour supply			Male labour supply	
Male	Female	NP	PT	FT	NP	FT
Baseline		28.95	40.36	30.69	8.03	91.97
0	1	− 3.22	1.46	1.76	0.04	− 0.04
0	2	− 6.18	2.51	3.67	0.09	− 0.09
1	0	3.13	− 1.76	− 1.37	− 0.29	0.29
1	1	− 0.39	− 0.03	0.43	− 0.25	0.25
1	2	− 3.68	1.29	2.38	− 0.21	0.21
2	0	6.75	− 3.87	− 2.88	− 0.60	0.60
2	1	2.93	− 1.88	− 1.05	− 0.57	0.57
2	2	− 0.68	− 0.27	0.95	− 0.52	0.52

income to wives) and has a modest effect on male work. Two years has around double this effect. Adding education to both spouses tends to have counteracting effects, because of the effect on unearned incomes, so that the net effect of expanding overall education turns out to be modest for women.[26]

6. POLICY SIMULATIONS

The UK has recently introduced payments to the children of low-income parents that are conditional on remaining at school. These are known as Educational Maintenance Allowances (EMAs) and are payments to 16- and 17-year-olds that are conditional on remaining in full-time education whose amounts will be means-tested against parental income. To simulate this we need to be able to match the income of the parents with the school-leaving of their children and acknowledge that there is a correlation between them. Unfortunately the FRS data do not tell us about school-leaving decisions of the children – all we know is whether children (under 18) who are present in the household and are still in education.

Thus, we proceed as follows. We use the BHPS data to find the parental gross earnings (EMA is means tested against earnings) distribution corresponding to the recorded age at which we observe in BHPS children finished their education. Figure 1 shows the means (reflated to 2001 by a real earnings index) of this distribution which clearly shows the correlation between

26. The simulated effect of the additional education keeping net incomes constant are large. For example, adding one year to wives' educations increases the wives' average FT probability by close to 0.6% compared to the increase of close to 1.5% in Table 4 which allows for the additional effect via the budget constraint.

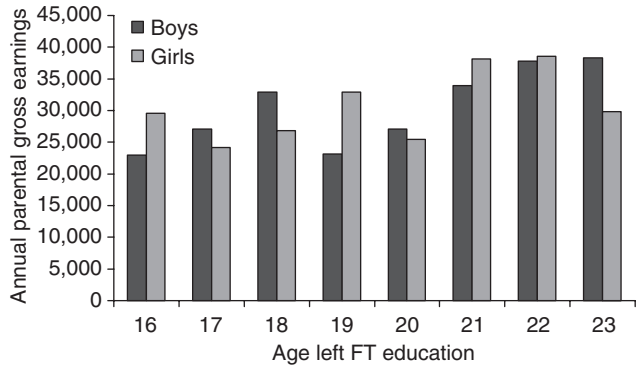

Figure 1 Gross earnings distributions (BHPS parents of children with completed education)

education and parental incomes.[27] For every pair of parents in our FRS data we take a single draw from the BHPS distribution corresponding to their own school-leaving age. So for men in FRS who are recorded as having left school at 16 we take a draw from the BHPS distribution of parental incomes for BHPS children who left school at 16. This allows us to estimate the EMA entitlement that every FRS observation would have faced had EMA existed when they were young. The simulated average amount paid in EMA is close to £15 per week and the distribution of this is shown in Figure 2. Note that, while it is true that those who left school at an early age on average are simulated to receive most EMA we also find that large amounts of EMA would have been received by those individuals who would have stayed on in education without the subsidy. That is, despite the strong correlation between parental income and early school leaving[28] there are many children who choose to stay on at school despite the low incomes of their parents. Averaging the amount paid to those who would have stayed on in the absence of the subsidy we find that 90% of EMA payments are deadweight.

Having estimated EMA entitlements for individuals in the FRS data we then apply the estimated effects of a marginal pound of EMA obtained by Ashworth *et al.* (2002) from their analysis of the EMA pilot areas[29] to estimate the probability that each individual would have been induced to stay on one and two further years[30] had they faced an EMA when they were young. Table 5 gives the estimated effects on the probability of staying on for one and two

27. This is for the 1,246 children in BHPS that have ever completed education. Note that the data are quite sparse for children leaving education at age 19, 20 and 23.
28. See, for example, recent results in Chevalier *et al.* (2005).
29. EMA was evaluated by comparing the behaviour of recipients in pilot areas with that of non-recipients in carefully matched control areas. The estimated effects of £1 of EMA receipt was 0.002427 for boys and 0.00153 for girls. Thus, for a full entitlement of around £30 per week the predicted effect was a rise in the probability of staying on at 16 of around 7%.
30. We assume that EMA does not change the probability of staying on beyond 18.

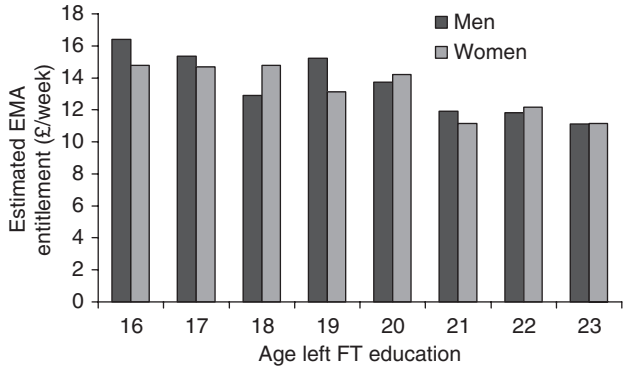

Figure 2 Estimated EMA entitlements for FRS adults

Table 5 Estimated probability of one or two additional years of education

		Actual education leaving age:	
		16	17
Men	+ 1	4.2	3.9
	+ 2	0.3	–
Women	+ 1	2.2	2.3
	+ 2	0.1	–

additional years beyond 16. The effects for women are smaller because of the smaller estimated effect per pound of EMA from the evaluation study.

Individuals who left at 16 and 17 are randomly assigned an extra year or two of education according to the estimated probabilities. We then predict the direct effects of this additional education on the education and labour supply and the indirect effects that work through the covariances in the error terms. This allows us to compute the effects on net incomes taking into account both the effects on gross wages and on labour supply as well as the interaction with the tax and welfare system. The result is in Figure 3 which shows that the benefits are almost entirely confined to individuals who would have left school at an early age.[31] The average effects are small but they conceal wide variation arising from the fact that just a small proportion of individuals are indeed encouraged to increase their education. So, for example, for those men who left at 16 that do increase their education from 16 to 17 (around 5%) the gain in net income is almost £20 per week. The

31. Indeed the only reason why the benefits leak to those who left school beyond 17 is because they are married to individuals who left school below 18.

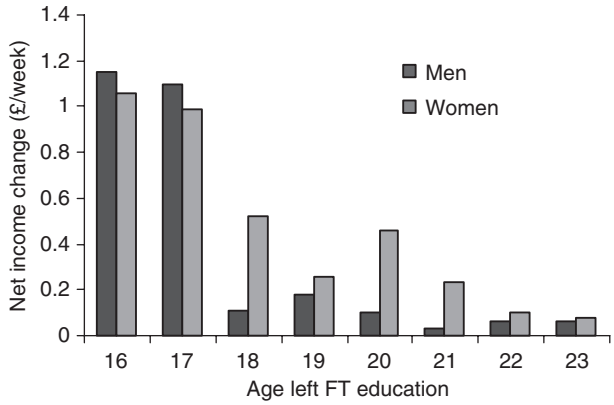

Figure 3 Distribution of net income gains from EMA by age of leaving full-time education

effect over the whole population is a rise in average net incomes of £0.82 per week.

7. SUMMARY AND CONCLUSIONS

The aim of the paper has been to illustrate the importance of the interaction between labour supply and education in the determination of wage rates and incomes. This arises because of the importance of non-linearities in the budget constraint induced by the means-tested welfare programmes and the income tax system in the UK, and the correlation between unobservable preferences for work and education. We find that the correlation between work and education preferences, and between preferences for work and wage rates, are statistically significant. We reject the exogenous education model and this has important implications for how labour supply models should be estimated as well as how the returns to education should be computed.

In our empirical exercise, identification is achieved through functional form assumptions, non-linearities in the tax/benefit system and exclusion of quadratic terms of mother's age at first birth, and these are shown to be statistically valid instruments for education. It is worth noting that treating fertility as predetermined (in the usual econometric sense) is standard practice in the analysis of labour supply decisions in the developed world and there is little reason to expect age at first birth to affect current labour supply or wages over and above its impact on education. Of course, a more convincing identification awaits a dataset that contains better instruments such as family backgrounds that are uncorrelated with labour supply but not with education, or even 'natural' experiments in the education system. Given the sort of data currently available, the empirical model we present might

best be viewed as an illustration, but at the very least it points to the need for future research.

Part of the motivation for the research is to see if we can exploit the joint determination of education and labour supply for policy purposes. Thus, we use the estimated model to support a simulation of the effects of an education subsidy that is means-tested against parental income. We find that, because of the large variance in parental incomes at any level of education of children, there is a large deadweight loss of such a policy. However, extra education has a strong effect on living standards and, for those who are encouraged to invest in additional education, there are large increases in net incomes.

ACKNOWLEDGEMENTS

This research was funded by the Centre for the Economics of Education, via the Department for Education and Skills, and our collaboration was supported by the EU TSER programme. We are also grateful to the Office of National Statistics and the ERSC Data Archive for supplying the data. The data are used with the permission of Her Majesty's Stationery Office. The usual disclaimer applies.

Address for correspondence: Ian Walker, Department of Economics, University of Warwick, Coventry CV7 7AL, UK. Tel.: + 44/0 2476 523054; Fax: + 44/0 2476 523032; E-mail: i.walker@warwick.ac.uk

REFERENCES

Altonji, J. and R. Blank (1999), 'Race and Gender in the Labour Market', in: O. Ashenfelter and D. Card (eds.), *Handbook of Labour Economics III*, North-Holland, Amsterdam.

Arellano, M., P. Hansen and E. Sentana (1999), 'Underidentification?', mimeo, CEMFI.

Ashworth, K., J. Hardman, Y. Hartfree, S. Maguire, S. Middleton, D. Smith, L. Dearden, C. Emmerson, C. Frayne and C. Meghir (2002), 'Educational Maintenance Allowances: The First Two Years', DfES Research Report No. 352.

Bingley, P. and I. Walker (1997), 'The Labour Supply, Unemployment and Participation of Lone Mothers in In-Work Transfer Programmes', *Economic Journal* 107, 1375–1390.

Blinder, A. S. and Y. Weiss (1976), 'Human Capital and Labour Supply: A Synthesis', *Journal of Political Economy* 84, 449–472.

Blundell, R. W. and T. MaCurdy (1999), 'Labour Supply: A Review of Alternative Approaches', in: O. Ashenfelter and D. Card (eds.), *Handbook of Labour Economics III*, North-Holland, Amsterdam.

Blundell, R. W., A. Duncan and C. Meghir (1998), 'Estimating Labour Supply Responses using Tax Reforms', *Econometrica* 66, 827–862.

Card, D. (1999), 'Education and Earnings', in: O. Ashenfelter and D. Card (eds.), *Handbook of Labour Economics III*, North-Holland, Amsterdam.

Carneiro, P. and J. J. Heckman (2002), 'The Evidence on Credit Constraints in Post-Secondary Schooling', *Economic Journal* 112, 705–734.
Chevalier, A. and T. Viitanen (2003), 'Long-Run Consequences of Teen Motherhood', *Journal of Population Economics* 16, 323–343.
Chevalier, A., C. Harmon, V. O'Sullivan and I. Walker (2005), 'The Impact of Parental Income and Education on the Schooling of their Children', IZA Working Paper No. 1496.
Chiappori, P.-A. (1992), 'Collective Labor Supply and Welfare', *Journal of Political Economy* 100, 437–467.
Goodman, A., G. Kaplan and I. Walker (2004), 'Understanding the Effects of Early Motherhood in Britain: The Effects on Mothers', IFS Working Paper No. 04/20.
Harmon, C., H. Oosterbeek and I. Walker (2003), 'The Returns to Education: A Review of the Evidence, Issues and Shortcomings in the Literature', *Journal of Economic Surveys* 17, 115–156.
Hausman, J. and D. Wise (1978), 'Conditional Probit Model for Qualitative Choice: Discrete Decisions Recognizing Interdependence and Heterogeneous Preferences', *Econometrica* 46, 403–426.
Heckman, J. J. (1976), 'A Life-Cycle Model of Earnings, Learning, and Consumption', *Journal of Political Economy* 84, S11–S44.
Heckman, J. J., L. Lochner and C. Taber (1998), 'Tax Policy and Human-Capital Formation', *American Economic Review (Papers and Proceedings)* 88, 293–297.
Hoynes, H. (1996), 'Welfare Transfers in Two-Parent Families: The Case of AFDC-UP', *Econometrica* 64, 295–332.
MacFadden, D. and K. Train (2000), 'Mixed MNL Models of Discrete Response', *Journal of Applied Econometrics* 15, 447–470.
MaCurdy, T., D. Greene and H. Paarsch (1990), 'Assessing Empirical Approaches for Analyzing Taxes and Labor Supply', *Journal of Human Resources* 25, 415–490.
Polachek, S. (2004), 'How the Human Capital Model Explains Why the Gender Wage Gap Narrowed', IZA Discussion Paper No. 1102.
Puhani, P. (2000), 'The Heckman Correction for Selection and Its Critique', *Journal of Economic Surveys* 14, 53–68.
Sianesi, B. and J. van Reenan (2003), 'The Social Returns to Education: A Review of the Empirical Macro-Economic Literature', *Journal of Economic Surveys* 18, 157–200.
Trostel, P. A. (1993), 'The Effect of Taxation on Human Capital', *Journal of Political Economy* 101, 327–350.
Trostel, P. A. and I. Walker (2004), 'Education and Work', mimeo, University of Maine.
Weiss, Y. and R. Gronau (1981), 'Expected Interruptions in Labour Force Participation and Sex-Related Differences in Earnings Growth', *Review of Economic Studies* 48, 607–619.