Approximate word count: 5100 + 30% for tables/charts

Education, Work and Wages in the UK

Paul Bingley

National Center for Register Based Research, Department of Economics, Århus University, DK-8000 Århus C, Denmark

Ian Walker

Department of Economics, University of Warwick, Coventry CV4 7AL, UK
Institute for Fiscal Studies, 7 Ridgmount St., London WC1E 7AE, UK

and

Yu Zhu

Department of Economics, University of Kent, Canterbury CT2 7NZ, UK
Monday, 20 January 2003

JEL codes: I38, J22, R31

Keywords: welfare programmes, labour supply, returns to education

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 utilisation but the benefits will be higher the greater the utilisation rate. Thus the returns will depend on how intensively that capital is utilised 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.

* 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 is used with the permission of Her Majesty's Stationery Office. The usual disclaimer applies.

Corresponding author: Ian Walker, Department of Economics, University of Warwick, Coventry CV7 7AL, UK
Tel +44/0 1203 523054 Fax +44/0 1203 523032 **Email i.walker@warwick.ac.uk**

1. Introduction

This paper is concerned with the relationship between education, wages and working behaviour. The work has two main motivations. Firstly, there is a sharp distinction in the literature between the returns to education and the effect of wages on labour supply – the former ignores the fact that labour supply is the utilisation rate of human capital, while the latter assumes that education can be used to identify the model by excluding education from labour supply equations but not from the determination of wages. Education is the investment that cumulates in the form of human capital while labour supply is the utilization rate of that stock. Yet, education is usually the basis for identifying labour supply models – it is typically assumed that education determines wages but does 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 utilisation but the benefits will be higher the greater is the utilisation rate. Thus the returns will depend on how intensively that capital is utilised. Thus we would expect that those who intend to work least will also wish to invest least in human capital.

A second consideration is that the system of poverty relief may act as a "tax" on the acquisition of human capital since welfare payments may be "means-tested" against income. On the other hand, in-work welfare may act as a wage subsidy that reduces the net costs of on-the-job general training. The 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[1].

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

[1] Indeed, there is little evidence even of the effect of selectivity into work on the estimated returns to education conditional on working.

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. The externality literature is reviewed in Sianesi and van Reenan (2003) who also find little supporting evidence. However, a standard second best argument for subsidising 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 that reduces labour supply might be offset by a subsidy that increases education (see Trostel (1993)).

Thus, here we attempt to model the relationship between wages, work, and education incorporating the tax/welfare system and allowing for the possible endogeneity of education as well for the correlations between the unobservable components of wages and working behaviour.

Our analysis is conducted on UK data: 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 10 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 an increase in post-compulsory participation and there is still a significant minority that leave school at the age of 16 with minimal formal qualifications. The problem is regarded as acute and the present government is introducing payments to children from poor backgrounds to stay on at school beyond 16 (Educational Maintenance Allowances, EMAs)[2].

We use the estimates to simulate the net private returns to education, and hence the returns to the government 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.

2. 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

[2] This follows their successful piloting in a number of areas. See Ashworth *et al* (2002) for detailed evaluation.

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 single Benefit Unit households (i.e. without other non-dependent adults in the household), 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 of Work and Pensions for policy analysis purposes. 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. Table 2 shows the means and standard deviations of the data used in estimation broken down by labour market status.

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

3. 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 discretising the hours distribution. Modelling labour supply behaviour in the context of non-convex budget constraints gives rise to a number of empirical difficulties, as summarised in Blundell and MaCurdy (1999). Essentially, the choice model is simplified to be discrete choice in order to make it empirically tractable.

Table 2	*Married & Cohabiting Couples Descriptive Statistics by Labour Supply Status*											
	Means and standard deviations											
Variable						Labour Supply						
Male Labour Supply			Non-work						Work			
Female Labour Supply	Non-work		Part-time		Full-time		Non-work		Part-time		Full-time	
cohabiting	0.2554		0.1775		0.1765		0.1064		0.0776		0.1021	
# kids 0-4	0.8396	*0.8206*	0.3789	*0.6320*	0.5107	*0.6819*	0.8892	*0.7949*	0.4921	*0.6695*	0.3775	*0.5876*
# kids 5-10	0.8408	*0.9102*	0.8825	*0.8733*	0.6524	*0.7729*	0.7079	*0.8245*	0.7094	*0.7928*	0.4715	*0.6856*
# kids 11-15	0.5241	*0.7887*	0.6403	*0.7404*	0.5187	*0.7420*	0.3454	*0.6438*	0.4962	*0.6956*	0.5616	*0.7135*
# kids 16-18	0.1123	*0.3502*	0.1223	*0.3353*	0.1310	*0.3682*	0.1029	*0.3302*	0.1607	*0.3955*	0.2323	*0.4613*
Male												
log wage							2.2652	*0.6836*	2.2873	*0.5441*	2.2443	*0.5520*
education/10	1.6503	*0.2272*	1.6384	*0.1927*	1.7179	*0.2585*	1.7583	*0.2692*	1.7154	*0.2391*	1.7398	*0.2612*
age/10	3.5649	*0.8938*	3.8863	*0.8209*	3.9166	*0.8094*	3.6793	*0.7637*	3.8806	*0.7224*	3.9651	*0.7354*
(age^2)/100	13.5072	*6.8884*	15.7759	*6.6094*	15.9930	*6.5678*	14.1204	*5.9253*	15.5805	*5.7633*	16.2625	*5.8811*
age difference/10	2.6946	*0.7156*	2.8381	*0.6764*	2.9955	*0.6943*	2.9123	*0.6045*	2.9226	*0.5444*	2.9372	*0.5689*
(age difference/10)^2	7.7727	*4.3351*	8.5113	*4.1129*	9.4534	*4.4697*	8.8469	*3.7203*	8.8379	*3.3330*	8.9510	*3.4599*
ethnic origin	0.2125		0.0815		0.1230		0.1072		0.0306		0.0706	
Female												
log wage			1.4924	*0.4849*	1.9603	*0.6116*			1.7380	*0.5743*	1.9555	*0.5752*
education/10	1.6322	*0.1826*	1.6463	*0.1632*	1.7682	*0.2620*	1.7259	*0.2272*	1.7121	*0.2081*	1.7587	*0.2396*
age/10	3.2538	*0.8043*	3.6002	*0.7723*	3.6562	*0.7201*	3.4288	*0.7270*	3.6683	*0.6823*	3.7624	*0.6800*
(age^2)/100	11.2340	*5.5686*	13.5568	*5.7152*	13.8847	*5.3941*	12.2852	*5.2215*	13.9218	*5.1191*	14.6181	*5.1299*
age difference/10	2.3835	*0.5842*	2.5520	*0.5975*	2.7350	*0.6031*	2.6618	*0.5389*	2.7103	*0.4782*	2.7346	*0.4918*
(age difference/10)^2	6.0222	*3.1789*	6.8691	*3.2943*	7.8431	*3.5101*	7.3757	*3.0012*	7.5745	*2.6769*	7.7198	*2.7512*
ethnic origin	0.2062		0.0624		0.1203		0.1085		0.0289		0.0700	
# observations	1746		417		374		7182		10666		8187	
Notes: FRS 1994/5-2000/1 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.												
Hours groupings are defined as Female PT=1-29, FT=30+, Male FT as 1+												

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[3]. 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 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. The empirical problems multiply, because now hours, wages and education may all be simultaneously determined. Furthermore, we have the usual partial-observability problem of wages in our labour supply analysis. 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). Our model is static in the sense that we only consider within-period hours substitution. 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[4].

Multinomial choice problems are most often estimated through multinomial logit (less often multinimial 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

[3] The proportion of men working less than full-time hours is negligible.
[4] Hoynes (1996) further allows "approximation error" within each alternative. We do not pursue this, in lieu of added complexity elsewhere.

problem numerically tractable. Furthermore, following Hausman and Wise (1978), we allow for taste heterogeneity via random parameters on income[5].

The main empirical difficulty in all labour supply modelling, is addressing the endogeneity of the gross wage. Most often, 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, Greene and Paarsch (1990) for a critique). Education is most often included as a wage determinant but assumed not to affect hours preferences. This is an assumption we test and reject. In the absence of exclusion restrictions, we rely on a joint normality assumption about 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. In practise, we estimate the wage and labour supply equations jointly and missing wages for men and women are integrated out.

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 formalised as follows for the labour supply equation:

$$U_j^* - U_k^* = g(Y_j - Y_k)y + X^H b_{jk} + E^m a_{jk}^m + E^f a_{jk}^f + (e_j + e_k)$$

where j and k denote combinations of household labour supply alternatives, U_k^* is unobservable utility in state k, *g(.)* is some function of income differences between states (in this case linear), y is an associated coefficient vector with mean $\overline{y}$ and variance $(1+\widetilde{y})$, X^H is a vector of state-invariant explanatory variables, b_{jk} is an associated vector of coefficients for the comparison between alternatives j and k, E^m is education for the male, a_{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*, $e_j - e_k$ is a normally distributed composite error term. For the wage equations we have $W^s = X_W^s b_W^s + e_W^s$, where W^s denotes the log wage for each spouse $s = m, f$, X_W^s is a vector of explanatory variables including

[5] Recent generalisations of the multinomial logit allow heterogeneity by including mixing terms which are normally distributed (MacFadden and Train (2000) or of unspecified distribution (Hoynes (1996)). While these approaches are arguably more general that that presented here, their extension to endogenous right hand side variables is not obvious.

education, b_W^s is an associated vector of coefficients and e_W a random error term. The novelty of the paper is to extend this conventional model 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, $E^s = X_E^s b_E^s + e_E^s$, where E^s denotes the level of education, measured as the age left full-time education, for each spouse, X_E^s is a vector of explanatory variables, b_E^s is an associated vector of coefficients and e_E a random error term.

All error terms are assumed jointly normal. Identification requires excluded instruments in the education equation: determinants of education, which are not also determinants of wages and hours of work.

4. Identification and Results

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. While normality alone would be sufficient for identification, it would not, of course, be convincing. Identification is achieved through a combination of restrictions on functional form, plausible exclusion restrictions and significant tax/welfare non-linearities. Our instruments for education in the wage and hours equations are (quadratic) functions of the age difference between mother and oldest child. The rationale for this choice is that women who have their children early may have found staying on in education more difficult that those that had their children later in life[6]. There is a great deal of evidence that teenage motherhood is associated with low educational achievement[7]. It is, of course, possible that early motherhood has an

[6] Evans and Montgomery (1994) find evidence that smoking while young is correlated with education but not wages.
[7] Chevalier and Viitanen (2003) produce evidence for the UK that teen motherhood has significant adverse consequences for education but not on wages conditional on education.

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. Ultimately, these exclusion restrictions are empirical assumptions and two different tests for the validity of our education instruments appear supportive. First, an overidentification (likelihood ratio) test shows that both age-difference 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. Secondly, a likelihood-ratio test against the exogenous education model suggests the instruments have sufficient explanatory power[8]. 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.

The results of the model with endogenous education are given in Table 3[9]. The age difference variable measures the age of first birth so we find that the longer that children are postponed the higher is education[10]. This effect is statistically significant but, as in Chevalier and Viitanen (2003), modest in size – mothers who postpone childbirth by one year have around 0.04 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 rates of return to education of around 9% for men and 10% for women. This is consistent with the view that the UK has an early school-leaving problem[11]: many able children, lacking the confidence and/or resources to progress further in education and into higher education, leave school early despite their ability.

[8] The log-likelihood of the restricted, exogenous education, model is 782399 compared to 782477 for our preferred model with our exclusion restrictions imposed and allowing education to be endogenous. This amounts to a chi-squared of 96 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 782450 giving a chi-squared of 6 and, with 10 restrictions, a p-value of only 0.18. Although 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 Arrellano *et al* (1999) on this point).

[9] The results presented here are for the model with a random coefficient on income in the labour supply model - $(1+\widetilde{y})$ in our description above – but this is not significantly different from unity.

[10] 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.

[11] It is also consistent with evidence in Harmon, Oosterbeck and Walker (2000) which uses a variety of UK datasets and a variety of instruments to show IV returns of around 10% and higher.

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 than education and labour supply are jointly determined and that the latter is the utilisation 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 of 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 (ie 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 4 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 0.01 fall in FT; raising PT income 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

Table 3 *Married & Cohabiting Couples Labour Supply, Education & Wages*

Maximum Likelihood Model Estimates and Standard Errors

Variable	Education/10				Log Wage				Labour Supply					
	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*
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 1994/5-2000/1 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 as 44 hours/week, Female PT as 18, FT at 38.

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: raising NP income by £10 reduces the FT probability by 0.03 (ie from 91.5% to 91.2%)[12].

Table 4 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

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 inappropriate. Moreover we find that unobservable determinants of labour supply preferences affect education and wages – there are important selection effects from using samples of workers only[13].

4. Policy Simulations

Analysing the policy implications of the results require that the labour supply effects be computed. Thus, we first 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 5 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 (uprated to April 1999) and averaging. These calculations allow for the effects of education to impact on labour supply probabilities both directly and through the indirect of education on wages and hence on net incomes at each labour supply point. That is, the figures in Table 5 allowing for the

[12] The corresponding simulations using the model with exogenous education show very similar effects for women but suggest even more inelastic responses by men.
[13] 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.

impact of the tax and welfare system[14]. Adding 1 year of education to all wives has an average effect of reducing female non-participation by more than 3%, while adding 2 years has around double the effect. Adding 1 year to all husbands increases wives' NP probability by about 3% (because we treat husbands' earnings as unearned income to wives) and has a modest effect on male work. 2 years has around double the 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 education turns out to be modest for women[15].

Table 5 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

The results are also potentially important for policy. Our finding that education and labour supply are jointly determined implies that a second best case for subsidising education can be made if high marginal tax rates cause significant work disincentives[16]. 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 rich and 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

[14] We use very detailed code, derived from the IFS TAXBEN routines, to capture the tax and welfare rules.

[15] The simulated effect of the additional education keeping net incomes constant are large. For example, adding 1 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 6 which allows for the additional effect via the budget constraint.

inequality. The UK is about to introduce just such a policy – known as Educational Maintenance Allowances (EMAs). These will be 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. Thus, while these simulation results above illustrate the issues raised in the modelling, they are not of practical significance because policy would never be addressed to raising everyone's education by one year. However, simulating the effects of EMA requires that we acknowledge the correlation between parental incomes and childrens' school leaving decisions. Unfortunately the FRS data does not tell us about school leaving decisions of the children – all we know if whether children (under 18) who are present in the household and 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 education and parental incomes[17]. 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 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 £20 per week and the distribution of this is shown in Figure 2. Notice 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. Averaging the amount paid to those who would have stayed on in the absence of the subsidy we find that 25% of EMA payments are deadweight.

[16] See Blundell, Duncan and Meghir (1999) 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.

[17] This is for the 1246 children in BHPS that have ever completed education. Note that the data is quite sparse for children leaving education at age 19, 20 and 23.

Figure 1 *Gross Earnings Distributions*
BHPS Parents of Children with Completed Education

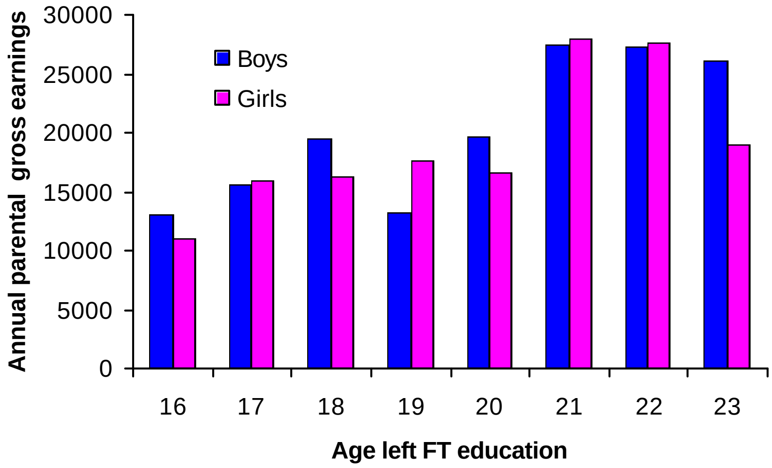


Figure 2 *Estimated EMA Entitlements for FRS Adults*

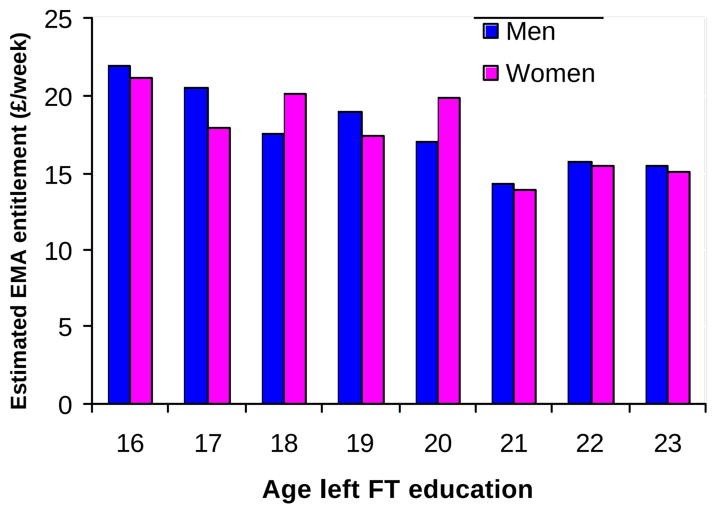
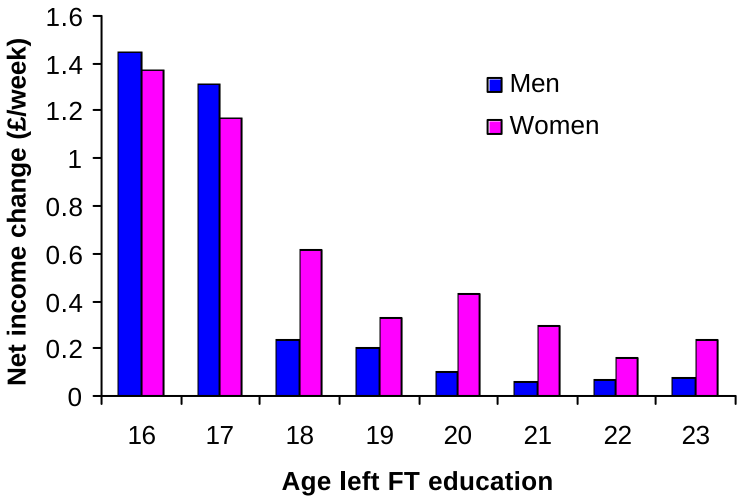


Figure 3 *Distribution of Net Income Gains from EMA*
by Age of Leaving Full Time Education



Having estimated EMA entitlements 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[18] to estimate the probability that each individual would have been induced to stay on one and two further years[19]. Table 6 gives the estimated effects on the probability of staying on for one and two additional years beyond 16. The effects for women are smaller because of the smaller estimated effect per pound of EMA from the evaluation study.

Table 6 Estimated Probability of 1 or 2 Additional Years of Education

Actual education leaving age:		16	17
Men	+1	5.3	0.3
	+2	4.7	-
Women	+1	3.3	0.1
	+2	3.0	-

Individuals who left at 16 and 17 are randomly assigned an extra year or two of education according to the estimated probabilities. We then calculate the direct effects of this additional education on 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[20]. 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 effect over the whole population is a rise in average net incomes of £1.03 per week.

[18] 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%.

[19] We assume that EMA does not change the probability of staying on beyond 18.

[20] 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.

5. 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 nonlinearities 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 wages rates are statistically significant. We reject the exogenous education model which has important implications for how we estimate labour supply models as well as how we compute the returns to education.

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 a 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.

References

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

Ashworth K. *et al* (2002), "Educational Maintenance Allowances: the First Two Years**", DfES Research Report** 352.

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

Bingley, P. and Walker, I. (2001), "Household Unemployment and the Labour Supply of Married Women", **Economica**, 68, 157-185.

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

Blundell, R.W. and Macurdy, T. (1999), "Labour Supply: A Review of Alternative Approaches", in O. Ashenfelter and D. Card (eds.) **Handbook of Labor Economics III**, North Holland.

Card, D. (1999), "Education and Earnings", in O. Ashenfelter and D. Card (eds.) **Handbook of Labor Economics III**, North Holland.

Chevalier, A. and T. Viitanen, (2003), "Long-run Consequences of Teen Motherhood", forthcoming **Journal of Population Economics**.

Chiappori, P-A. (1992), "Collective Labor Supply and Welfare", **Journal of Political Economy**, 100, 437-467.

Evans, W. and Montgomery, E. (1994), "Education and Health: Where There's Smoke There's an Instrument", **NBER Working Paper** 4949**.**

Harmon, C. and I. Walker (1995), "Estimates of the Economic Return to Schooling for the United Kingdom", **American Economic Review**, 85, 1278-1286

Harmon, C., Oosterbeek, H. and Walker, I. (2003), "The Returns to Education: a Review of the Evidence, Issues and Shortcomings in the Literature", mimeo, forthcoming **Journal of Economic Surveys**.

Hausman, J. and D. Wise (1978), "Conditional Probit Model for Qualitative Choice: Discrete Decisions Recognizing Interdependence and Heterogeneous Preferences", **Econometrica**, 46, 403-426.

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. Paarch (1990), "Assessing Empirical Approaches for Analyzing Taxes and Labor Supply", **Journal of Human Resources**, 25, 415-90

Sianesi, B and J van Reenan (2003), "The Social Returns to Education: a Review of the Empirical Macro-economic Literature", **IFS working paper** 02/05, forthcoming, **Journal of Economic Surveys**.

Trostel, P.A, (1993), "The Effect of Taxation on Human Capital", **Journal** of **Political Economy**, 101, 327-50.