HIGHER EDUCATION FUNDING REFORMS IN ENGLAND: THE DISTRIBUTIONAL EFFECTS AND THE SHIFTING BALANCE OF COSTS*

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This article undertakes a quantitative analysis of substantial reforms to the system of higher education (HE) finance in England, first announced in 2004 and revised in 2007. The reforms introduced deferred fees for HE, payable by graduates through the tax system via income-contingent repayments on loans subsidised by the government. The article uses lifetime earnings simulated by the authors to consider the likely distributional consequences of the reforms for graduates. It also considers the costs of the reforms for taxpayers, and how the reforms are likely to shift the balance of funding for HE between the public and private sectors.

The Higher Education Act of 2004 introduced a set of substantial reforms to the system of higher education (HE) finance in England. These reforms, which included an increase in fees, income-contingent loans (ICLs) and means-tested grants and bursaries, were preceded by lengthy discussions on the relative merits of alternative funding systems. Among the desired elements of the reforms that emerged from this debate were:

   (i) that a greater share of the costs of HE be borne by graduates, the main beneficiaries of HE;
  (ii) that the system include an insurance element to protect graduates against low realised returns from HE; and
 (iii) that universities see increased funding per head. Further refinements to these reforms were announced in July 2007. The 2004 reforms came fully into operation in September 2006 and the latest refinements will apply to students starting from September 2008.

This article assesses the extent to which the new reforms are likely to realise the above aims. We start off with an analysis of the distributional effects of the reforms by student parental income. This reveals that the poorest students gain the most from the reforms, due to generous increases in maintenance grants and subsidies outweighing the total increase in the costs of entering university and that students from relatively well-off backgrounds will typically face higher net costs of HE. As the

amount that graduates pay for HE will depend on the amount and timing of their lifetime earnings, we then consider the distributional effects of the reforms by graduate lifetime earnings. This analysis makes use of a new set of simulated earnings profiles, developed in Dearden *et al.* (2006), that account for earnings mobility and spells out of work, explicitly capturing the notion that some graduates will experience better labour market outcomes than others. We find that relative to the system that was replaced, graduates with the lowest lifetime earnings can expect to see a reduction in the cost of HE, while higher-earning graduates will contribute more to the cost of their HE. In this way, we find that the HE reforms do in fact include a substantial insurance component. We conclude by taking a look at how the reforms affect university funding and how they shift the balance of funding for HE between the public sector and the private sector. We find that universities gain financially from the reforms, both through additional taxpayer funding and through contributions from graduates.

Our article contributes to the existing literature in a number of ways. First, it analyses quantitatively an HE funding policy that is complex and multifaceted. There are a number of existing studies on the empirical effects of HE policies, contained for example in Keane and Wolpin (1997), Heckman *et al.* (1998), Lee (2001) and Gallipoli *et al.* (2006). However, the overriding contribution of these papers is in analysing HE policies within partial or general equilibrium frameworks, and in so doing they consider straightforward HE interventions, such as tuition subsidies. Whilst we do not use a structural framework, we add to this (largely US literature) by considering the quantitative effects of a relatively more complex set of HE reforms.

Second, our article adds important empirical evidence to the literature that emphasises the potentially valuable role of education policies with insurance elements, such as income-contingent loans. The concept of ICLs as a means to fund human capital investment dates back to Friedman (1955). Since then, numerous works, such as Nerlove (1975), Barr (1993), Greenaway and Haynes (2003) and Chapman (2005), have discussed their potential usefulness as a source of funding for HE. Our work adds empirical evidence on the likely distributional effects of such policies to this literature. There is also a large literature on the background to the new HE reforms in England, a comprehensive summary of which is contained in Barr and Crawford (2005). However, this article is the first to provide an in-depth analysis, after the reforms have been implemented, of how they may affect different graduates differently and of their implications for the public finances.

Third, at the heart of the reforms is the provision of built-in insurance against an inability to repay loans, thus giving central importance to the role of uncertainty in returns to human capital investments. Moreover, in analysing the distributional effects of the new reforms for graduates, we implicitly acknowledge the key role of heterogeneity in returns to HE. This initially gained prominence through important works such as Levhari and Weiss (1974), Eaton and Rosen (1980) and Kodde (1986). There is more recent work on the design of an optimal education finance system in the presence of uncertainty over the benefits of education, such as that by Fernandez and Rogerson (1995), Bénabou (2002) and De Fraja (2002), though the exact link between theoretically optimal systems and ICLs in practice is an area of open research. Our work adds empirical evidence to this largely theoretical debate.

The article proceeds as follows. Section 1 briefly describes the HE reforms. Section 2 considers how lifetime payments for HE depend on parental income and sets out the distributional implications of the reforms along this dimension. Section 3 assesses the distributional effects of the reforms on graduates according to graduate lifetime earnings and sets out the likely distributional consequences of a number of potential future reforms, including increasing the fee cap and reducing loan subsidies. Section 4 shows how the new system of HE funding alters the balance of funding between graduates, students, universities and taxpayers. Section 5 concludes.

1. The 2004 Reforms

The recent reforms to the funding of HE in England originated with the Department for Education and Skills' White Paper published in January 2003, which set out plans for increasing fees for higher education, together with full fee deferral and the re-introduction of means-tested grants for student support. The full reforms, somewhat altered since the publication of the White Paper, came into effect in England in 2006. Further changes to the system were announced in 2007, mainly concerning upfront support for students, which will affect students starting university from 2008–9.[1] In this article, we analyse this most up-to-date HE funding system (for ease of notation, we refer to it as the 'new system'). One of the key motivations for the reforms was to reverse the long-term decline in funding per head for university teaching seen in England over a number of decades, by increasing graduate contributions.

Compared with the system it replaced (referred to for convenience as the 'old system'), maximum fees are higher – with fees variable, up to a £3,000 cap, which will remain in place at least until 2010.[2] In addition, there are no longer any exemptions for fees based on parental income (see Table 1). Instead of being payable upfront, all fees

Table 1

An Outline of the Old and New Systems for HE Funding in England

The 'old' system	The 'new' system
Students would pay £1,200 in 2006–07[*]	From 2006–7, students pay £3,000
Upfront fee	Deferred fee (subsidised loans: zero real interest, 25-year debt write-off)
Flat fee rate	Variable fee rate
Exemptions based on parental income	No exemptions
Pre 2004–5, no grant	Up to £2,700 in grants, plus additional bursaries

Sources. Department for Education and Skills: *The Future of Higher Education*, Cm. 5735, 2003; *The Higher Education Bill*, Bill 35, 2004; *The Future of Higher Education and the Higher Education Act 2004: Regulatory Impact Assessment*, 2004; *Moving toward a Single Combined Grant for Higher Education*, 2004. Department for Innovation, Universities and Skills, *Increased Support for Students in Higher Education*, Press Release, 5 July 2007.
Note. For more detail, see Dearden *et al.* (2005).
[*]The fee is £1,175 in 2005–6, and in the absence of reform this is uprated in line with inflation each year.

[1] See John Denham's statement to the House of Commons on 5 July 2007, http://www.dti.gov.uk/science/page40318.html.
[2] The system against which we measure changes is the system in place in 2003–4, which was the final year before any of the new reforms, first set out in the 2003 White Paper, had begun to be implemented. Note also that all figures throughout the article are expressed in 2006–7 prices.

are now deferrable until after graduation, with loans available at a zero real interest rate, repayable according to income (at 9% above a threshold of £15,000). New grants are available for many students (up to £2,700 for the poorest students, tapered to zero at parental income of £60,000) and bursaries are now received by the poorest students (at least £300 for the full fee). Further details are set out in Dearden *et al.* (2005) and Dearden *et al.* (2007).

2. Distributional Effects of the Reforms: By Parental Income

Much concern has been expressed about the equity or distributional consequences of the new fee regime. In this Section, we consider the distributional consequences in one particular dimension, namely how individuals are affected according to their parents' income. By looking at how payments balance out across the lifetime, we show that students from relatively less well-off backgrounds are more than compensated for the increases in fees by large additions to upfront support in the form of maintenance grants and subsidies. For students from richer backgrounds, the total additional costs of entering university under the new regime outweigh the total additional payments made to them through the student support system.[3]

The net financial improvement per year to a student from switching from the old system (the system in place in 2003–4) to entering under the new system (the system in place from 2008–9) is illustrated in Figure 1. The calculations underlying this Figure assume that a student takes out the maximum student loan,[4] receives the average loan subsidy through the course of their working life[5] and incurs the maximum fee. To provide a better idea of how the figures were derived, Table 2 shows the underlying calculations for students with parental incomes of under £22,500, of £25,000, of £45,000 and of over £60,000.

Clearly, the effects vary considerably across the parental income distribution. Despite the higher fees and the loss of fee remissions, students with parental incomes below around £46,000 should be better off under the new system. This is because they gain in grants, bursaries and loan subsidies by more than the additional fees they will be required to pay. As we will show when we look at the distributional consequences of the system of loan repayments, this advantage under the new system will be higher if they go on to be low earners later in life. It can also be seen from Figure 1 that for those with parental income above £46,000 per year, the additional costs to enter HE outweigh any additional benefits in the form of direct financial support from the state.

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[3] Note, however, that this needs to be balanced against the fact that the removal of upfront tuition fees might remove some immediate liquidity constraints for students. Moreover, changes in quality might arise from the increased funding for universities. However, we do not consider the potential improvement in education quality arising from the introduction of top-up fees to be an additional benefit that students take into account when making their education decisions. If the reforms lead to an increase in funding per head, however, then this should, all other things being equal, increase quality and thereby demand (i.e. improve the incentive to attend).

[4] Given the zero real interest rate, it makes sense for all students to borrow the maximum available to them.

[5] Based on DfES projections, the average maintenance loan subsidy will be 21% and the average fee loan subsidy will be 33%. *Source: Hansard*, 10 November 2005, 'Education finance', http://www.publications.par-liament. uk/pa/ld200506/ldhansrd/vo051110/text/51110-25.htm. If lifetime earnings are lower than the level that attracts the average loan subsidy, then the subsidy will be higher.
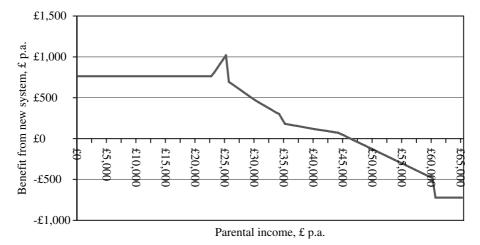
Fig. 1. *Change in Net Financial Position Due to Moving to the New funding Regime, by Parental Income*

Source. Goodman (2005), updated using DfES, Loan, Grant and Fee Rates for Academic Year 2006/07, Memorandum 1: Support Available under the Student Support Regulations and Department for Innovation, Universities and Skills, Increased Support for Students in Higher Education, Press Release, 5 July 2007.

Note. Illustration is for a student in their first or second year living away from home outside of London. The spike in the figure between £22,500 and £25,000 reflects the new entitlement to the full grant and the removal of partial upfront fees (see also Table 2).

Table 2

Change in Net Financial Position due to Moving to the New Funding Regime, by Parental Income (£ p.a.)

	Parental income			
	<£22,500	£25,000	£45,000	>£60,000
Old system				
Costs of attending:				
Fees	1,200	1,200	1,200	1,200
Payments for attending:				
Fee remissions	1,200	943	0	0
Maintenance loan subsidy	905	905	678	678
Net position	905	648	−522	−522
New system				
Costs of attending:				
Fees	3,000	3,000	3,000	3,000
Payments for attending:				
Grant	2,700	2,700	755	0
Bursary	300	300	0	0
Maintenance loan subsidy	676	676	773	767
Fee loan subsidy	990	990	990	990
Net position	1,667	1,667	−482	−1,243
Overall gain from switching systems (p.a.)	*£762*	*£1,019*	*£40*	*−£722*

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3. Distributional Effects of the Reforms: By Graduate Lifetime Earnings

In this Section, we consider how the new reforms affect different individuals, depending on where they end up in the lifetime earnings distribution as graduates. We also consider the likely effects of some variants of the new system. For this analysis, we use new lifetime earnings simulations of graduates, set out in Dearden *et al.* (2006) and summarised in the Appendix, to estimate the repayment profiles of different graduates for any given level of debt, as well as the likely per-student cost to the taxpayer of fee deferral. These simulations provide us with estimates of the future distribution of graduate earnings, on the assumptions that the present observed structure of earnings dynamics amongst graduates continues into the future and that in addition to any simulated change in earnings due to age or experience, earnings increase by 2% in real terms each year due to underlying future productivity growth in the economy.[6] The simulations represent one of the only published empirical characterisations of the distribution of lifetime earnings for graduates in the UK. The only other work that we are aware of that attempted a similar exercise for the UK is that of Barr *et al.* (1995), who developed a dynamic cohort microsimulation model, based on one year of cross-sectional earnings data, to investigate the potential effects of different ICL schemes. In contrast to their work, we use panel data to account for dependence in earnings across time and movements into and out of the workforce. This allows us to characterise the distribution of earnings more realistically.

3.1. *Lifetime Earnings Simulations*

This Section provides a very brief summary of our methods for simulating lifetime earnings (a more detailed description is contained in the Appendix). The lifetime earnings distributions are constructed using functions known as copulas, the name being a reference to the fact that they 'couple together' *k* univariate distributions to form a *k*-variate distribution. In our case, the construction of *k*-variate distributions is simplified by assuming that wages follow a first-order Markov process, meaning that only the most recent draw of wages affects the distribution of the next draw. This allows us to model the dynamics of earnings over the life cycle from just two wage observations for the same individual.[7] In practice, the way in which this is done is that within cells defined on the basis of age, gender and whether or not the individual is a graduate,[8]

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[6] This is in accordance with HM Treasury, which uses 2% as the rate of long-term earnings growth. Please note that our previous simulations in working versions of this article, and others, did not allow for this economy-wide real earnings growth, making our simulations of the effects of policy rather different: in particular, by simulating lower absolute levels of earnings going forward, we in general projected a greater cost to the taxpayer in loan subsidies and a lower cost to the individual; the length of time we simulated that it would take graduates to repay their loans was also generally considerably longer than with our current earnings simulations.

[7] A relaxation of first-order Markov to second-order Markov would come at a considerable technical cost and would not enable us to use the Labour Force Survey (LFS) data-set, which only has a maximum of two earnings observations per individual.

[8] A graduate is defined as an individual holding a higher-education qualification. This includes qualifications that constitute Levels 4 and 5 under the Qualifications and Curriculum Authority's original National Qualifications Framework: doctorates, masters degrees, postgraduate certificates and diplomas, bachelors degrees, graduate certificates and diplomas, diplomas of higher education and further education, foundation degrees and higher national diplomas.

each individual's two observed wage levels are converted to ranks or relative positions, and the parameters of the copula function that best capture the dynamics of these ranks between the two periods are estimated using Maximum Likelihood methods. This leads to a sequence of bivariate distributions across ages spanning the working life cycle for each gender/education group.[9] These are then pieced together to form the group-specific overall lifetime earnings distributions. Finally, we simulate a series of ranks from these joint probability distributions and map on the observed wage levels corresponding to these ranks to form earnings paths.

One appealing feature of this approach is that the copula function allows us to model the dependence in wages between ages, thus characterising the observed dynamics in earnings (up to the first-order Markov assumption).[10] But another important feature of the earnings paths is that in simulating them, we allow for a stochastic component to employment and assign earnings accordingly. In particular, if an individual is unemployed in a particular period, (s)he is assigned zero earnings; if (s)he becomes employed, his/her earnings are allowed to depend on the length of time unemployed and his/her wage when last employed. Not only does this generate realistic mobility patterns in earnings and employments but also the cross-sectional distributions of simulated earnings at each age match those in the data.

Earnings simulations are based on data from the UK Labour Force Survey (LFS) covering the period 1993 to 2003.[11] The LFS is a representative household survey made up of a five-quarter rotating panel. Prior to 1997, data on earnings were collected in the fifth quarter, and from 1997 onwards, data on earnings were also collected in the first quarter. To estimate the dependence in earnings for graduates, we restrict the sample to graduates aged 22 to 60 who are full or part-time employees or in government employment or training programmes, and for whom we observe two positive earnings observations, which leaves us with a sample of just under 35,000 graduates.[12] Note that the earnings simulations are drawn from all available years of LFS data, and for these we use graduates for whom we observe at least one earnings observation, which gives us a total of just over 135,000 earnings observations. The simulated employment paths and re-entry earnings ranks are based on mobility patterns observed in the British Household Panel Survey (BHPS) between 1991 and 2004 inclusive.

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[9] We model the evolution of wages from age 22 (19) to age 60 for graduates (non-graduates).

[10] Note that the benefits from allowing for earnings mobility in this way accrue from examining the entire distribution of lifetime earnings paths. If we were to focus on the effects of the policy on an example 'average' graduate, then it would not be necessary to model the extent of intertemporal dependence in earnings.

[11] In Dearden *et al.* (2006), we used the British Household Panel Survey (BHPS) to estimate the earnings models. This is because the analysis carried out in that paper relies on a panel of longer than two years, so the relatively large sample sizes afforded by the LFS were traded off against this (approximately 60,000 households are interviewed each quarter in the LFS, compared with around 5,500 households recruited in wave 1 of the BHPS). It is worth noting, however, that our simulations of the lifetime earnings distributions from the two data sources are very similar.

[12] This means that we drop employees who did not provide data on earnings in both quarters, whether due to attrition from the survey (around 40% of our sample of graduate employees leave the sample between waves 1 and 5) or refusal to answer earnings-related questions (in general, this applies to between 10% and 20%). Note that we nonetheless retain large samples to estimate dependence in earnings. It is difficult to know the extent of the biases, if any, induced by sample selection and a full analysis of this is beyond the scope of this article.
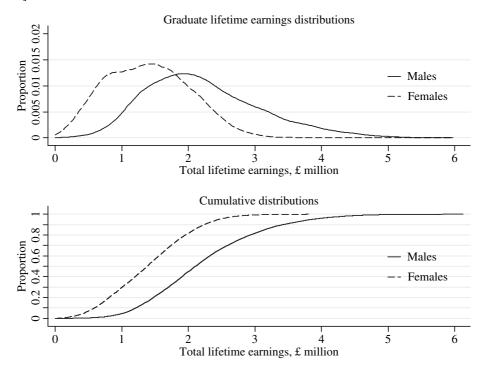

Graduate lifetime earnings distributions

Cumulative distributions

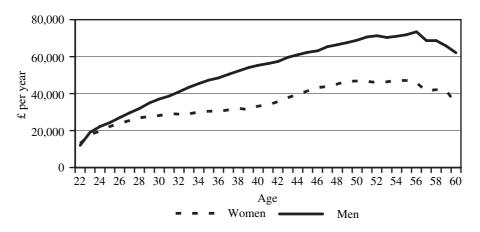Fig. 2. *Simulated Lifetime Earnings Distributions for Graduate Men and Women*

Fig. 3. *Simulated Median Annual Earnings for Men and Women at Ages 22–60*

Figure 2 provides a picture of the simulated lifetime earnings distributions for graduate men and women.[13] The median values for lifetime earnings (between ages 22 and 60) are simulated to be £2 million for men and around £1.3 million for women. One important feature of these distributions to note is that they are much less skewed than more commonly observed cross-sectional distributions of wages. This is because

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[13] In this Figure, lifetime earnings are simply added across ages 22–60, without any discounting.

taking into account mobility in individual earnings ranks over time reduces the level of inequality considerably.

Figure 3 shows the simulated median annual earnings at each age for male and female graduates. They are simulated to rise from around £12,000 for men and women at age 22 to a peak of around £73,000 (£47,000) for men (women) at age 56 (age 54). It must be remembered that these simulated earnings values are considerably higher than the median values observed in today's distribution of graduates (where the median male graduate annual earnings across the population aged 22–60 is around £30,000 and the median female graduate earnings is around £21,000[14]). This is because we are simulating future earnings for a graduate cohort starting undergraduate university in 2008–9, building in 2% real earnings growth each year, over 40 years, in addition to any increment to earnings due to age or experience.

It is worth emphasising that our earnings simulations are not predictions of the future; they are instead simulations based on a series of assumptions. Predicting the future earnings of graduates poses more severe challenges, in particular because the distribution of future earnings of graduates is itself likely to be affected by the reforms, for a number of reasons. First, the reforms may affect the decision to participate in HE, which may alter the composition of students/graduates and thus earnings. Second, the reforms may affect choices at university, such as courses studied and the length of time spent at university, both of which may affect lifetime earnings. Finally, the reforms may have general equilibrium effects, for example through affecting the supply of graduates, which may alter the relative wages of future graduates.

With this in mind, our estimated effects of HE funding policies on incomes do not represent forecasts or predictions of what we think the effects will be. Rather, they are estimates of what the effects would be, given our simulations of the distribution of graduates' lifetime earnings. They thus serve to highlight the varying distributional impacts of different HE funding policies.

3.2. *The Effects of Different HE Funding Systems on Graduates*

Before we are in a position to assess the distributional impact of the new funding system, we need to consider how much students are likely to borrow under the new system. Although in practice there is likely to be less than 100% take-up of loans, in fact it makes economic sense for all students to borrow the maximum fee and maintenance loans available to them. This statement holds regardless of what other sources of income are available, and is due to the large subsidy inherent in the zero real interest rate and to the possibility of debt write-off. For this reason, we base our simulations on the full take-up of loans.

This implies that students taking courses that charge the maximum fee of £3,000 per year will graduate with between £18,340 and £21,560 of debt for a three-year course (£9,000 of this is for fees and the remainder is for maintenance), varying by parental income due to slight variations in maintenance loan entitlements. This compares with a maximum £12,350 of subsidised loans – all for maintenance – under the system that has been replaced. Some example maximum levels of debt to the

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Table 3

Expected Levels of Debt on Graduation under the Old and New Systems* (at Example Levels of Parental Income)

Parental income	Old system		New system
	Maximum debt to government	External funding	
Below £22,500 p.a.	£12,350	£5,990	£18,340
Around £33,500 p.a.	£12,350	£4,665	£18,340
£35,000	£11,940	£4,610	£18,400
Around £50,000 p.a.	£9,265	£7,225	£20,285
£60,000	£9,265	£7,180	£21,560
Above £60,000 p.a.	£9,265	£4,925	£19,590

*Expected debt levels show the amount students could borrow in government loans available under both systems, plus the private debt that would be required under the base system to reach the standard of living achievable through maintenance loans and grants under the new system. The figures relate to students living away from home outside London on a three-year course for which the maximum fee is charged. All amounts are expressed in 2006–7 prices.

government under the old and new systems are shown in Table 3 at six different parental income levels.[15]

Table 3 also shows 'external funding', which is the amount of non-government funding that students under the old system would need in order to attain the same standard as living whilst at university as under the new system, whether by borrowing or other means.[16] The higher availability of resources that can be put towards living expenses at university under the new system is mainly due to the removal of the requirement to pay upfront fees and/or the introduction of grants.

In what follows, we assume an initial debt level of £18,340, representing the maximum amount of government loans available to those with parental incomes below around £35,000. As the variation in maximum debt across parental incomes is relatively little compared with the size of the overall debt, repeating the forthcoming analysis over different maximum debt levels would not change the inferences much.

Note that to calculate net present values of debt repayments and the value of taxpayer subsidies, we assume a real discount rate of 2.2% per year (this follows the government's present convention for discounting; see Department for Education and Skills (2007)).[17]

We also assume that no graduates avail themselves of the option to take a five-year holiday from loan repayments (announced in July 2007). Although it would be in the

[15] There are currently no reliable data on what percentages of students fall into different income categories, although we can obtain some indication from 2006–7 data on grant take-up from the Student Loan Company (SLC). Around 23% of HE students receive the full grant (parental income below £17,500), 17.5% of HE students receive a partial grant (parental income below £33,500) and the remainder receive no grant. However, a caveat is that around 20% of students do not apply to the SLC.

[16] External funding is calculated as the difference between the upfront support for living expenses under the new and old systems. Under the old system, upfront support is equal to maintenance loans minus upfront fees. Under the new system, it is the sum of maintenance loans, grants and bursaries.

[17] Note that our previous simulations in working versions of this article, and others, used a 2.5% discount rate. By using that higher discount rate, we in general projected a greater cost to the taxpayer in loan subsidies, and a lower cost to the individual, than we do here; the length of time we simulated that it would take graduates to repay their loans was also generally longer.

financial interest of all graduates to take this option (assuming the zero real interest rate on loans is maintained), it is difficult to predict when graduates would choose to take this holiday and just how extensively the option will be taken up when it becomes available. However, it should be noted that we estimate that a graduate who takes the five-year holiday in the first five years of being eligible for repayments stands to gain an additional £850 in subsidies from the government, regardless of his/her position in the lifetime earnings distribution. Further details are available from the authors on request.

3.2.1. *Distributional effects of the new system*

The first exercise we perform using our estimated graduate lifetime earnings profiles is to assess the net present value of debt repayments that graduates will be expected to make (i.e. net of any subsidies they gain from the zero real interest rate and debt write-off), the number of years that graduates can be expected to take to repay their loans, and the taxpayer subsidy (expressed as a proportion of the original loan) that they can expect to receive under the new system. In all cases, we show how these outcomes vary across the distribution of graduate lifetime earnings.

Figures 4 to 6 and Table 4 show the combined distributional effect of the interest subsidy and the debt write-off provision. Each Figure and each panel of the Table shows first the effect for the whole population of graduates, though this masks substantial heterogeneity between men and women, so the effects on these are also shown separately. For a given level of debt on graduation, lower lifetime-earning graduates will eventually repay less of their debt than higher earners (Figure 4 and Table 4, panel *a*).
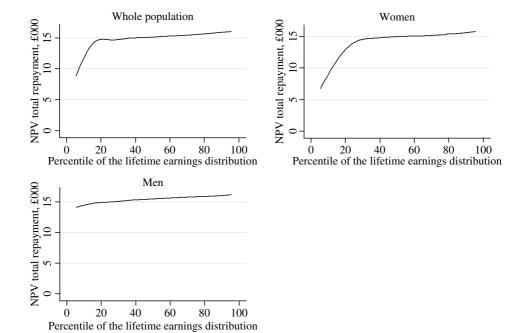

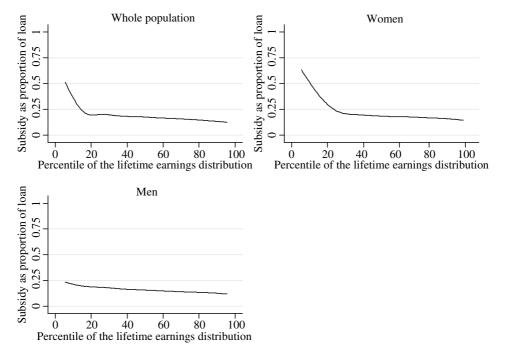Fig. 4. *Net Present Value of Graduate Repayments Under the New HE System*

Fig. 5. *Subsidy as a Proportion of Loan Under the New HE System*

This is not a surprising feature of the income-contingent loan system, given its design, but this to our knowledge represents the first empirical estimation of such distributional effects.

By the same token, the value of the government subsidy (expressed as a proportion of the face value of the loan – Figure 5 and Table 4, panel *b*) is strongly decreasing in income. For women, it ranges from around 60% for the lowest lifetime earners to around 15% for the highest earners (with the average across all women at around 25%). For men, the range of taxpayer subsidy is narrower, from around 27% for the lowest-earning men to 12% for the highest earners (with the average subsidy at around 17%).

The number of years taken to repay the loan (Figure 6 and Table 4, panel *c*) is also decreasing in lifetime earnings – it ranges from 25 years for the lowest earners (at which point all outstanding debt will be written off) to between 10 and 15 years for the highest earners. The average time for repayment is around 17 years for women and around 13 years for men. Around 21% of graduate women can expect to have some debt written off, with their repayment capped at the 25-year cut-off, whilst this is the case for only around 2% of graduate men. These results all highlight the fact that the longer the loan is held by a graduate, the bigger is the taxpayer contribution to the repayment of that loan. This of course runs counter to a commonly held notion that holding graduate debt for a long time is an indication of the 'heavy burden' of that debt.

The analysis in Figures 4–6 illustrates the potential benefits of the new system in terms of the insurance it provides against low realised returns to investments in HE.
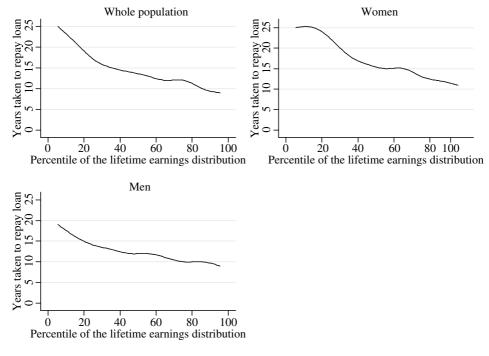
Fig. 6. *Years Taken to Repay Loan Under the New HE System*

This is seen most clearly through the dependence of the level of government subsidy on *realised* labour earnings later in life. Our results thus provide empirical support for the use of income-contingent loans as a mechanism for providing insurance in the face of uncertain and heterogeneous returns to human capital investments.

Table 4

Average Graduate Payments under the New HE System (Debt of £18,340), *by Decile of Graduate Lifetime Earnings Distribution*

Decile of lifetime earnings distribution	(a) NPV repayments, £			(b) Subsidy as a % of loan			(c) Years taken to repay loan		
	All	Women	Men	All	Women	Men	All	Women	Men
Poorest	9,075	7,435	13,430	50.5	59.5	26.8	22.7	23.8	18.6
2nd	13,315	10,900	14,640	27.4	40.6	20.2	19.4	21.6	15.7
3rd	14,420	13,180	14,925	21.4	28.1	18.6	17.2	19.9	14.4
4th	14,790	14,225	15,160	19.3	22.4	17.4	15.4	17.9	13.3
5th	14,965	14,645	15,330	18.4	20.1	16.4	14.4	16.4	12.5
6th	15,165	14,850	15,490	17.3	19.0	15.5	13.4	15.3	11.7
7th	15,335	14,980	15,630	16.4	18.3	14.8	12.6	14.5	11.1
8th	15,525	15,185	15,790	15.3	17.2	13.9	11.7	13.4	10.4
9th	15,755	15,340	15,880	14.1	16.4	13.4	10.6	12.6	9.9
Richest	16,005	15,670	16,105	12.7	14.6	12.2	9.4	11.1	9.0
All	*14,440*	*13,640*	*15,240*	*21.3*	*25.6*	*16.9*	*14.7*	*16.6*	*12.7*

3.2.2. *How does the new system compare with the old system?*

An interesting question our simulations can address is how these patterns of graduate repayments and taxpayer subsidies compare with those under the previous HE funding system. Such a comparison highlights the distributional effects of various key aspects of the reforms. There are three important differences between the two systems that we will consider here. First, the new system has more generous loan subsidies. Second, it has higher levels of debt to the government on graduation. Third, it allows students to obtain a better standard of living at university, due to the availability of grants and/or the removal of upfront fees, which reduces student reliance on external sources of funding such as bank loans. In this Section, we analyse each of these three aspects.

However, in making comparisons across the two HE funding systems, it is important to emphasise that our analysis here is *partial*: it focuses on the impact on graduates of the debt repayment element of these systems, but ignores how much graduates as taxpayers would be expected to pay, in tax, to raise the required government revenue to finance these systems. We will return to this issue in Section 4.

Figures 7–9 set out the differences between the old and new systems along the above three dimensions. Each Figure presents the distributional pattern of graduate debt repayments under the new system and under the system being replaced. Due to the substantial differences between men and women, which are masked by considering the whole graduate population (as seen in the previous Section), from here on we show all analyses separately by gender.

First, we show the effects of the two new changes to the loan repayment conditions – the provision for debt write-off after 25 years and the raising of the repayment threshold to £15,000. By comparing the two systems for a given level of debt (here fixed at a level of £18,340), Figure 7 shows that this combination of reforms is progressive across the distribution of graduate earnings – it reduces the amount that all graduates will have to repay, but it reduces the amount for the lowest-earning graduates the most. The biggest gains clearly arise for approximately the poorest fifth of women, who repay an average of around £3,600 less under the new system. These are the women who, as we illustrated earlier, gain from debt write-off after 25 years.

Next we present the pattern of graduate repayments under the old and new systems taking into account that the level of debt on graduation will be considerably higher under the new system than under the old system, due to the requirement to pay higher fees. As we set out in Table 3, the maximum total maintenance loan after three years under the old system amounted to £12,350, compared with the counterpart for these individuals under the new system of £18,340 for maintenance and fees. Of course, these extra payments are offset to varying degrees by the reforms to the loan repayment system that we highlighted above. Figure 8 presents the net effects of the increased government borrowing under the more favourable terms. It shows that whilst most individuals will be required to pay considerably more in debt repayments after graduation under the new system than under the old, approximately the poorest tenth of women will actually make smaller total debt repayments under the new system despite graduating with considerably more debt: as we have already seen, this is largely due to the provision for debt write-off after 25 years.
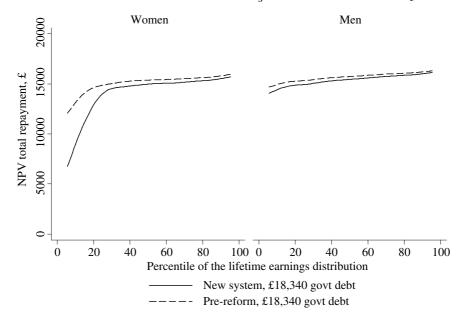
Fig. 7. *Distributional Effects of Reforms to Loan System* (raising of repayment threshold to £15,000 and introduction of debt write-off after 25 years)
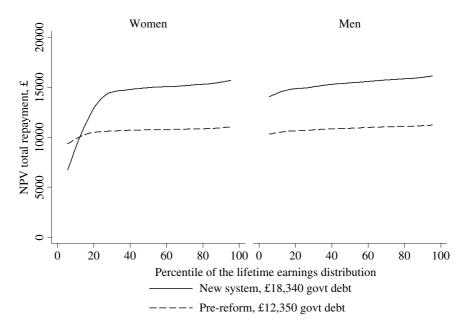

Fig. 8. *Net Distributional Effects of Increased Government Debt and Reforms to Loan System*

Finally, we take into account the fact that under the new system, the requirement to take out private debt is likely to be reduced, because of the new upfront support in the form of grants and bursaries and because of the removal of the requirement to pay any
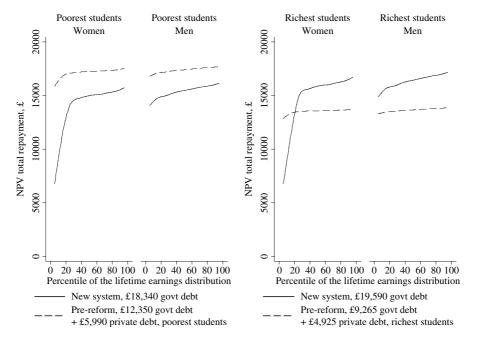
Fig. 9. *Net Distributional Effects of Increased Government Debt, Reforms to Loan System and Reduction in Requirement for Private Debt*

fees upfront. As we discussed above, the effects of these changes to upfront grant entitlements and fee liabilities differ quite markedly according to parental background. Here we show the effects for individuals at the lower and upper ends of the parental income distribution (see Table 3): first, the reduction in private debt required under the new system amounts to £5,990 over three years for those at the lower end, mainly due to the new grants and bursaries; second, the reduction in the need for private debt amounts to around £4,925 over three years for those at the top end, mainly from the replacement of upfront fees with fees that are fully deferrable. In order to estimate the costs of such private debt, we assume fixed payments over 10 years at a 4% real rate of interest.[18] As shown in Figure 9, once the effects of the removal of upfront fees and the addition of grants and bursaries are taken into account, for all students from poor backgrounds the total payments required on graduation will actually be *lower* under the new system than under the old system. The opposite is the case for students from richer backgrounds, the majority of whom would repay *more* under the new system, with the exception of women from the bottom 20% of the female graduate earnings distribution.

So although graduates in general will be asked to contribute more to the costs of their higher education under the new system, the ones who as students were poorest will end up repaying *less* in loans than prior to the reforms. This is due to the combination of two factors: first, the fact that they will not have to borrow as much money privately under the new system, and second, the two changes to the loan repayment

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[18] Our assumption that all students would take on private debt to achieve the same standard of living under the old system as under the new system helps to simplify the exposition. In reality, many would instead obtain funding from their parents or take on part-time jobs, which could affect educational outcomes.

conditions that are coming into force at the same time as fees are being increased[19] – a higher repayment threshold and the debt write-off after 25 years.

Related to this point, one could argue that one of the biggest losers from the reforms may in fact turn out to be private banks, who in the past may have profited from extending commercial loans to students whose parents had not picked up the full costs of their HE (although see also footnote 18). As we have just seen, increases in upfront support from taxpayers will almost certainly reduce the need for recourse to such relatively expensive types of loan.

3.2.3. *Possible reforms to the new system*

Looking to the future, it is likely that the level and form of taxpayer subsidy inherent in the loans may come up for review in 2009, when the DfES reports to Parliament on the effects of the reforms. A number of suggestions have been made for reducing taxpayer costs, including the abolition of the zero real interest element of the subsidy – see Barr (2004) and Astle (2006). The reason for this proposal given by its proponents is that, given the introduction of debt write-off after 25 years in 2006–7, the additional benefit from the interest subsidy actually goes to those who are *not* the lowest earners.

Figure 10 illustrates this by showing how two variants – both of which restrict the value of the interest subsidy – compare with the new system of income-contingent loans to be introduced in 2008–9. Here we continue to assume a level of debt of £18,340 and we compare the total value of debt repayments, the interest subsidy and the number of years taken to repay under each of three repayment schemes:

- New system. This is the system to be introduced in 2008–9 and already described above.
- Variant 1: 2.5% real interest rate on debt. Under this variant, the repayment of loans remains income-contingent, with debt write-off after 25 years, but the interest rate subsidy is effectively eliminated by charging interest on the debt of 2.5% p.a. above inflation.
- Variant 2: 'NZ system'. Under this variant, similar to the one currently in place in New Zealand, the repayment of loans again remains income-contingent, with debt write-off after 25 years, and the interest rate subsidy is eliminated by charging interest on the debt of 2.5% p.a. above inflation. However, when earnings are low, the income-contingent repayment amount may be too low to cover the interest element of the loan, in which case under this scheme the government would pay on behalf of the borrower the additional interest due. This would mean that the outstanding balance on the loan would be prevented from spiralling during periods of low earnings.

Our calculations suggest that the removal of the interest subsidy (i.e. a switch from the new system to variant 1) would amount to the equivalent of removing an average upfront grant of around £2,465 for each female graduate and £2,880 for each male graduate (whilst the additional cost to the graduate of the 'NZ system' relative to the new system would be around £1,935 and £2,280 respectively).

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[19] Although, strictly speaking, the repayment threshold changed one year before the introduction of top-up fees, in 2005–6.
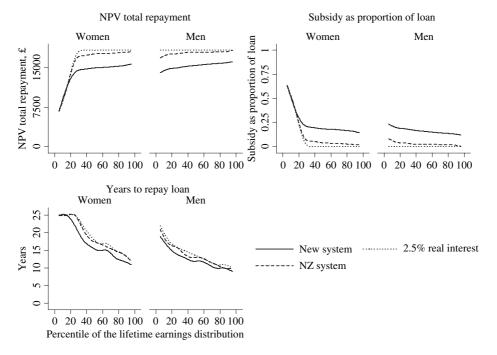
Fig. 10. *Comparison of Possible Future Reforms: Removing Interest Subsidies*

However, as can be seen from Table 5, these savings for the Exchequer and costs to the graduate would be highest for men in the 2nd to 4th deciles of the male graduate lifetime earnings distribution and for women in the 5th to 7th deciles of the female distribution. The very lowest female earners would lose relatively little from the removal of the interest subsidy, since many are protected by the provision for debt write-off after 25 years.

Other options for reducing the taxpayer cost of graduate loans include extending beyond 25 years the length of time after which the loans are written off or reducing the repayment threshold – for example, by removing the default indexation provision after 2010 – so that its real value erodes over time.[20] It should be noted that both of these options would affect low lifetime earners more than the withdrawal of the interest subsidy.

Another alternative, and a potentially revenue-saving reform to the loan system from the point of view of the Exchequer, is to offer students the choice of a discount on their

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[20] The current system of uprating the £15,000 threshold in line with inflation means that, year on year, the system becomes less progressive for relatively low earners. This is because the threshold increases at a relatively slower rate than earnings. So, each year, fewer and fewer individuals have earnings below the threshold, and therefore the subsidies to these individuals are lower. Indeed, considering the effects of the reforms for graduates in 2009 rather than 2011, as in previous versions of this article, we see that the system is less progressive for the 2011 cohort of graduates for this reason. This is unlike the situation in Australia, for example, where the threshold is set relative to average earnings to ensure that the progressivity of the system remains.

Table 5

Average Additional Costs to Graduates of Removing Interest Subsidies, Relative to the New System, by Decile of Graduate Lifetime Earnings Distribution

Decile of lifetime earnings distribution	Variant 1, 2.5 real interest		Variant 2, 'NZ system'	
	Women	Men	Women	Men
Poorest	370	2,925	300	2,120
2nd	1,015	3,490	820	2,580
3rd	1,825	3,390	1,450	2,540
4th	2,615	3,170	2,080	2,455
5th	3,210	3,010	2,470	2,380
6th	3,420	2,850	2,575	2,305
7th	3,355	2,710	2,555	2,250
8th	3,155	2,550	2,465	2,155
9th	3,000	2,460	2,410	2,070
Richest	2,670	2,235	2,240	1,930
All	*2,465*	*2,880*	*1,935*	*2,280*

fee if they pay upfront. For example, in Australia until 2005, students had the option of paying the fee upfront at the beginning of each academic term, at a 20% discount.[21] According to our calculations, just over half of women and around three-quarters of men would benefit financially from this option in England.[22] These are individuals whose earnings are sufficiently high that they would not gain much from the fee loan subsidies. This means that a substantial proportion of people would lose out financially if they were to go for the discount option, and only those students who have information to suggest that they will fall into a relatively high earning category should consider taking the discount.[23] Note also that risk-averse students (or their parents), who might prefer to pay off a fixed sum while studying, could lose out financially from this decision.

Finally, it is worth considering what the additional costs to the graduate and Exchequer might be if the fee cap, currently imposed at £3,000 per year, were lifted to £5,000. Figure 11 shows that of the extra £6,000 in fees over a three-year course that such a lifting of the cap would imply (i.e. an additional £2,000 per year above the current £3,000 cap), a very substantial proportion would in fact be covered by the taxpayer rather than by graduates, because of fee deferral. On average, female graduates would have to contribute £3,300 extra in total towards the increased fees (or 55% of the fee increase) and male graduates would have to contribute around £4,400 (73% of the fee increase) but the amount payable would be strongly increasing in lifetime

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[21] This was reduced from 25% in 2005. The proportion of eligible students choosing to pay upfront was just over 20% in 2002.

[22] These figures are calculated by comparing the sum of the net present value of total fee and maintenance loan repayments with the sum of the discounted value (at 80%) of upfront fees and the net present value of maintenance loan repayments.

[23] Note that the levels of uncertainty in future earnings and employment, which are at the core of this article, would render this an extremely difficult decision for the student.
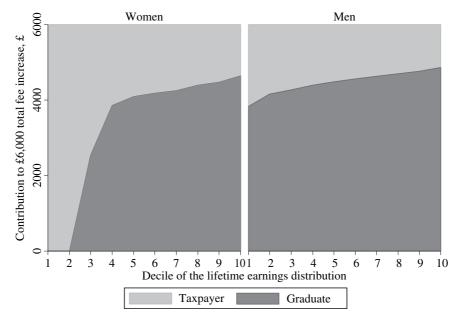
Fig. 11. *Taxpayer and Graduate Contributions to a Rise in the Fee Cap from £3,000 to £5,000 p.a.*
Note. Shows median payment by decile group of lifetime earnings distribution

earnings. Notice that the taxpayer subsidy for additional fee increases is greater than the average subsidy calculated for a loan of £18,340 (Table 4), since the income-contingent system combined with the zero real interest rate means that each additional £1 borrowed comes at a greater cost to government and a lower cost to the borrower. Clearly, any increase in the fee cap would boost universities' income but at the same time put considerable upward pressure on public expenditure, unless the system of loan subsidies were reformed.

4. The Shifting Balance of Funding

Whilst the analyses of the previous sections have highlighted the distributional effects of the new system for students and graduates, in this Section we take each of these groups as a whole, as well as taxpayers and universities, and consider how they are affected financially by the reforms. In so doing, we show how the reforms shift the balance of funding for HE between the public and private sectors.

We illustrate who pays for the system of HE funding in England by means of a circular flow of payments. Table 6 sets out our calculations of the net balance of payments (negative in the Table) and receipts (positive in the Table) for different participants within the HE system – universities, students, graduates and taxpayers – under the old and new systems of HE funding in England. Accounting for both where payments come from and where they go to results in a zero-sum. Comparing such zero-sums across different systems gives us a clear indication of the net winners and losers (or, less

emotively, receivers and payers) from the new reforms.[24] Note that these figures are mainly based on official government public expenditure projections from 2005.

Looking at the first column of Table 6, we see that under the old system, universities received about £5.5 billion in total funding for teaching, coming mainly from taxpayers (via direct payments to universities in the form of the recurrent teaching grant made to HEFCE each year, and fee exemptions) and also from students (via upfront fees). Graduates gained around £0.6 billion, from maintenance loan subsidies (paid for by taxpayers). The second column shows that under the new system, university coffers are significantly swelled, to around £6.7 billion. This increase is paid for by graduates, through deferred fees (subsidised by taxpayers). Students become net recipients, receiving around £1.1 billion in total from new grants and subsidies.

The final column of Table 6 shows the net impact of all these changes. First, universities' net position improves by around £1.3 billion, from £5.5 billion of funding under the old system to around £6.7 billion under the new system. On aggregate, this should make a significant inroad into the well-documented shortfalls of the university sector.[25] Second, the overall taxpayer contribution to the costs of HE rises by around £1.1 billion compared with an unchanged 2003–4 system for tuition and student support. Third, students are better off under the new system due to grants and fee deferral, by around £1.6 billion (note that voluntary bursaries from universities, likely to amount

Table 6

Circular Flows of Payments Under the Old and New Systems (£ billion)

	Old, 2003–4 system	New, 2008–9 system	New system compared with old system
Taxpayers	−5.6	−6.7	−1.1
Students	−0.5	1.1	1.6
Graduates	0.6	−1.1	−1.7
Universities	5.5	6.7	1.3
Sums of gains and losses	*0.0*	*0.0*	*0.0*

Sources. Authors' calculations outlined in Dearden *et al.* (2005) and updated based on best information available as of 21 May 2007, using official public expenditure projections from 2005, *Hansard Written Ministerial Statements* for 10 November 2005 (column 22WS) and information on the cost of extending student grants from 2008–9, estimated by DIUS at £182 million. Note that the cost of graduate repayment holidays, estimated by DIUS at £40 million, is not included.
(http://www.publications.parliament.uk/pa/cm200506/cmhansrd/vo051110/wmtext/51110m01.htm#column_ 22; DfES, *Departmental Expenditure Report*, 2007; HEFCE grant letter from DfES, 2007.).
Notes. Totals may not sum due to rounding. For simplicity, student gains calculated here include gains from the introduction of maintenance grants compared with the 2003–4 system (transfers from taxpayers) but do not include changes to maintenance loans (which might be thought of as transfers from graduates to students). Bursaries are assumed to be the minimum mandated (£300) and to be received by a third of students.

[24] Of course, in reality, the distinction between these different groups is more blurred than our analysis suggests: for example, students go on to become graduates, so transfers between these two groups are really transfers across time rather than between people; most graduates, and some students, are taxpayers; money paid to universities will, in general, benefit the students who attend them and the graduates they go on to become.
[25] See, for example, the submission from Universities UK to the 2004 Spending Review (http://bookshop.universitiesuk.ac.uk/downloads/SR2004.pdf).

to £300 million in total, improve students' positions further). Finally, graduates contribute around £1.7 billion more, through increases in fees, offset by new loan subsidies from the taxpayer.

This analysis also highlights the changing balance of funding between the public and private sectors as a whole as a result of the new reforms. Taking students and graduates together, we see that the net increase in contributions from these two groups combined amounts to the relatively small sum of £100 million, whilst the net increase in contributions from the taxpayer amounts to around £1.1 billion. This suggests that while the university sector as a whole is growing, the biggest net increase on aggregate is from the public, not the private, sector. However, if we consider tuition alone, it is certainly the case that the share of private contributions will be rising. This is illustrated in Figure 12. Prior to the introduction of top-up fees in 2006–7, the private contribution to tuition costs, which amount to nearly £5,000 per student per year, was 8%.[26] With the new system in place, funding could increase to around £6,000, or by 23% [27] on average in real terms per head, if all universities charge the full fee. The private fee contribution will amount to around 33% of the total, though this will be substantially subsidised by the taxpayer in the form of loan subsidies, arising from the zero real interest rate on the new fee loans and the provision for debt write-off after 25 years. Taking into account the loan subsidy element of the fees, the private contribution will be around 23%.
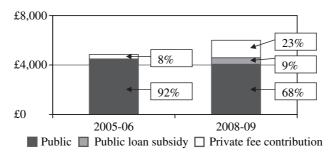

Fig. 12. *The Balance Between Public and Private Costs of Tuition*
Source. Authors' calculations based on Department for Education and Skills, Departmental Report 2005, table 12.7 (http://www.dfes.gov.uk/aboutus/reports/pdfs/2005deptrep.pdf) and National Statistics, First Release SLC SFR 01/2004, table 2C (http://www.slc.co.uk/pdf/slcsfr012004.pdf). All figures are uprated to 2006–7 prices using GDP deflator.
Notes. Public funding excluding loan subsidies is reduced between 2005–6 and 2008–9 due to the removal of fee exemptions. The public money currently spent on fee exemptions will, of course, partly pay for additional loan subsidies shown in this Figure.

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[26] Based on HEFCE recurrent grant for teaching in England (which covers undergraduate and postgraduate teaching), plus public and private contributions to the basic fee, divided by the number of full-time-equivalent undergraduate and postgraduate students. Note that these funding-per-head figures are calculated on a different basis from those produced by the DfES and presented in its yearly departmental reports.

[27] Based on DfES public expenditure estimates, projecting in total £2.25 billion in fee revenues each year in steady state. This figure assumes that 91% of universities charge the full fee and excludes only the minimum mandated bursary amount of £300 for the poorest students on courses where the full fee is charged. The Office for Fair Access has estimated that around 91% of higher education institutions (HEIs) and further education colleges (FECs) are planning to charge the full tuition fee of £3,000 and that a 'typical' bursary would be considerably more than the minimum, at around £1,000; see Press Release from 17 March 2005 (http://www.offa.org.uk/category/press-releases).

The analysis in this Section also suggests that some of the most important effects of the reforms will be distributional effects within the private sector, both over time (for example, where there are shifts in costs from students to graduates) and, as we have seen already, between different types of individuals (for example, by parental income or by the level of lifetime earnings as graduates).

5. Conclusions

This article has shown that the reforms to the funding of higher education (HE) in England, which were first introduced in 2006 and which will come into place fully in 2008, will result in a significant increase in transfers from graduates and taxpayers, directed towards both the funding of universities and student support. A closer inspection reveals a more nuanced picture than this, with a relatively small overall net increase from the private sector, but with important distributional consequences of the reforms.

Individuals from the lowest part of the parental income distribution will typically find a substantial net reduction over their lifetime in the cost of their HE, due to the new grants and bursaries. On the other hand, individuals from the middle to high parts of the parental income distribution will typically end up seeing the costs of their HE increase.

If people are grouped by where they end up in the lifetime graduate earnings distribution, rather than by their parental origin, another interesting picture emerges: women with the lowest lifetime earnings will see a reduction in the cost of their HE as a result of the reforms (so long as they defer all possible payments through the subsidised loans on offer), while higher-earning graduates will indeed in general pay more of the cost of their own HE as a result of the reforms. Our findings suggest that the income-contingent nature of loans under the new system does provide some level of insurance against low realised returns from HE for graduates.

Looking to the future, any cost reductions achieved by the possible removal of the zero real interest subsidy would hit hardest those men in the 2nd to 4th deciles of the male graduate lifetime earnings distribution and those women in the 5th to 7th deciles of the female distribution. The lowest earners would in general be protected by such reforms, because of the provision for debt write-off.

We conclude by stressing that our analysis highlights the varying distributional impacts of different HE funding policies. It does not represent a prediction of the effects of the reforms, as the lifetime earnings distributions do not represent forecasts of future earnings of graduates. Rather, they are based on current earnings data. Estimating the distribution of future earnings of graduates poses more severe challenges, particularly as this distribution is itself likely to be affected by the reforms, for a number of reasons. First, the reforms may affect the decision to participate in HE, which may alter the composition of students/graduates and thus earnings. Second, the reforms may have general equilibrium effects, for example through affecting the supply of graduates, which may alter the relative wages of future graduates. Third, the reforms may affect choices at university, such as courses studied and the length of time spent at university, both of which may affect lifetime earnings. We leave these important topics for future work to address.

Appendix: Copula Model for Earnings Dynamics

The approach that uses copula functions is relatively new to the literature on modelling earnings dynamics.[28] An outline of the methodology is provided here.

Let a be the labour market experience of an individual and let $\mathbf{X}$ be a vector of observed characteristics of the individual. We can write the logarithm of the observed wage, y_a, of an individual as

$$\log y_a = \mathrm{g}(a, \mathbf{X}) + w_a, \tag{1}$$

where $\mathrm{g}(a, \mathbf{X})$ is the conditional expectation $\mathrm{E}(\log y_a|a,\mathbf{X})$. The aim is to estimate a statistical model for the distribution of the vector of residuals $\mathbf{w} = \{w_a\}_{a=1}^T$, where T is the total number of years spent in the labour force. We denote this conditional density $f(\mathbf{w}|\mathbf{X}_1)$, for a subset $\mathbf{X}_1 \supseteq \mathbf{X}$. In our application, the variables contained in $\mathbf{X}_1$ include gender and whether or not the individual is a graduate.

The curse of dimensionality renders a fully non-parametric estimator of $f(\mathbf{w}|\mathbf{X}_1)$ infeasible for large T. Rather than assume a multivariate normal distribution, our approach is to use Sklar's (1959) theorem to decompose $f(\mathbf{w}|\mathbf{X}_1)$ into a sequence of marginal densities and a copula density which completely describes the intertemporal dependence structure in the vector $\mathbf{w}$. We refer the reader to Nelsen (1999) and Joe (1997) for details on the definition of a copula and examples of parametric forms.

$$f(\mathbf{w}|\mathbf{X}_1) = c[F(w_a|a,\mathbf{X}_1),\dots,F(w_T|T,\mathbf{X}_1)|\mathbf{X}_1] \prod_{a=1}^T f(w_a|a,\mathbf{X}_1). \tag{2}$$

If wages follow an n-order Markov process, the copula density may be written as

$$f(\mathbf{w}|\mathbf{X}_1) = \prod_{a=1}^T f(w_a|a,\mathbf{X}_1) \prod_{a=1}^{T-n} c[F(w_a|a,\mathbf{X}_1),\dots,F(w_{a+n}|a+n,\mathbf{X}_1)|a,\mathbf{X}_1]. \tag{3}$$

Under the assumption that $\{w_a\}_{a=1}^T$ is a first-order Markov process, the copula density in (3) can be decomposed into the product of a sequence of bivariate copula densities which describe the dependence structure between adjacent observations of w_a:

$$f(\mathbf{w}|\mathbf{X}_1) = \prod_{a=1}^T f(w_a|a,\mathbf{X}_1) \prod_{a=1}^{T-1} c[F(w_a|a,\mathbf{X}_1),F(w_{a+1}|a+1,\mathbf{X}_1)|a,\mathbf{X}_1]. \tag{4}$$

Since, under the first-order Markov assumption, an observation will correspond to a vector of length 2, $\{w_a,w_{a+1}\}$, the log likelihood function for the sample is

$$\begin{aligned}
\log l(f, c; \mathbf{w}, \mathbf{X}_1) = &\sum_i \log f(w_a^i|a_i,\mathbf{X}_{1i}) + \sum_i \log f(w_{a+1}^i|a_i+1,\mathbf{X}_{1i}) \\
&+ \sum_i \log c\big[F(w_a^i|a_i,\mathbf{X}_{1i}),F(w_{a+1}^i|a_i+1,X_{1i})|a_i,\mathbf{X}_{1i}\big].
\end{aligned} \tag{5}$$

To estimate the model, we use the two-step pseudo maximum likelihood procedure of Genest *et al.* (1995). We first estimate the sequence of marginal distribution functions using the rescaled conditional empirical distributions, denoted $\hat{F}$ below. We then replace the true distribution with the empirical one in the likelihood function and maximise the resulting function with respect to the copula parameters:

$$\hat{\theta} = \arg\max_{\theta \in \Theta} \sum_i \log c\big[\hat{F}(w_a^i|a_i,\mathbf{X}_{1i}),\hat{F}(w_{a+1}^i|a_i+1,\mathbf{X}_{1i})|\theta(a_i,\mathbf{X}_{1i})\big]. \tag{6}$$

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[28] The exception to this is Bonhomme and Robin (2006). The use of copula functions is much more common in financial econometrics. See, for example, Patton (2006*a, b*).

This two-step semi-parametric approach has the advantage that inference about the copula parameters and copula model selection is robust to misspecification of the marginal distributions. However, it is not efficient; a more efficient one-step estimator is provided in Chen *et al.* (2006). However, we favour the two-step approach mainly for reasons of computational efficiency.[29]

The parametric copula used in this paper is the t-copula, which outperformed all but one of the other parametric copulas we tested to model selection tests are presented in Dearden *et al.* (2006). Its parameters are simple to interpret and it is relatively straightforward to estimate and simulate, making it considerably attractive. The t-copula is the dependence structure implicit in a bivariate t distribution.[30] It has two parameters – the correlation parameter, ρ, and the degrees of freedom parameter, v. These can be broadly interpreted as describing the overall level of immobility in the distribution and the excess immobility in the tails of the distribution. The function $\theta(a_i, X_i)$ describes the way in which we restrict the copula parameters to depend on experience and the observable characteristics. We assume the following functional forms:

$$\rho(a, X) = g_\rho(\beta_0^X + \beta_1^X a + \beta_2^X a^2 + \beta_3^X a^3);$$
$$v(a, X) = g_v(\beta_0^X + \beta_1^X a + \beta_2^X a^2), \tag{7}$$

where g_ρ and g_v are monotonic functions designed to keep ρ and v inside their respective ranges:

$$g_\rho(z) = \frac{1 - e^{-z}}{1 + e^{-z}}$$
$$g_v(z) = e^z. \tag{8}$$

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[29] Note also that the two-step approach allows one the flexibility of using two different data-sets to estimate marginal distributions and mobility. This feature is exploited by Dearden *et al.* (2006), who use large samples of good-quality cross-sectional earnings data to estimate the marginals.
[30] For detailed information on the t-copula, including a formal definition, see Demarta and McNeil (2005).

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