The external benefits of higher education

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Abstract

The private market benefits of education are widely studied at the micro level, although the magnitude of their macroeconomic impact is disputed. However, there are additional benefits of education, which are less well understood. In this paper the macroeconomic effects of external benefits of higher education are estimated using the "micro-*to*-macro" simulation approach. Two types of externalities are explored: technology spillovers and productivity spillovers in the labour market. These links are illustrated and the results suggest they could be very large. However, this is qualified by the dearth of microeconomic evidence, for which we hope to encourage further work.

Keywords: Supply-side impact; higher education institutions; computable general equilibrium model; Social and external benefits.

JEL Codes: I23, E17, D58, R13.

1 Introduction

A range of evidence testifies to the beneficial returns to education for individuals through the labour market. This paper, however, aims to quantify the system-wide effects of the external impacts from individuals' education. Micro-econometric evidence is used to project the direct impact of externalities upon productivity. Then a dynamic computable general equilibrium (CGE) model is used to simulate endogenous adjustments in the economy and to estimate impacts on macroeconomic aggregates. This approach is demonstrated for productivity spillovers benefiting other workers and knowledge spillovers between higher education (HE) and industry. Although the range of estimated outcomes is large the impacts for the wider economy are in all cases of a significant order of magnitude. This suggests that education externalities should not be ignored when formulating education policy. Furthermore, it reinforces the need to strengthen the evidence base on external benefits of education.

It is pertinent to explore the external impacts of HE as, despite significant evidence, these impacts are not widely acknowledged in the policy process. In the UK, radically different funding mechanisms for HE apply to England and Scotland. The English system largely reflects the recommendations of the BROWNE (2010) report which emphasises the private benefits that graduates receive and argues that it is therefore reasonable for individuals to pay for these benefits through higher fees. From an economics perspective, such a proposal would only be socially efficient if the external benefits of HE were negligible, though no evidence was offered on this issue by BROWNE (2010).

On the other hand, the Scottish Government has decided on no "upfront" fees and no "backdoor" graduate contribution, although the number of places at higher education institutions (HEIs) for domestic students is rationed.[1] In practice, both English and Scottish domestic students are subsidised to a certain extent. From an economics perspective the socially optimal solution occurs where the level of subsidy reflects the excess of external over private benefits. It would be purely fortuitous if the implicit judgements in either the English or Scottish systems about the external benefits of HE were correct.

Why are external impacts overlooked in policy design? One possibility is the relative underdevelopment of the evidence base. A second is that due to their microeconomic nature, perhaps they do not command attention in a policy environment accustomed to articulating impact in terms of macroeconomic aggregates, such as GDP and employment. Some of the evidence drawn on in this paper is itself controversial, reflecting the difficulties that beset attempts to measure accurately the external returns to education, and the comparatively limited body of research that has been devoted to this to date, compared to research on the private market returns to education. Part of the motivation for this work is to identify more clearly the gaps in our knowledge of the external impacts of HE.

Section 2 provides a summary of the various impacts of education on the economy and the relevant evidence. Section 3 briefly reviews the methods that have been used to estimate the external benefits of education in general and higher education in particular. Section 4 presents the "micro-*to*-macro" approach to identifying the system-wide consequences of the external returns to HE and gives a brief account of the AMOS model.[2] Sections 5 and 6 illustrate this approach by analysing the impact of technology spillovers from HEIs to firms drawing on evidence from HARRIS et al*.* (2011) and considering the likely system-wide effects of productivity spillovers from graduates to other workers based on MORETTI (2004). Section 7 concludes, focusing primarily on the further research that would allow a full "micro-*to*-macro" analysis of the external returns to HE.

2 Benefits of Education

This paper differentiates four types of returns to (or benefits of) education (see Table 1): private market returns, private non-market returns, external market returns and external non-market returns. Private market returns to education are the labour market benefits enjoyed by individuals who possess a higher level of education. They manifest themselves in higher earnings and lower unemployment rates. Private non-market returns to education are the benefits outside of the labour market enjoyed by people with a higher level of education. They include positive effects on health, longevity, happiness and many other benefits and are discussed in detail in McMAHON (2009, chapter 4).

External returns to education (or externalities) refer to benefits enjoyed by the wider society if its members choose to acquire a higher level of education. External market returns are expressed in terms of higher productivity and are manifest in higher wages, profits and per capita GDP. However, they are not "internalised" by graduates or HEIs and are enjoyed by other agents in the economy. Examples would include the higher productivity and wages of other employees when working with graduates and HEIs' contribution to R&D and innovation of a public good nature. External non-market returns improve quality of life, but are not necessarily directly translatable into pecuniary benefits. Examples include HE-induced reduction in crime levels and improvements in public health, democratisation and political stability.

Table 1 Classification of returns to education

Type of benefit		Who benefits? Private	Who benefits? External
Type of benefit	Market	Higher wages	Higher productivity of other workers (productivity spillovers)
Type of benefit	Market	Higher employment Lower unemployment	Higher Total Factor Productivity (TFP) due to knowledge spillovers
Type of benefit	Non-market	Better own health	Lower crime
Type of benefit	Non-market	Longer life expectancy	Democratisation
Type of benefit	Non-market	Improvement in happiness	Civic society

2.1 Private market benefits

There exist numerous studies of the private market benefits of education in general, and HE in particular, which are reviewed, for example, by BLUNDELL *et al* (1999) and PSACHARAOPOULOS and PATRINOS (2004). While the results of these studies vary, depending on the data sets, control variables and specific econometric methods used, there is no doubt that HE yields substantial private market benefits in the form of increased earnings over the lifetime of a graduate. Among the most influential UK and US studies are BLUNDELL et al. (2000, 2005) and HECKMAN et al. (2000, 2008). Empirical work for the UK often mentions estimated rates of return of around 10%, but significantly higher returns have been reported (PSACHAROPOULOS and PATRINOS, 2004). Furthermore, there is evidence that these returns are rising, not falling, in the face of the dramatic increase in the HE participation rates in the UK, suggesting that demand for graduates' skills is increasing at an even greater rate than their supply (e.g. MACHIN and McNALLY, 2007).

2.2 Private non-market benefits

McMAHON (2009, chapter 4) discusses private non-market benefits of HE, notably: own health; longevity; child health; child education; husband's health; fertility; happiness; job and location amenities; lifelong learning; consumption benefits. He estimates that the non-market benefits to the individual are 122% of the earnings increase. This is huge, with obvious implications for the incentives for individuals to invest in HE provided they have access to the relevant information. We do not pursue the analysis of non-market private benefits further in this paper, although the approach adopted here can, in principle, accommodate these impacts.

2.3 External benefits

There are few UK studies of external benefits of HE (though see McMAHON and OKETCH, 2010). This is unfortunate since for the appropriate formulation of policy from the perspective of society as a whole, it is the total costs and benefits generated by HE that really matter. If total rates of return to HE are higher than private rates this suggests underinvestment in HE by society as a whole. The solution would be to induce greater investment in HE, and *vice versa* if the opposite were to hold.

Few researchers in this area go beyond simply acknowledging the potential importance of external returns. This is understandable. It is difficult to estimate accurately earnings differentials attributable to HE *per se* through the analysis of large microeconomic databases. However, it is even more difficult convincingly to identify the external returns to education and there is a natural tendency to focus on those effects that are easier to measure. Furthermore, there is undoubtedly scepticism about the likely scale of externalities from HE. As McMAHON (2009) argues, perhaps this is in part due to a tendency to, in effect, "control away" some of the possible external impacts of HE.[3] Yet the potential policy significance of these external impacts of HE is such that it seems essential to explore this systematically, and consider whether mainstream scepticism is justified by the available evidence.

This paper focuses on two aspects of education externalities that have generated much academic interest, particularly in a regional context: local earnings spillovers and knowledge spillovers. The analysis for the former draws on MORETTI (2004) and for the latter on HARRIS et al. (2011). These are discussed in detail in the context of calibrating the simulation scenarios, which are described in Section 5 and 6 respectively.

3 Approaches to valuing the externalities associated with higher education

This section of the paper provides a brief review of each of the main approaches to measuring (and valuing) the external returns to HE. The review can be brief because an extensive account is available in McMAHON (2009).

One approach is based on the macroeconomic growth-accounting literature, which was the original source of the famous "residual" in GDP per capita growth that could not be explained by the growth in labour and capital inputs and was interpreted as reflecting "technical change" (SOLOW, 1956; BARRO, 1999; CONNORS and FRANKLIN, 2015). The approach can be straightforwardly extended to incorporate the impact of education (see e.g., STEVENS and WEALE, 2004). However, while the accounting attribution approach is useful, it fails to take into account other endogenous changes that typically accompany an efficiency shock. Also in its "residual" formulation it cannot resolve the issue of causality.

The most widely used approach, which at least in principle overcomes many of the limitations of growth accounting, is what we term the "macro-*less*-micro" approach (HECKMAN and KLENOW, 1997; TOPEL, 1999;). Here macroeconomic growth models are estimated and interpreted as capturing the total (private plus external) market returns to education in general, or higher education in particular. These models can be either neoclassical, with disaggregated labour input, or one of the variants of the endogenous growth approach. There exist a number of relevant reviews of such models, including one on the macroeconomic returns to education (SIANESI and VAN REENEN, 2003) and on the potential role for HE within endogenous growth models (GEMMELL, 1996). Conventional micro-econometric estimates of private market returns (such as those reported in BLUNDELL et al., 2000, 2005) are subtracted from the macroeconomic returns estimated from macroeconomic growth models (with disaggregated labour input) to yield estimates of external returns.

The literature is valuable but the underlying assumption is that all relevant externalities are captured by aggregate models, and there are numerous issues of specification, estimation, interpretation and observational equivalence. In particular, there is no clear resolution of whether human capital affects the level of per capita GDP or its growth rate. Whilst the UK evidence indicates positive externalities, the US studies are less clear cut, with a suggestion perhaps of signalling effects and negative externalities (BENHABIB and SPIEGEL, 1994; KRUEGER and LINDAHL, 2001; SIANESI and VAN REENEN, 2003). Furthermore, this approach can at best provide an estimate of aggregate externalities that are reflected in GDP (i.e. external market returns) but fails to identify their detailed source or the relevant transmission mechanisms.

A third approach brings an element of macro into micro by, for example, incorporating some measure of average “system-wide” human capital which is external to the individual or firm into an augmented Mincerian earnings function, directly reflecting the LUCAS (1988) variant of endogenous growth. Examples include MORETTI (2004), in which there is positive productivity spillover from individual graduates to non-graduates and other graduates. The basic idea here is that productivity can be enhanced through human capital externalities arising from the interaction of graduates with other workers. Attention focuses on the coefficient of the external human capital term. Again the approach is interesting, but controversial due to a range of econometric (and theoretical) issues, including the difficulties of controlling for demand driven effects on the proportion of graduates in the local labour force.

The McMAHON (2002, 2004, 2009) dynamic simulation model of endogenous development draws on endogenous growth, but augments it in two main ways. First, it shifts the focus to the shorter and medium terms and so to dynamics. Secondly, it broadens the focus in an attempt to provide a comprehensive means of capturing externalities, in part through inclusion of a Becker-like model of household time allocation. The approach is novel and interesting, though not specifically focussed on HE.

In the regional literature, by far the main focus, in terms of HE externalities, has been on estimating the scale of HE spillover effects in knowledge production functions. The approach began by incorporating spatial impacts more effectively into a knowledge production function in which the influence of HE is separately identified (JAFFE, 1989). In a wider context, studies of the knowledge economy encompass a broad range of typically more descriptive, case-study-based approaches, though the generality of their results is questionable (see, for example, GOLDSTEIN, 2009). Many of these analyses are microeconomic in orientation. HARRIS et al. (2011) is a recent example, which is estimated on GB data.[4] However, estimates of spillovers could be calibrated as a productivity shock in a system-wide model to simulate likely aggregate effects. This is demonstrated by GIESECKE and MADDEN (2006), which provides a CGE analysis of impact of HE research in

Tasmania by linking total factor productivity to the stock of knowledge, which in turn is expanded through HE research.

4 A "micro-to-macro" approach.

The present paper adopts a "micro-*to*-macro" approach to assess the possible system-wide impacts of HE externalities. This approach was first introduced by HERMANNSSON et al. (2014a) which used it to estimate macroeconomic effects of labour productivity increases in response to projected increases in the share of graduates in the labour force.

The approach is rather straightforward. It uses relevant micro-econometric evidence of the external returns to HE to inform simulations in a dynamic macro model, calibrated on data for the Scottish economy. This allows the capture of the transmission mechanism from micro level changes in productivity to macro level output, the disaggregated impacts across economic agents, and the dynamic transition path of the external benefits of HE.

The "micro-to-macro" approach has a number of advantages. It employs a multi-sectoral, dynamic general equilibrium model where the demand- and supply-side of the economy are explicitly incorporated. It can therefore identify the system-wide ramifications of any particular external benefit of HE, or any group of such benefits, for which micro-econometric evidence exists. This also allows an analysis of any interdependencies that might characterise the impact of particular external benefits. Another advantage of the "micro-to-macro" method is that the transmission mechanism from the externality to the wider economy can be captured by the model, at least in broad-brush terms, and the causal sequence is clear in any subsequent simulations of impacts.

While there are advantages of this general approach it is important to emphasise the illustrative nature of this particular application, given that very little relevant Scottish, or indeed UK, evidence on external returns to HE exists. Furthermore, this paper is not comprehensive in its coverage of external effects, but considers the evidence concerning just two examples which have clear transmission mechanisms: the stimulus to total factor productivity as a consequence of firms' interaction with HEIs and the impact of graduates on the productivity of non-graduates and other graduates. In these examples, the nature and the scale of the external benefits of HE are translated into Hicks- and Harrod-neutral productivity shocks, respectively.

4.1 AMOS: A macro-micro model of Scotland

The macroeconomic simulations undertaken in this paper use AMOS – a CGE modelling framework parameterised on data from Scotland. A brief account is given here; greater detail is available in LECCA et al. (2011, 2014). It is calibrated using a Social Accounting Matrix based around the 2006 Scottish Input-Output Tables.[5] Essentially, it is an inter-temporal, multi-sectoral, general equilibrium, empirical implementation of a LAYARD, NICKELL and JACKMAN (1991, 2005) model of a regional economy. It has three domestic transactor groups: the household sector, corporations and government; and four major components of final demand: consumption, investment, government expenditure and exports. There are twenty five sectors.

Consumption and investment decisions reflect inter-temporal optimization with perfect foresight (LECCA et al., 2011). The representative consumer chooses a sequence of consumption that maximizes lifetime utility, then in each time period chooses a particular consumption bundle given a fixed constant elasticity of substitution (CES) consumption function and the ruling commodity prices. The path of industrial investment is obtained by maximizing the present value of the firm's cash flow (HAYASHI, 1982). The details are given in on-line Appendix B.

Government expenditure is fixed in real terms and no constraints are imposed on the government budget. This reflects the population-based UK regional funding mechanism discussed in greater detail in Sections 5 and 6. The demand for exports to the rest of the UK (RUK) and the rest of the world (ROW) is determined via conventional export demand functions for which the price elasticity is set at 2.0 (GIBSON, 1990).. Imported and locally produced intermediate goods are considered imperfect substitutes and are combined under a CES function with substitution elasticities of 2.0 (ARMINGTON, 1969).

All of the simulations in this paper use a single Scottish labour market characterised by perfect sectoral mobility. Labour inputs supplied by workers with different qualification levels are homogeneous. Graduates are more productive (have more efficiency units) but in other respects graduate and non-graduate labour are perfect substitutes. We assume no natural population change and no migration so as to isolate the effect of HEI externalities from the effect of changing size of the labour force. Wage setting is determined by a regional wage curve that embodies the econometrically derived specification given in LAYARD et al. (1991).

All sectors are taken to be perfectly competitive and have a multi-level production structure. Total gross output, X, is produced by combining value added, Y, and intermediate inputs, V, through Leontief technology:

$$X_t = min\left(\frac{Y_t}{a^Y}; \frac{V_t}{a^V}\right) \qquad 1.$$

where a^Y and a^V are input coefficients. Value added, Y, is given by a CES combination of labour (N) and private capital (K):

$$Y_t = \left[a(A_t^K K_t)^{\vartheta} + b(A^N{}_t N_t)^{\vartheta}\right]^{\frac{1}{\vartheta}} \qquad 2.$$

In equation (2) $\vartheta = (\psi - 1)/\psi$, where ψ is the elasticity of substitution, which takes the value 0.3 (HARRIS, 1989). The parameters a and b are distribution parameters and A_t^K and A_t^N are technical change indices for capital and labour respectively. In the Hicks neutral (TFP) technical change simulations reported in Section 5.1, the parameters A_t^K and A_t^N are augmented equally. In the simulations reported in Section 6.1, where a Harrod-neutral (labour-augmenting) technical improvement is introduced, only the parameter A^N is increased. .

Financial flows are not explicitly modelled, the assumption being that Scotland is a price-taker in competitive UK financial markets. Furthermore the free flow of capital ensures equilibrium in the balance of payments without imposing restrictions in the current account.

5 The impact of HEIs on total factor productivity

HARRIS *et al* (2011) estimates the direct impact of HEI - firm knowledge links on establishment-level total factor productivity (TFP) in Great Britain. It uses a dataset that merges the Community Innovation Survey (CIS) with the Annual Respondents Database (ARD) and estimates a basic production function model (3), augmented to include the impact of any establishment-level engagement with HEIs as captured in the CIS:

$$y_i = \alpha + \beta_E e_i + \beta_K k_i + \beta_x X_i + \beta_{ATT} HEI_i + \varepsilon_i \qquad 3$$

where: y_i is the log of gross value added (GVA) for establishment *i*, e_i is the log of employment, k_i is the log of the capital stock, X_i is a vector of control variables and HEI_i is a dummy variable that equals unity if the establishment collaborates with HEIs on innovation, and zero otherwise.

Notice that β_{ATT} is a measure of the impact of HEIs on enterprises through their "sourcing knowledge from HEIs and/or cooperating on innovation with HEIs" on TFP, since the latter is measured simply by moving the terms in capital and employment to the left-hand-side of the equation. We interpret this coefficient here as indicating the presence of a positive externality of HEIs on TFP. However, it has to be acknowledged that since the precise nature of the co-operation is not known it might be that some part (or all) of this is internalised, for example in the form of research grants. When estimated on all industries in Great Britain, with a sample based on propensity score matching, HARRIS et al. (2011) finds that β_{ATT} is positive and statistically significant, and indicates that collaborating with HEIs is associated with TFP that is around 12% higher, given all the control variables included.[6] It should be noted that these are by no means the largest estimates of these effects. For example, HASKEL and WALLIS (2010) estimates of the marginal effects of research funding suggest a growth rate of TFP of between 3 and 7% per year.

Since the impacts are based on the 2007 CIS, the results are taken to relate to 2006 and are interpreted as implying that the existence of HEIs increases TFP by 12% in firms reporting cooperation with HEIs, *ceteris paribus*. There are a number of problems involved in trying to deduce the size of the Hicks-neutral technical change shock that should be introduced into the CGE model to reflect these results. First, the estimated impact only applies to those establishments that actually report collaboration with HEIs, that is only to those establishments that indicated that they had either sourced knowledge or cooperated on innovation-related activities in the CIS. In 2006, based on weighted CIS data, 30.1% of GB establishments (in output terms) collaborated with HEIs, although this varied significantly by firm size and by sector. Accordingly, from the perspective of the economy as a whole, the scale of the impact on TFP is 3.6% (i.e., 30.1% of 12%).

Second, because of the binary ("all or nothing") form of the dummy variable indicating HEI activity, this estimate is effectively a measure of the impact of a "hypothetical extraction" of HEIs on TFP. It reflects the impact of the HE sector as a whole and therefore presumably reflects the impact of the stock of knowledge attributable to the sector. This suggests one approach to investigating the system-wide consequences of the estimated impact of HE: we could simulate the impact of extraction of HE sector on TFP (103.6 to 100 or a 3.5% reduction in TFP). Of course, this may not be that informative if interest is in the likely impact of marginal changes in HE policy. However, it suggests the likely scale of research-induced supply-side changes on the Scottish economy, if Scottish establishments respond like those in GB as a whole.[7]

5.1 TFP shock. Simulation results.

Table 2 presents the long-run equilibrium results of removing the estimated technology spillover stemming from the contact between Scottish industry and HEIs. We assume that Scottish and GB establishments are similar, implying a Hicks-neutral (TFP) reduction in efficiency of 3.5% and long-run equilibrium is achieved where all capital stock and labour market adjustments are complete. Since we are simulating the impact of a hypothetical extraction of the (positive) effect of HEIs on industry TFP, the impacts on GDP and employment are negative. To avoid confusion we present these as positive figures here.

The standard growth accounting approach would show a 3.5% impact on Scottish GDP, just equal to the change in the Hicks-neutral improvement (STEVENS and WEALE, 2004). In contrast, the CGE simulation reports a 4.9% change in GDP, reflecting not only the increased productivity of capital and labour but also the endogenous 1% increase in employment and 2.3% increase in the capital stock that accompany the productivity improvements. The increased efficiency leads to a fall in commodity prices, with a reduction in the consumer price index (CPI) of 1.7%. This increased competitiveness generates higher exports to the Rest of the UK and Rest of the World of 4.9% and 4.8% respectively. This leads to an increased derived demand for factors of production resulting in an inflow of capital, a fall in unemployment and a rise in the real wage of 1.6%.[8] The growth accounting therefore significantly underestimates the full GDP impact.

Table 2. TFP shock of 3.5%. Long run percentage change

GDP - Growth accounting	3.5
GDP	4.9
Households Consumption	1.7
Investment	2.3
Total Employment	1.0
Unemployment Rate*	-0.9
Nominal Wage	-0.1
Real Wage	1.6
Consumer Price Index	-1.7
Replacment cost of capital	-1.4
Export RUK	4.9
Export ROW	4.8
Capital Stock	2.3

*percentage point change

However, growth accounting in this case substantially overestimates the impact on regional welfare. If improvements in welfare are identified with increased consumption, then in the CGE simulations both public and private consumption fail to rise in line with factor productivity. The real labour and capital incomes increase by 2.6% and 2.7% respectively.[9] This is lower than the increase in GDP because of the reduced regional terms of trade. However, this subsequently translates to an even lower increase in consumption because of the particular characteristic of the funding of devolved regions in the UK.

Public expenditure in Scotland is determined by a population-based formula and is not linked systematically to taxes raised in Scotland (CHRISTIE and SWALES, 2010). Given that in these simulations we assume that population remains constant, real public expenditure is fixed. Private consumption is determined through changes in real factor incomes and government transfers. Again, we take transfers to be fixed in these simulations, generating an increase in private consumption of 1.7%. Essentially there is an increase in the regional tax take, not matched by corresponding changes in government expenditure and transfers.[10] This essentially means that regional public savings rise, matched by an increase in Scottish RUK and ROW exports. The long-run sectoral results and their sensitivity to trade elasticities are presented in on-line Appendix A.

6 The spillover effects of graduates on the productivity of non-graduates and (other) graduates

This section takes as an example regression analysis that includes some indicator of the average (external) level of human capital in an earnings equation and interprets the coefficient on that variable as indicating the spillover effect on the individual/group whose earnings are captured in the dependent variable. The specific work used is MORETTI (2004). This estimates an earnings function in which external effects are measured through the incorporation of a city-wide measure of human capital, namely the share of college graduates.

This section of the paper focusses on the external impact of the graduate share on the earnings of non-graduates and other graduates. The underlying assumption is that the higher earnings reflect higher productivity. The fundamental source of such effects is a matter of some debate. However, they have long been recognised as potentially important (MARSHALL, 1890) and are the most direct way, at the comparatively disaggregated level, of testing for the effects that are the core of the LUCAS (1988) variant of endogenous growth theory.

The area is controversial, in particular in respect of the appropriate estimation and interpretation of the coefficient of the proxy for average human capital in the earnings equation. Whilst a number of researchers have adopted this approach, mostly in a US context, the empirical evidence is mixed. For example, RAUCH (1993) identifies significant externalities, using earnings and rental rate equations, and ACEMOGLU and ANGRIST (2000) find apparent evidence of such effects for schooling using OLS, though this largely disappears under IV estimation.

MORETTI (2004) reports significant impacts, and this work seems most relevant here in that it estimates external effects for groups with different education levels; high school drop outs, high school graduates and college graduates. It suggests that differences from ACEMOGLU and ANGRIST (2000) are down to: its inclusion of a time period in which returns grew; its focus on returns at the higher end of the earnings spectrum; its analysis being of city-level rather than state-wide effects (which are lower in its sample). Further, the pattern of results given in MORETTI (2004) is broadly consistent with the argument of KRUEGER and LINDHAL (2001) that the external benefits to education at lower levels of the education system impact largely through reduced levels of crime and benefit claims, whereas at the upper levels they impact through technology and productivity.

LANGE and TOPEL (2006) maintain that the estimates in MORETTI (2004) must be regarded as upwards biased as the notion of spatial equilibrium implies that the human capital intensities of cities may be demand driven, although MORETTI (2004) does try to correct for this. On the other hand, ACEMOGLU and ANGRIST (2000) must be regarded as providing a lower bound though, as noted above, this is zero, at least for their IV estimates for the earlier period. It would be instructive to estimate these effects for the UK regions, given that spatial equilibrium seems likely to be less applicable in that context given a lower degree of labour mobility.

The "base" simulation scenario uses the MORETTI (2004) estimate of a 1.6% and 0.4% increase in earnings for non-graduates and graduates for every 1 percentage point increase in the proportion of graduates in the labour force. However, the only component of this change that unambiguously reflects the presence of an externality is the 0.4%, since the normal market reaction to an increase in the proportion of graduates would be an increase in the non-graduate wage. To account for that, the present paper estimates a second "conservative" scenario in which 0.4% is taken as a measure of the external effect on graduates and non-graduates alike. While this is a conservative interpretation of the externality estimated in MORETTI (2004), the qualifications to our analysis are nonetheless substantial: the LANGE and TOPEL (2006) critique of upward bias remains; the size of these effects tends to be bigger the smaller the spatial scale; and the estimates are based on US cities, while the simulations here are for a UK region.

To determine the scale of the productivity spillovers the projected share of graduates in the Scottish labour force has first to be determined. This will increase even with an unchanged HE participation rate, given demographic processes and the higher participation rates for recent cohorts. After that, the external effects are applied to determine the resultant changes in the productivity of both graduates and non-graduates. Of course, if there were no change in the share of graduates, there would be no (additional) induced productivity change.

The analysis builds on the projection of the future Scottish labour force composition described in HERMANNSSON et al. (2014a), which extrapolates from the 2006 skill composition of the Scottish labour force. The base year skill composition is calculated from age-specific shares of graduates from the Annual Population Survey and the 2006 population structure. In 2006 the 25 year old age group had the highest share of graduates at 46%. It is assumed that new cohorts entering the labour force in the future, will achieve the 46% share of graduates by the age of 25. Those aged 20-24 are assumed to have the same age-specific shares of graduates as cohorts that were in this age group in 2006. Therefore, as the cohorts age, more age groups contain a 46% share of graduates. By 2045 all age groups over 25 will have a 46% share of graduates (those aged 20-24 are assumed to be still in the process of acquiring their qualification). The projected future skill mix is applied to the projected Scottish population aged 20-64 from the 2008-based principal ONS Scottish population projections to arrive at the total future number of graduates. The implicit assumption here is that age-specific labour force participation rates and unemployment rates will stay the same.

The projected future share of graduates in the Scottish labour force increases from just above 34% at the beginning of the period to 44.5% by 2051. It should be stressed that we are not projecting an increase in the participation rate in Scottish HEIs from the 2006 level. Rather, older cohorts have a significantly lower proportion of graduates than more recent ones. Accordingly, through time "less skilled" older cohorts are replaced by "more skilled" younger cohorts, and the total share of graduates in the labour force increases.[11]

The incremental change in total labour productivity (ΔLP_t) in each period associated with the growing proportion of graduates in the labour force is calculated according to formula (4)

$$\Delta LP_t = (e_g g_t + e_{ng} (1 - g_t)) \Delta g_t \qquad 4$$

where g_t is the proportion of graduates in the labour force in period t, Δg_t is the percentage change in the graduate share of the labour force, e_g is the external effect on the productivity of graduates (0.4%) and e_{ng} is the external effect on the productivity of non-graduates (which is 1.6% and 0.4% under the base and conservative scenarios respectively). Using these calculations, by 2051 the cumulative labour productivity shock reaches 11.47% or 4.08%, depending on scenario. In each case this shock is applied to the homogeneous labour input, with the only difference between graduates and non-graduates being their higher productivity.

6.1 Labour productivity. Simulation results

Table 3 presents the long-run results of the positive shock to labour productivity associated with the external effect of graduates on the productivity of non-graduates and other graduates. These are the result of introducing a Harrod-neutral efficiency increase, as against the Hicks-neutral stimulus in Section 5.1. That is to say, in this simulation we simply increase the efficiency of labour whereas in the results reported in Table 2 we increased the efficiency of both labour and capital equally.

Table 3 Simulation results. Long-run percentage change

	Base Scenario	**Conservative Scenario**
Labour productivity shock	11.5	4.1
GDP - Growth accounting	7.1	2.5
GDP	11.8	4.2
Households Consumption	2.9	1.0
Investment	10.5	3.7
Total Employment	1.0	0.3
Unemployment Rate*	-0.9	-0.3
Nominal Wage	-3.9	-1.5
Real Wage	1.9	0.6
Consumer Price Index	-5.6	-2.1
Replacment cost of capital	-5.0	-1.9
Export RUK	9.9	3.5
Export ROW	9.0	3.2
Capital Stock	10.5	3.7

*percentage point change

Using a standard growth accounting perspective, the increase in GDP would be calculated as the percentage change in labour productivity weighted by the share of labour in the base year GDP (HERMANNSSON et al., 2014b). Therefore for the base and conservative scenarios, the associated impact on GDP would be given as 7.1% and 2.5% respectively. However, as with the results reported in Section 5.1, the CGE simulations produce much higher GDP impacts through the endogenous increases in the use of labour and capital. The stimulus to GDP, as a consequence of the productivity spillovers generated by the increasing proportion of graduates in the labour force, is 11.8% in the base scenario and 4.2% in the conservative scenario. Again the additional stimulus is driven by increased competitiveness, which results in a substantial increase in interregional and international exports. [12]

The major qualitative difference between the results for the TFP improvement given in Section 5.1 and the labour productivity stimuli reported here concerns the resulting demand for the factors of production, labour and capital. In the productivity change reported in this simulation, only labour receives the productivity increase. Measured in efficiency units, the price of labour falls and this also generates a fall in domestic prices reflected in the 5.6% or 2.1% reduction in the CPI. There are therefore output and substitution effects stimulating the demand for labour in efficiency units. However, the increase in labour productivity means that one unit of labour measured in efficiency units now translates to a lower demand for labour, measured in natural units (number of employees). In these simulations, the expansionary income and substitution effects dominate, and employment rises (by 1.0% or 0.3%) with a corresponding reduction in unemployment and an increase in the real wage. But for capital, whose productivity is unchanged, demand increases to a much greater extent, at 10.5% or 3.7% – the positive output effects clearly dominating the negative substitution effects in this case.

Again in these simulations, the impact on Scottish welfare, as measured by changes in public and private consumption, is much lower than the growth accounting approach would suggest. The key rests with the change in real wage income, which increases only 1.9% or 0.6%. These values are much lower than both the percentage change in GDP and especially the capital income, which increases by 10.5% or 3.7%. However, whilst all of wage income is transferred to Scottish households, a share of capital operating in Scotland is owned outside the region so that a share of capital income fails to find its way into Scottish household income. This, together with the impact of fixed public consumption and transfers discussed in Section 5.1, means that household consumption increases by only 2.9% in the base scenario, and 1.0% in the conservative scenario. Again, the Scottish long-run balance of payments will improve, accompanied by an increase in public saving generated by the increased tax take.

Figure 1 plots the adjustment path of GDP in response to the projected increase in labour productivity associated with the positive external effect of graduates on the productivity of non-graduates and other graduates. The two lines represent results for the two scenarios.

The adjustment paths for employment are shown in Figure 2. Note that employment actually falls in the first three periods, reflecting the fact that initial capacity constraints restrict the positive output and substitution effects on labour demand, so that in the first few periods the negative efficiency effect dominates.

Figure 1. The adjustment path of GDP in response to labour productivity increase

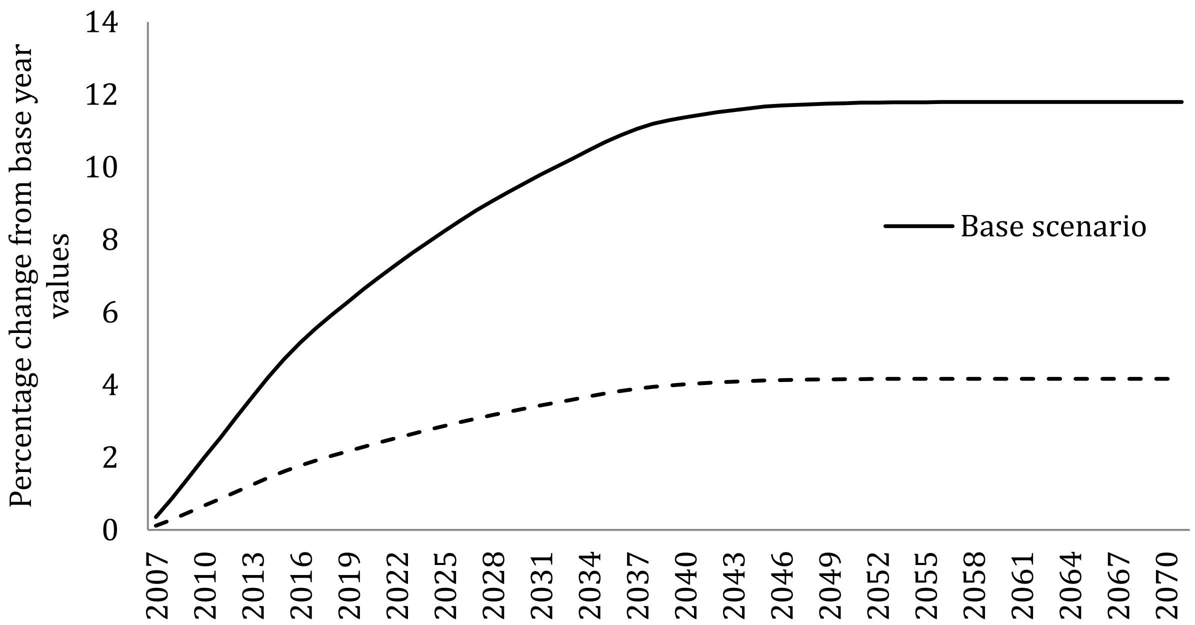
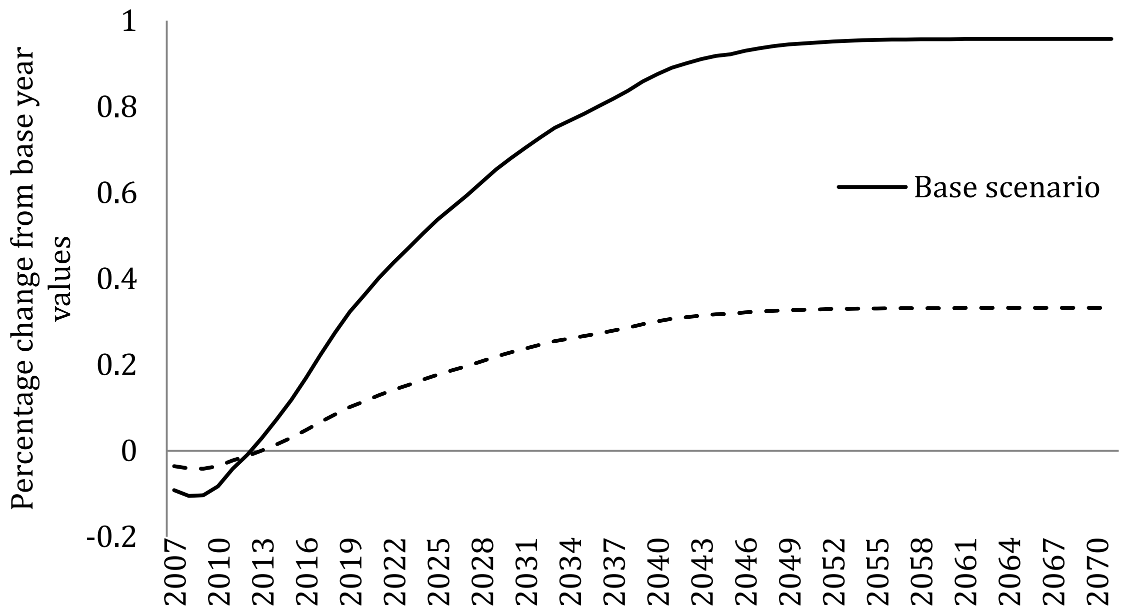


Figure 2. The adjustment path of employment in response to labour productivity increase



However, employment can fall even in the long run if the trade elasticities for imports and exports are close to zero. This is because the expansionary effects obtained through a downward pressure on prices generated by the labour productivity shock is limited if imports and exports are insensitive to variation in the price of goods and services.

Table 4 reports the sensitivity of the long-run percentage changes in employment and GDP to varying the trade elasticity between 0.2 and 4. Whilst GDP change is always positive, regardless of the imposed value of the trade elasticity, the aggregate level of employment falls by 6.67% and 2.3% in the base and conservative scenarios respectively when the trade elasticity is set to 0.2. Furthermore, with low elasticities, bigger productivity change would also generate larger falls in employment. The opposite occurs when higher trade elasticities produce a greater stimulus to exports and import substitution.

Table 4. Long-run effects, percentage change

	ρ=0.2	ρ=2	ρ=4
Base Scenario			
GDP	2.2	11.8	14.2
Employment	-6.3	1.0	2.6
Conservative Scenario			
GDP	0.9	4.2	5.1
Employment	-2.3	0.3	1.0

7 Conclusions

This paper adopts a "micro-*to*-macro" approach for assessing the system-wide impacts of two specific external benefits from HEIs. Furthermore, the transmission mechanisms from the direct HEI productivity effects to economic activity are identified and causality is clear within the CGE simulation framework. The approach therefore offers advantages over the "macro-*less*-micro" approach that characterises much of the literature in the UK, in which macroeconomic returns to education are used to identify externalities when compared to micro-econometric estimates of private market returns. Such studies can at best yield a measure of *aggregate* external market benefits as reflected in GDP, though this is, of course, a valuable contribution.

Although the simulation results reported here are sensitive to particular assumptions and therefore generate a wide range of values, the aggregate GDP effects are always positive. In the context of recent policy debates about tuition fees, it is clear that by focussing only on private benefits there is a risk of underinvesting in higher education. However, placing a precise figure on the total social benefits is extremely challenging and, as a result, so is calculating the optimal rate of subsidy. Nevertheless, the evidence clearly shows that the debate should be about the extent, rather than the existence, of the subsidy.

The analysis also demonstrates that implementing the "micro-*to*-macro" approach on Scottish data is problematic, given the very limited nature of existing micro-econometric analyses of HE externalities. First, the simulations have not typically used Scottish-specific estimates of external returns to education, for the simple reason that these estimates usually do not exist. Second, some of the extant studies of external returns to HE are themselves exploratory. There is no counterpart to the breadth and depth of studies that estimate the private market returns to HE in the analysis of external or private non-market returns for any country or region.

Third, the full possibilities of the "micro-*to*-macro" approach are not exploited here in that a comprehensive coverage of external benefits of HE is not attempted; rather, because of the limited evidence, only an illustrative analysis of two types of externality is provided. Fourth, the private non-market benefits of HE are not assessed, although the "micro-*to*-macro" framework offers this possibility. The estimate of private non-market returns would have to be included in any comprehensive assessment of the total costs and benefits associated with HE. McMAHON (2009, chapter 4) calculates private non-market returns to be equivalent to 122% of the private market returns. HERMANNSSON et al (2014a) estimate that private market returns contribute 3.7% for regional GDP in the long run (baseline scenario). This suggests that non-market returns could contribute as much as 4.5% of GDP to the economy in the long run. However, this does assume that all these effects are equivalent to a productivity stimulus and while this may be reasonable for some of the non-market benefits (e.g. health effects), it may be less reasonable for others. Nevertheless this suggests that these non-market returns merit further rigorous investigation.

Clearly, the nature of an illustrative study of this kind is that the list of further research is challenging: indeed part of the motivation in attempting to implement the "micro-*to*-macro" approach is to reveal the extent of the current gaps in our knowledge. First, and most crucially, there is a need for further micro-econometric studies of HE externalities in a UK-wide and regional context. While there are major issues to be resolved here, if the same ingenuity is applied to this as has already been applied to the earnings issue, significant progress is likely – as indeed a number of US studies already suggest.

Second, once this evidence base is improved, the transmission mechanisms and appropriately specified behavioural functions can be integrated into a "micro-*to*-macro" model to allow an exploration of system-wide interdependencies. Third, within the basic framework it would be comparatively straightforward to offer a finer analysis of impacts that distinguished, for example, among graduates by subject area and allowed for possible industry-specific effects.

Fourth, the analysis can be applied to other regions and nations: certainly the CGE modelling framework can be implemented for the main country-regions of the UK. Fifth, there is the need for an explicitly interregional framework that can accommodate the regional HE systems of the UK and the full interdependencies of its integral regions and nations through trade and factor flows.[13] Finally, the complexity of spillovers in the context of a system of multi-level governance raises issues of the appropriate coordination of HE and other policies across integrated regions and nations. The funding challenges for HE add to the urgency of research into these key policy issues. However, the potential scale of externalities challenge HE funding policies predicated on an explicit or implicit assumption that the external benefits of HE are negligible.

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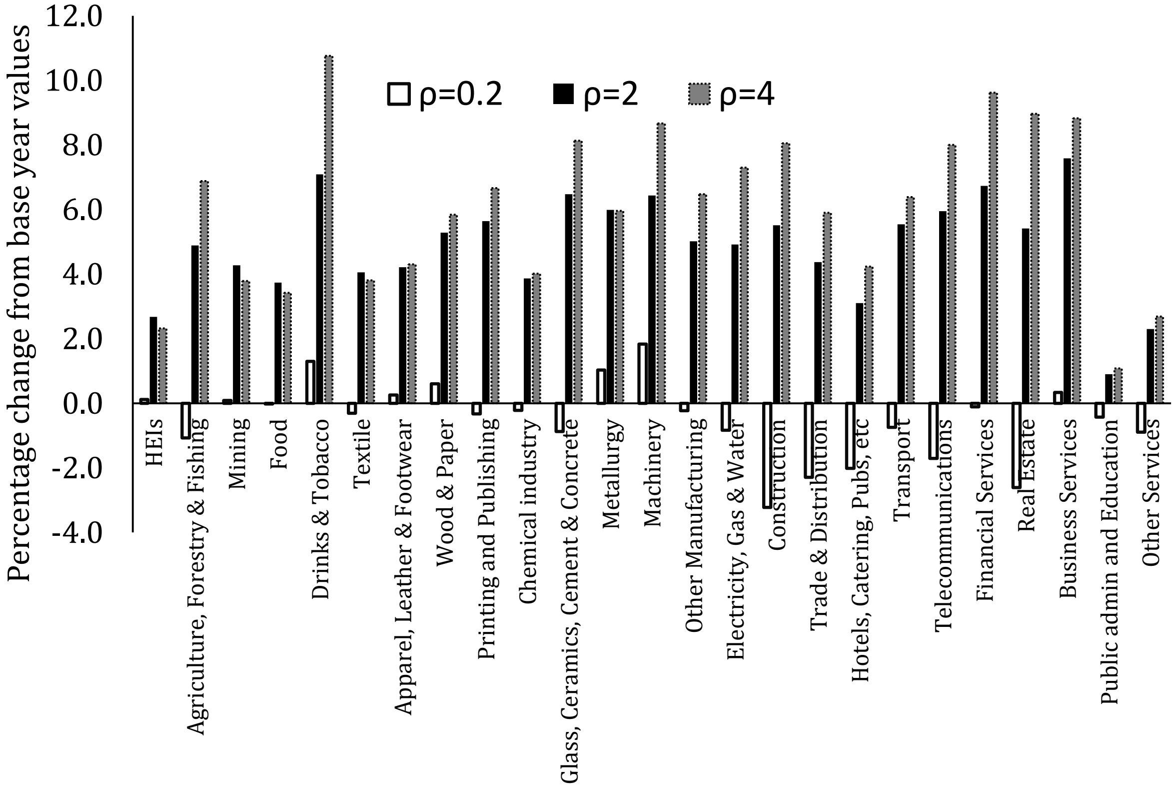
Appendix A.

Figure A1 shows long-run sectoral results and their sensitivity to trade elasticities. As in Table 2, the results are presented as a percentage change relative to the base year. The values for the trade elasticities are 0.2, 2 and 4, with the value 2 corresponding to our default case. The productivity shock applies to all sectors therefore the benefit of increasing TFP would, in principle, generate an increase in output in each industry. Nevertheless, this occurs only where the trade elasticities are not too small. With trade elasticities close to zero, we register negative effects in 17 of the 25 sectors.[14] This is particularly marked in the Construction, Trade and Distribution, Telecommunication and Real Estate sectors. However, value-added intensive and export oriented sectors such as Drink and Tobacco, Glass, Ceramic, Cements etc., together with Business Services and Financial Services are those that benefit most from the productivity shock. Nevertheless, in all sectors higher trade elasticities generate a larger impact on output, so that with the default elasticity of 2, all sectors experience an increase in output.

Figure A1 Sectoral Output



Appendix B

In the formulation of the AMOS model adopted in this paper, consumption and investment decisions reflect intertemporal optimization with perfect foresight (Lecca *et al*, 2011). The decision problem of the representative consumer is to choose a sequence of consumption that maximizes the present value of utility, as summarized by the lifetime utility function:

$$U = \sum_{t=0}^{\infty} \left(\frac{1}{1+\rho} \right)^t \frac{C_t^{1-\sigma} - 1}{1-\sigma} \qquad \text{B1}$$

where C_t is the consumption at time period t, σ and ρ are respectively the constant elasticity of marginal utility and the constant rate of time preference. The dynamic budget constraint ensures that the discounted present value of consumption must not exceed total household wealth, *W*:

$$\sum_{t}^{\infty} z(t) Pc_t C_t \leq W_t \qquad \text{B2}$$

where Pc is the household's aggregate consumption price index and $z(t) = \prod_t (1+r_t)^{-1}$, where *r* is the fixed interest rate.

Once the optimal path of consumption is obtained from the solution of the intertemporal problem, aggregate consumption is allocated between sectors through a constant elasticity of substitution (CES) function. Household demand for local and imported goods is a result of the intra-temporal cost minimization problem.

The path of investment is obtained by maximizing the present value of the firm's cash flow (Hayashi, 1982) given by profit, π_t, less private investment expenditure[1], I_t, subject to the presence of adjustment cost, $g(x_t)$, where $x_t = I_t / K_t$ (Devarajan & Go, 1998):

$$\sum_{t=0}^{\infty} \frac{1}{(1+r)^t} \left[\pi_t - I_t\left(1 + g(x_t)\right)\right] \qquad \text{B3}$$

subject to

$$\dot{K}_t = I_t - \delta K_t \qquad \text{B4}$$

where δ is capital depreciation rate.The solution of the dynamic problem gives the shadow price of capital, λ_t, and the time path of investment.

As regards demographic developments, we assume no natural population change and no migration to isolate the effect of HEIs from the effect of changing size of the labour force. Wage setting is determined by a regional bargained real wage function that embodies the econometrically derived specification given in Layard *et al* (1991):

[1] For simplicity of notation the sectoral index is omitted.

$$\ln\left[\frac{w_t}{cpi_t}\right] = c - 0.1\ln(u_t) \qquad \text{B5}$$

where *c* is a calibrated parameter, *w*, *cpi*, and *u* are the nominal wage, the consumer price index and the unemployment rate respectively. In this function the real wage is negatively related to the level of unemployment in the region, reflecting workers lower bargaining power in such circumstances.

[1] This also raises concerns about a possible "funding gap" of HE in Scotland as compared to England. Estimates of the scale of this gap are provided in the EXPERT GROUP REPORT (2011).

[2] AMOS is an acronym for A Macro-Micro Model of Scotland.

[3] The judgment is that some researchers incorporate control variables, such as occupation, that effectively absorb part of the contribution that may in fact be attributable to HE.

[4] HARRIS *et al* (2011) focuses on aggregate effects and does not adopt a spatial econometrics approach.

[5] The IO data base can be downloaded from http://www.gov.scot/Topics/Statistics/Browse/Economy/Input-Output/Downloads

[6] The impact is slightly reduced, however, when a positive and statistically significant dummy variable indicating the presence of an innovation within the period is introduced. The direct impact of HEIs is captured by the initial dummy variable but HEIs also exert an indirect impact through innovation, captured here by the coefficient on the innovation dummy (ARVANITIS et al., 2008). In the present context, it is more appropriate to use the estimate of impact which is not "corrected" for innovation, otherwise one of the mechanisms through which HEIs exert their influence is effectively being "controlled away".

[7] The locations of the HEIs with which links exist are not identified. Therefore part of the productivity increase might be due to the interaction between Scottish firms and non-Scottish Universities.

[8] Although the real wage increases by 1.6%, the rise in productivity reduces the CPI by 1.7%. This means that the nominal wage falls by 0.1%.

[9] The increase in real labour income equals the real wage growth,(1.6%) plus the proportionate increase in employment (1.0%). The increase in real capital income equals the increase in capital stock (2.3%) plus the proportionate change in the rate of return on capital (0.0%) plus the proportionate change in the capital price index (the replacement cost of capital, -1.4%) minus the change in the CPI (-1.7%).

[10] The fiscal relationship between Scotland and the rest of the UK is set to change with the implementation of the SCOTLAND ACT (2012) and the recommendations of the SMITH COMMISSION (2014). In the future the Scottish Government will be allowed to retain a bigger share of any induced tax revenue.

[11] In the CGE simulations the population and labour force are held constant, so that only the share of graduates in the labour force is changing. This is to disconnect changes in the skill-intensity of the labour force and changes in its size. Population projections are used simply to translate age-specific graduate shares to an aggregate share of graduates in the labour force. The impact of changes in population alone is analysed in LISENKOVA et al. (2010).

[12] This reflects the assumption that the proportion of graduates is unchanged in RUK and ROW. However, it could also be interpreted as the implication for Scotland of failing to match increases in the graduate share of the labour market if these are occurring elsewhere.

[13] For example, an explicitly interregional model would be required to assess the impact on Scotland of changes in the graduate intensities of the workforce in the rest-of-the UK.

[14] The significance of trade elasticities for CGE analyses of productivity changes is a widely recognised result (Giesecke and Madden, 2013, p457).