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The external benefits of higher education

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ABSTRACT

The external benefits of higher education. *Regional Studies*. 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 that 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 the authors hope to encourage further work.

KEYWORDS

supply-side impact; higher education institutions; computable general equilibrium model; social and external benefits

摘要

高等教育的外部效益 . *Regional Studies*. 教育私人市场在微观层级的效益受到广泛研究，尽管这些效益对钜观经济的影响程度仍然受到争议。但仍有额外的教育效益较不被清楚地认识到。本文运用"从微观到钜观"的模拟方法，评估高等教育的外部效益对钜观经济的影响。本文探讨两种类型的外部性：劳动市场的技术外溢和生产力外溢。本文阐明这些连结，而研究结果显示，这些连结可能非常巨大，但却缺乏微观经济的证据，而这正是作者期盼鼓励的未来研究方向。

关键词

供给面影响；高等教育机构；可计算的一般均衡模型；社会与外部效益

RÉSUMÉ

Les bénéfices externes découlant de l'enseignement supérieur. *Regional Studies*. À l'échelle microéconomique on a prêté beaucoup d'attention aux avantages du marché privé pour l'éducation, bien que l'importance de leur impact au niveau macroéconomique soit discutable. Cependant, l'éducation fournit de plus amples avantages moins bien connus. À partir des simulations 'micro-macro', ce présent article cherche à évaluer les effets macroéconomiques des avantages externes de l'enseignement supérieur. On examine deux sortes d'effets externes: les retombées sur la technologie et les retombées sur la productivité au marché du travail. On en illustre les liens et les résultats laissent supposer qu'ils pourraient s'avérer très importants. Néanmoins, cela est nuancé à la lumière de l'absence de résultats microéconomiques, d'où on souhaite encourager des recherches ultérieures.

MOTS-CLÉS

impact sur l'offre; établissement d'enseignement supérieur; modèle d'équilibre général calculable; avantages sociaux et externes

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ZUSAMMENFASSUNG

Externer Nutzen von Hochschulbildung. *Regional Studies*. Der privatwirtschaftliche Nutzen von Bildung wurde auf Mikroebene bereits ausführlich untersucht, doch der Umfang seiner makroökonomischen Auswirkung ist umstritten. Es gibt jedoch einen zusätzlichen Nutzen der Bildung, der weniger gut verstanden wird. Dieser Beitrag enthält eine Schätzung der makroökonomischen Auswirkungen des externen Nutzens von Hochschulbildung mithilfe eines ‘Mikro-*zu*-Makro’-Simulationsansatzes. Untersucht werden zwei Arten von Externalitäten: technische sowie Produktivitäts-Übertragungseffekte auf dem Arbeitsmarkt. Wir illustrieren diese Zusammenhänge, die den Ergebnissen zufolge äußerst umfangreich ausfallen könnten. Allerdings gelten diese Ergebnisse aufgrund der knappen mikroökonomischen Belege nur eingeschränkt, weshalb wir hoffen, zu weiteren Arbeiten motivieren zu können.

SCHLÜSSELWÖRTER

Auswirkungen auf Angebotsseite; Hochschulen; berechenbares allgemeines Gleichgewichtsmodell; gesellschaftlicher und externer Nutzen

RESUMEN

Beneficios externos de la enseñanza superior. *Regional Studies*. Los beneficios de la educación en el sector privado se han analizado exhaustivamente a nivel micro, si bien se cuestiona la magnitud de su impacto macroeconómico. Sin embargo, existen beneficios adicionales de educación que se entienden menos. En este artículo calculamos los efectos macroeconómicos de los beneficios externos de la enseñanza superior mediante un enfoque de simulación ‘micro-*a*-macro’. Exploramos dos tipos de externalidades: los efectos indirectos de la tecnología y los de la productividad en el mercado laboral. Ilustramos estos vínculos y los resultados indican que podrían ser muy grandes. Sin embargo, estos resultados están limitados debido a la escasa evidencia microeconómica, y esperamos que sirvan para estimular estudios adicionales.

PALABRAS CLAVES

impacto de la oferta; instituciones de educación superior; modelo computable de equilibrio general; beneficios sociales y externos

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INTRODUCTION

A range of evidence testifies to the beneficial labour market returns to education for individuals. This paper, however, aims to quantify the system-wide effects of the external impacts from individuals’ education. Microeconometric 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 substantial. 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 often ignored 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 emphasizes 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 subsidized 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 the 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, they might not command attention in a policy environment accustomed to articulating impact in terms of macroeconomic aggregates, such as gross domestic product (GDP) and employment. Some of the evidence used in this paper is controversial, reflecting the difficulties in measuring accurately the external returns to education, and the comparatively limited body of research devoted to this to date. Part of the motivation for this paper is to identify more clearly the gaps in the knowledge of the external impacts of HE.

BENEFITS OF EDUCATION

This paper differentiates four types of returns to (or benefits of) education (Table 1): private market returns,

Table 1. Classification of returns to education.

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

private non-market returns, external market returns and external non-market returns. Private market returns are the labour market benefits enjoyed by individuals through a higher level of education. These are higher earnings and lower unemployment rates. Private non-market returns are the benefits outside the labour market accruing to people with more education. These include positive effects on health, longevity, happiness and many other benefits, and are discussed in detail by McMahon (2009, ch. 4).

External returns to education (or externalities) refer to benefits to wider society from higher average levels of education. These are expressed in terms of higher productivity and result in higher wages, profits and per-capita GDP. However, they are not 'internalized' by graduates or HEIs and are enjoyed by other agents in the economy. Examples include the higher productivity and wages of other employees when working with graduates and HEIs' contribution to research and development (R&D) and innovation of a public good nature. External non-market returns improve the quality of life, but do not necessarily directly translate into pecuniary benefits. Examples include HE-induced reduction in crime and improvements in public health, democratization and political stability.

Benefits

There exist numerous studies of the benefits of education in general, and HE in particular, which are reviewed in Blundell, Dearden, Meghir, and Sianesi (1999) and Psacharopoulos and Patrinos (2004). While the results of these studies vary, depending on the datasets, control variables and specific econometric methods used, there is no doubt that HE yields substantial benefits in the form of increased earnings over the lifetime of a graduate. Among the most influential UK and US studies are Blundell, Dearden, Goodman, and Reed (2000), Blundell, Dearden, and Sianesi (2005), Heckman, Tobias, and Vytlacil (2000), and Heckman, Lochner, and Todd (2008). UK studies often mention estimated rates of return of around 10%, but significantly higher returns have been reported (Psacharopoulos & Patrinos, 2004). Furthermore, these returns appear to be rising, not falling, in the face of the dramatic increase in the HE participation rates, suggesting that demand for graduates' skills is increasing more rapidly than their supply (e.g., Machin & McNally, 2007).

Private non-market benefits

McMahon (2009, ch. 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; and 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. The analysis of non-market private benefits is not pursued further in this paper, although the approach adopted here can, in principle, accommodate these impacts.

External benefits

There are few UK studies of external benefits of HE (though see McMahon & 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 under-investment in HE by society as a whole.

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 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, in effect, to 'control away' some of the possible external impacts of HE.[2] Yet the potential policy significance of these external impacts is such that it seems essential to explore this systematically and to 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, Li, and Moffat (2011). These are discussed in detail in the context of calibrating the simulation scenarios, which are described in the fifth and sixth sections respectively.

APPROACHES TO VALUING THE EXTERNALITIES ASSOCIATED WITH HIGHER EDUCATION

This section briefly reviews each of the main approaches to measuring (and valuing) the external returns to HE, drawing on the extensive account in McMahon (2009).

One method 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' (Barro, 1999; Connors & Franklin, 2015; Solow, 1956). The approach can be straightforwardly extended to incorporate the impact of education (e.g., Stevens & Weale, 2004). However, while this approach is useful, it fails to incorporate 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 is termed here the 'macro-*less*-micro' approach (Heckman & 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 HE in particular. These models can be either neoclassical, with disaggregated labour input, or one of the variants of the endogenous growth approach. There are a number of reviews of such models, including Sianesi and Van Reenen (2003) on the macroeconomic returns to education and Gemmell (1996) on the potential role for HE within endogenous growth models. 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.

This 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 & Spiegel, 1994; Krueger & Lindahl, 2001; Sianesi & 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 augments the endogenous growth approach in two main ways. First, it shifts attention to the shorter and medium terms and so to dynamics. Secondly, it broadens the focus in order 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 focused 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. This 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 comprise a broad range of typically case study-based approaches, the generality of whose results is questionable (e.g., Goldstein, 2009). Many of these analyses are microeconomic in orientation. Harris et al. (2011) is a recent econometric example that is estimated on Great Britain (GB) data.[3] However, Giesecke and Madden (2006) show how estimates of spillovers can be calibrated as a productivity shock in a system-wide model to simulate likely aggregate effects. They provide a CGE analysis of impact of HE research in Tasmania by linking total factor productivity (TFP) to the stock of knowledge, which in turn is expanded through HE research.

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, Lecca, and Swales (2014) where it is used to estimate macroeconomic effects of labour productivity increases in response to projected increases in the share of graduates in the labour force. 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 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 sides of the economy are explicitly incorporated. It can therefore identify the system-wide ramifications of one or any group of external benefit of HE for which micro-econometric evidence exists. This also allows an analysis of any interdependencies that might characterize 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 to this general approach, the illustrative nature of this particular application should be emphasized, 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 TFP 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.

AMOS: a macro-micro model of Scotland

The macroeconomic simulations undertaken in this paper use AMOS – a CGE modelling framework parameterized on data from Scotland.[4] A brief account is given here; greater detail is available in Lecca, McGregor, and Swales (2011) and Lecca, McGregor, Swales, and Yin (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 trans-actor groups: the household sector, corporations and government; and four major components of final demand: consumption, investment, government expenditure and exports. There are 25 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). Details are given in Appendix B in the supplemental data online.

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 below. 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 the simulations in this paper use a single Scottish labour market characterized 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. The paper assumes 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 multilevel production structure. Total gross output, X, is produced by combining value added, Y, and intermediate inputs, V, through Leontief technology:

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

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):

$$Y_t = [a(A_t^K K_t)^{\vartheta} + b(A_t^N N_t)^{\vartheta}]^{\frac{1}{\vartheta}} \quad (2)$$

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 the fifth section, the parameters A_t^K and A_t^N are augmented equally. In the simulations reported in the sixth section, 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.

IMPACT OF HEIS ON TOTAL FACTOR PRODUCTIVITY (TFP)

Harris et al. (2011) estimates the direct impact of HEI – firm knowledge links on establishment-level TFP in GB. 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:

$$y_i = \alpha + \beta_E e_i + \beta_K k_i + \beta_x X_i + \beta_{\text{ATT}} \text{HEI}_i + \varepsilon_i \quad (3)$$

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. Here this coefficient is interpreted as indicating the presence of a positive externality of HEIs on TFP, though since the precise nature of the cooperation is not known, it might be that some part (or all) of this is internalized, 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) find that β_{ATT} is positive and statistically significant, and indicates that with all the control variables included, collaborating with HEIs is associated with TFP that is around 12% higher.[6] It should be noted that these are by no means the largest estimates of these effects. For example, Haskel and Wallis's (2013) 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 calculating the size of the efficiency 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. 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: one 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]

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. Scottish and GB establishments are taken to be 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 the impact of a hypothetical extraction of the (positive) effect of HEIs on industry TFP is simulated, the impacts on GDP and employment are negative. To avoid confusion these are presented as positive figures here.

Table 2. Total factor productivity (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[a]	–0.9
Nominal wage	–0.1
Real wage	1.6
Consumer price index (CPI)	–1.7
Replacement cost of capital	–1.4
Export rest of the UK (RUK)	4.9
Export rest of the world (ROW)	4.8
Capital stock	2.3

Notes: [a]Percentage point change.

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 & 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 the 2.3% increase in the capital stock that accompanies 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 RUK and the ROW 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.

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 & Swales, 2010). Given that in these simulations it is assumed that population remains constant, real public expenditure is fixed.

Private consumption is determined through changes in real factor incomes and government transfers. Again, transfers are 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 real 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 Appendix A in the supplemental data online.

SPILLOVER EFFECTS OF GRADUATES ON THE PRODUCTIVITY OF NON-GRADUATES AND (OTHER) GRADUATES

This section focuses 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 recognized 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 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.

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 ordinary least squares (OLS), though this largely disappears under instrumental variables (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; and 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 Lindahl (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 respectively 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, the qualifications to the 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. Given demographic processes and the higher participation rates for recent cohorts, this share will increase, even with an unchanged HE participation rate. 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. (2014), 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%. Cohorts entering the labour force in future are assumed to achieve the 46% graduate share by the age of 25 years. Those aged 20–24 years 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 years of age will have a 46% share of graduates. The projected future skill mix is applied to the 2008-based principal ONS Scottish population projections to arrive at the total future number of graduates. The implicit assumption 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.[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:

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

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 the 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.

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 the fifth section. That is to say, in this simulation the authors simply increase the efficiency of labour, whereas in the results reported in Table 2 the efficiency of both labour and capital was increased equally.

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, Lisenkova, Lecca, McGregor, & Swales, 2014). 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 the fifth section, 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 the fifth section 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. Therefore, output and substitution effects stimulate 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

Table 3. Simulation results.

	Base scenario	Conservative scenario
	Long-run percentage change	
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[a]	–0.9	–0.3
Nominal wage	–3.9	–1.5
Real wage	1.9	0.6
Consumer price index (CPI)	–5.6	–2.1
Replacement cost of capital	–5.0	–1.9
Export rest of the UK (RUK)	9.9	3.5
Export rest of the world (ROW)	9.0	3.2
Capital stock	10.5	3.7

Note: [a]Percentage point change.

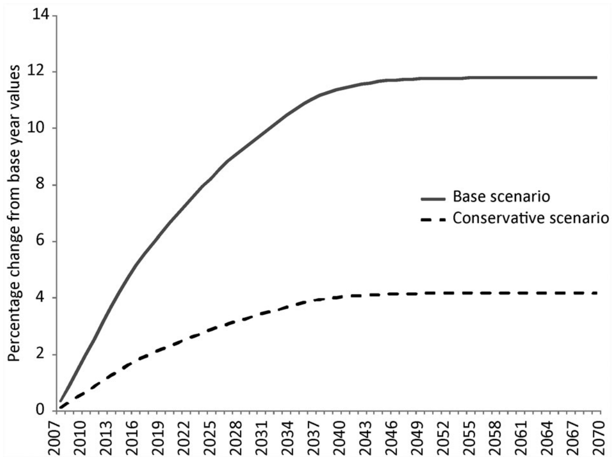

Figure 1. Adjustment path of gross domestic product (GDP) in response to a labour productivity increase.

increases by 10.5% or 3.7%. However, whilst all 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 the fifth section, 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.

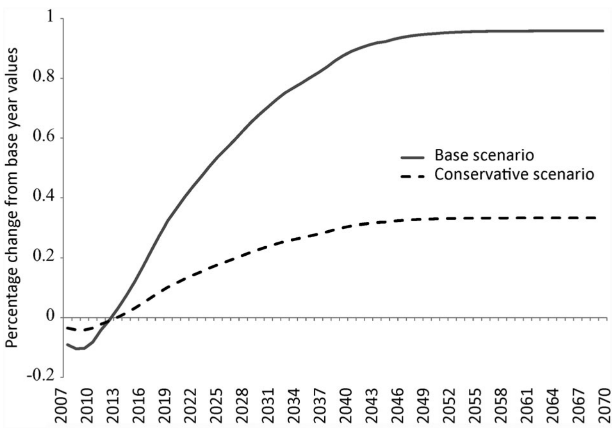

Figure 2. Adjustment path of employment in response to a labour productivity increase.

Table 4. Long-run effects, percentage change.

	$\rho = 0.2$	$\rho = 2$	$\rho = 4$
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

Note: GDP, gross domestic product.

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.[13]

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 characterizes much of the literature in the UK, in which macroeconomic returns to education are used to identify externalities when compared with 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 generate a wide range of possible values, the aggregate GDP effects are always positive. In the context of recent policy debates about tuition fees, focusing only on private benefits clearly risks underinvesting in HE. 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 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 studies of external returns to HE are themselves exploratory. The breadth and depth of studies that estimate the private market returns to HE is not matched 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 does offer 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, ch. 4) calculates private non-market returns to be equivalent to 122% of the private market returns. Hermannsson et al (2014) 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 which might be more reasonable for some of the non-market benefits (e.g., health effects) than for others. Nevertheless this suggests that these non-market returns merit further rigorous investigation.

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. 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. Within this 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.

Third, the analysis can be applied to other regions and nations. There is clearly 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. For example, such a framework would be required to assess the impact on Scotland of changes in the graduate intensities of the workforce in the RUK.

Finally, the complexity of spillovers in the context of a system of multilevel 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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SUPPLEMENTAL DATA

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NOTES

1. This also raises concerns about a possible 'funding gap' of HE in Scotland as compared with England (Expert Group Report, 2011).
2. For example, some researchers incorporate control variables, such as occupation, that effectively absorb part of the contribution that might be appropriately attributed to HE.
3. Harris et al. (2011) focus on aggregate effects and do not adopt a spatial econometrics approach.
4. AMOS = A Macro-Micro Model of Scotland.
5. For the IO database, see http://www.gov.scot/Topics/Statistics/Browse/Economy/Input-Output/Downloads/.

6. The impact is slightly reduced 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, but HEIs also exert an indirect impact through innovation, captured here by the coefficient on the innovation dummy (Arvanitis, Sydow, & Woerter, 2008). In the present context, it is more appropriate not to 'corrected' for innovation, otherwise one of the mechanisms through which HEIs exert their influence is effectively being 'controlled away'.
7. The locations of the linked HEIs are not identified. Part of the productivity increase might therefore 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% so 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 implementation of the Scotland Act 2012 (HM Government, 2012) and the recommendations of the Smith Commission (2014) will change the fiscal relationship between Scotland and the RUK. In future, the Scottish government will retain a bigger share of locally generated 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 by Lisenkova et al. (2010).
12. This reflects the assumption that the proportion of graduates is unchanged in the RUK and the 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. The significance of trade elasticities for CGE analysis of productivity changes is widely recognized (Giesecke & Madden, 2013, p. 457).

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