The Regional Economic Impact of More Graduates in the Labour Market:

A "Micro-to-Macro" Analysis for Scotland

Abstract

This paper explores the system-wide impact of graduates on the regional economy. Graduates enjoy a significant wage premium, often interpreted as reflecting their greater productivity relative to non-graduates. If this is so there is a clear and direct supply-side impact of HEI activities on regional economies. We use an HEI-disaggregated computable general equilibrium model of Scotland to estimate the impact of the growing proportion of graduates in the Scottish labour force that is implied by the current participation rate and demographic change, taking the graduate wage premium in Scotland as an indicator of productivity enhancement. While the detailed results vary with alternative assumptions about the extent to which wage premia reflect productivity, they do suggest that the long-term supply-side impacts of HEIs provide a significant boost to regional GDP. Furthermore, the results suggest that the supply-side impacts of HEIs are likely to be more important than the expenditure impacts that are the focus of most HEI impact studies.

Keywords: Supply-side impact; higher education institutions; computable general equilibrium model

1. Introduction and background

Higher Education Institutions (HEIs) stimulate their host economies through a range of channels (Goldstein, 2009; Hermannsson and Swales, 2010; McMahon, 2009). A large literature documents the local demand stimulus provided by HEIs through their expenditures (see Florax, 1992 and McGregor *et al*, 2006 for an overview), with a number of these studies having a Scottish focus (Battu *et al*, 1998; Blake and McDowell, 1967; Brownrigg, 1973; Kelly *et al*, 2004; Hermannsson *et al*, 2010a, b; Love and McNicoll 1990). Moreover, HEIs stimulate the supply side of their host regional economies through activities, such as knowledge exchange (Acs, 2009; Anselin *et al*, 1997; Fischer and Varga, 2002; Parker and Zilberman, 1993; Varga and Schalk, 2004) and innovation (Andersson et al, 2009; Anselin et al, 2000; Faggian and McCann, 2006; Jaffe, 1989; Lundvall, 2008). A persuasive case has also been made that a more educated population results in long term external benefits, such as improved public health and lower crime rates (Machin *et al*, 2011; McMahon, 2004, 2009).

In this paper we focus on a surprisingly neglected issue: how HEIs stimulate their host regional economy through increasing the skills of the workforce. A crucial element of HEI activity is the additional human capital embodied in their graduates. A wealth of evidence suggests graduates outperform non-graduates in the labour market, as reflected in wage levels and employment probabilities (Blundell et al, 2005; Checchi, 2006, Harmon and Walker, 2003; Psacharopoulos and Patrinos 2004, Walker and Zhu 2007). However, despite its salience and potential importance, this transmission channel does not feature widely in studies that seek to assess the overall regional economic impact of HEIs. There have been important contributions to filling this gap in the past, most notably in the use of econometric techniques (Bradley and Taylor 1996) and human-capital augmented growth accounting (Badinger and Tondl, 2003).[1] However, we propose an alternative "micro-to-macro" approach that exploits the micro-econometric evidence on the impact of HEIs on labour productivity to simulate the overall impact of graduates using an HEI-disaggregated Computable General Equilibrium (CGE) model. This has a number advantages over existing approaches: the ability to handle a wide range of demand- and supply side effects in a single framework; the potential to exploit relatively detailed micro-econometric findings; and the identification of an explicit transmission mechanism within a structural model of HEI impacts.

In Section 2, we review the evidence on the graduate wage premium and its usefulness as a measure of productivity differences between graduates and non-graduates, and describe our methodology for projecting the future productivity-adjusted Scottish Labour force. In Section 3 we outline our simulation strategy and the structure of the HEI-disaggregated CGE model of Scotland that we employ. In Section 4 we report the results of our simulations which illustrate the likely orders of magnitude of the impact of graduates on the Scottish economy if current higher education policy is maintained. We verify the robustness of our approach through a sensitivity analysis. In Section 5 we conclude, discuss the implications of our analysis and identify possible extensions.

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[1] For a recent overview of the role of human capital in regional development see Faggian and McCann (2009).

2. A "micro-to-macro" approach

In this section we begin by explaining and motivating our proposed "micro-*to*-macro" approach. Then we review the micro-econometric literature on the private market returns to higher education and discuss the relevant evidence on signalling. We go on to discuss our method of projecting the future skill composition of the Scottish labour force. Finally, we apply the implied graduate productivity differential to our labour force projections to yield the overall stimulus to labour efficiency.

2.1 The motivation for our approach

We propose to explore the system-wide or macroeconomic impacts of HEIs by adopting a "micro-to-macro" approach. This approach uses micro-econometric evidence to identify the nature of the shocks that HEIs transmit to their host regional economies. The system-wide impacts of these shocks are then simulated through a regional CGE model. In terms of previous literature our analysis is closest to Giesecke's and Madden's (2006) study of the economic impact of the University of Tasmania. We consider Scottish HEIs as a whole, and focus on the economic effect on the Scottish economy of the projected increases in the proportion of graduates in the labour force. The idea is to exploit the often sophisticated and extensive micro-econometric evidence on the effects of HEIs to infer their likely macroeconomic impacts.

Our micro-*to*-macro approach has a number of strengths. Firstly, we can, in principle, isolate the system-wide ramifications of any particular demand or supply-side impact associated with HEI activity. At present our concern is with the system-wide impact of the productivity stimulus associated with graduates, but other impacts can also be accommodated provided relevant empirical evidence exists. Secondly, in a broader context, the micro-to-macro approach can be used to measure the system-wide impacts of the *social* and the *non-market private* benefits of higher education, such as those that arise through enhanced health (but are not reflected in earnings). McMahon (2009, ch. 4) reviews this literature and suggests that these wider impacts of HEIs may be substantial. Thirdly, the transmission mechanism from any particular supply-side or demand-side stimulus to the wider economy generated by HEIs can, in principle, be captured by the model, at least in broad-brush terms, and the causal sequence is clear in any subsequent simulation of impacts. Fourthly, the modelling framework can readily be implemented for regions provided an appropriate input-output table exists. Overall, we believe that the micro-to-macro approach provides a useful additional means of exploring both demand and supply-side regional impacts of HEIs in a system-wide context.

2.2. Graduate wage premium and productivity differentials

In the absence of direct measures, it is common to assume that labour productivity is closely correlated with observed wage rates. We follow this approach and assume that the graduate wage premium reflects the higher productivity of graduates. [2] For our purposes, however, it is important to understand how much of this wage differential can be attributed to the impact of higher education. Whilst the correlation between earnings and education is a well-established

[2] The graduate wage premium is the wage of a graduate relative to the wage of a similar individual with a lower qualification level. In our calculations we compare graduates to all non-graduates. However, it is also common to calculate a "college" wage premium where those who have obtained university-entry qualifications, i.e. A-levels in England/Wales or Highers in Scotland, are used as a benchmark (e.g., Blundell *et al*, 2005; Walker and Zhu, 2007). Our approach would typically indicate a higher graduate wage premium.

fact, the presence of correlation is not sufficient to establish causality. There are two main strands of literature on this subject.

The human capital school has its origins in the works of Mincer (1958), Schultz (1960) and Becker (1964, 1975). This tradition maintains that education is an investment in human capital, which in turn increases the productivity of workers. An alternative perspective is that of the signalling school. This stems from the works of Spence (1973) and Stiglitz (1975). In the most extreme version of this theory, education has no impact on hum productivity, but simply reveals (signals) innate ability to employers.[3]

The main difficulty in differentiating between the signalling and human capital views through empirical testing is that they predict observationally equivalent equilibrium outcomes (Lange and Topel, 2006). Over the past four decades researchers have used a number of empirical strategies to distinguish between these two effects, such as exploiting natural experiments and using samples of twins to control for fixed effects (Brown and Sessions, 2004). Most studies find that the effect of signalling on the wage premium is modest. For our baseline scenario we draw on Lange and Topel (2006), who estimated, using a model of employer learning, that signalling explains 10% of the graduate wage premium.

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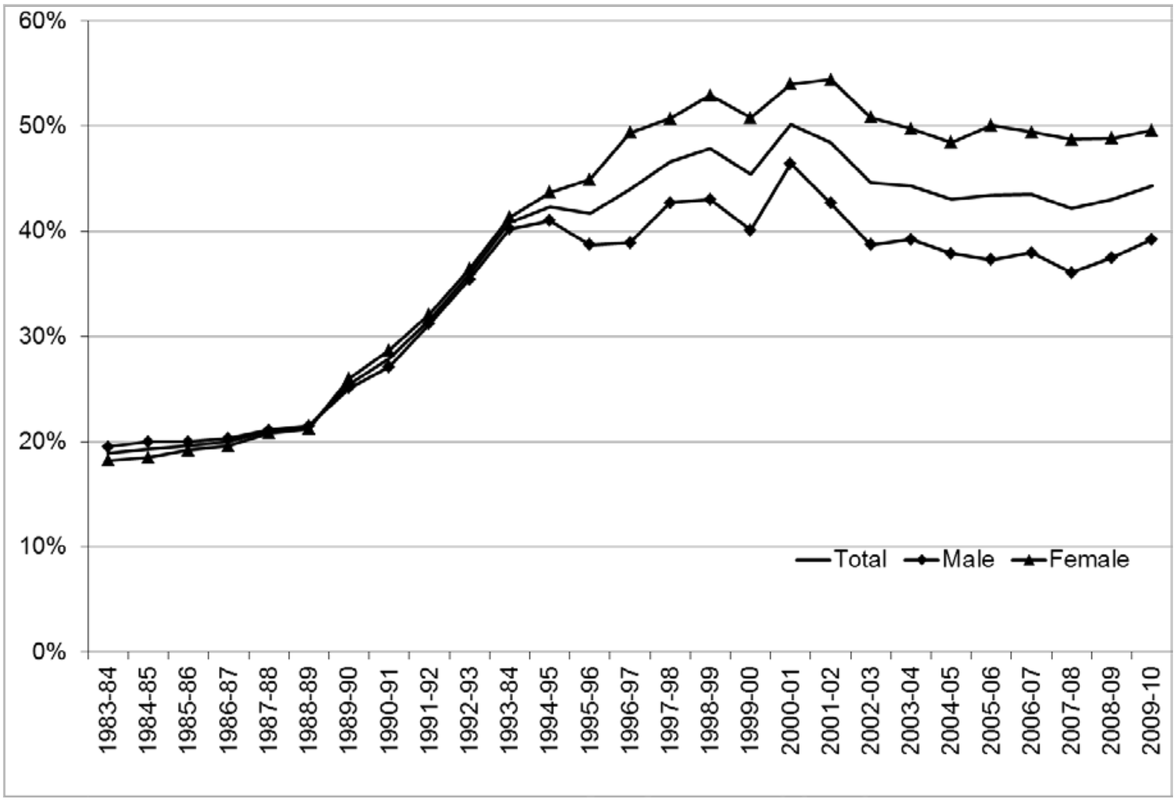
[3] A third alternative is the assignment approach, which explains the distribution of earnings as result of an optimising process, whereby workers are assigned to jobs in the labour market. For an overview, see Sattinger, (1993). This work has its origin in Tinbergen (1951, 1956) and Roy (1951). These papers offer a general equilibrium framework, where demand factors play a role in determining the distribution of wages. A fourth view is that of Thurow (1975), where labour market rigidities create job queues and where education again acts only as a signal of a worker’s trainability. These models suggest that longer job queues disproportionately impact on less skilled workers, such as during a cyclical downturn, as is demonstrated by Ours & Ridder (1995).

Figure 1. Higher Education Cohort-Age Participation Index, Scotland, 1983/84-2009/10.



Source: Scottish Government

One of the most striking features of the labour market over the last few decades is the apparent insensitivity of the graduate wage premium to the scale of the increase in the HEI participation rate. Figure 1 shows the recent significant increase in higher education participation rates for Scotland, though this phenomenon applies also to the rest of the UK.[4]

[4] The participation rate for any cohort year is calculated as the number of new young (under 21) Scottish entrants to HEIs divided by the number of 17 year-olds in Scotland. For more details see http://www.scotland.gov.uk/

The participation rate for men has increased from 19.5% for the 1984 cohort to 41.2% for the 2007 cohort. For women the change is even more marked, from 18.2% for 1984 to 52.9% for the 2007 cohort.

Other things being equal, we might expect such a major increase in the supply of graduates to result in a fall in their "price", but the graduate wage premium has exhibited remarkable stability over the period. The longest wage premium series available for Scotland can be found in Walker and Zhu (2007). They report graduate wage premia separately for men and women and for different cohorts for 3-year groups starting from 1996 until 2005. They define the graduate wage premium as the wage of graduates relative to those holding university-entry qualifications. The aggregate graduate wage premium for the period 1996-2005 is mostly constant – it increased slightly for men from 28% to 35% and decreased slightly for women from 45% to 41%. Similar results are found by Gasteen and Houston (2007), who pool 4 years of data from the Labour Force Survey (1999-2003) to examine the return to qualifications in Scotland.

Similar evidence is available for Great Britain as a whole suggesting remarkably stable graduate wage premia (Blundell *et al* 2005; O'Leary and Sloane, 2005; Walker and Zhu, 2008). Furthermore, such evidence is not restricted to the UK (Machin and McNally, 2007). However, there is, of course, no "law" in operation here. Goldin's and Katz's (2007) analysis of a century-long history of returns to education in the US shows that the college wage premium has fluctuated between 30% and 60%, influenced by demand for and supply of graduates. A potential explanation for the recent stability of the graduate wage premium is that accompanying the increase in supply of graduates, there has been a parallel increase in demand for graduate labour. This shift in demand is attributed to skill-biased technical change, i.e. that the application of new technologies in the workplace has required the employment of skilled operators, thereby favouring graduates in the labour market (Acemoglu 2002, Machin 2004).

Further econometric evidence could be important for directing HEI policy. From cross-sectional evidence, we know that there is significant variation within the average labour market outcomes. One indicator of this is the rate at which graduates obtain jobs appropriate to their skill level. A share of graduates ends up in work where their qualifications are not necessarily required and as a result suffer a reduced wage premium. That is to say, they earn less than those suitably matched with occupation but are typically better off than non-graduates (Battu and Sloane, 2004; Chevalier, 2003; McGuinness, 2006). There is also some evidence to suggest that wage premia vary by subject (Blundell and Deardren, 2000; O'Leary and Sloane 2005) and is influenced by proxies for HEI quality (Black and Smith, 2004; Dale and Krueger, 2004).

One issue is whether the quality of graduates has deteriorated with increased participation. This depends on what is the main reason for non-participation – low returns to education, caused by low ability, or high cost and supply constraints. If the first reason predominates, the relative “quality” of graduates will decrease as participation increases. However, if the latter reason dominates, the relative “quality” of graduates can actually increase as participation widens. Both theoretical and empirical studies show that this mechanism can operate either way (Card, 2001; D'Amato and Mookherjee, 2008; Freeman, 1996; Galor and Zeira, 1993; Mookherjee and Ray, 2003). However, it should be stressed that in our scenarios we are not projecting increases in the participation rate of future cohorts. Rather we model an accumulation of graduates in the labour market driven by past changes in participation[5].

We use the evidence of the recent comparative constancy of the UK graduate wage premium (during and after the rise in participation) to adopt an important simplifying assumption: we treat human capital as homogenous, in an approach similar to that of Acemoglu and Autor (2012). This implies that the difference between graduates and non-graduates is simply the average quantity of human capital that these two groups possess. This approach allows us to treat the labour market as unified, and so to avoid a number of complexities. Essentially graduates and non-graduates are treated like perfect substitutes; "as if" it simply takes more non-graduates to perform the same task as graduates.

In this paper we define the wage premium as the percentage difference in the average wages of a graduate, relative to that of a comparable non-graduate. To accommodate the varied findings relating to the graduate wage premium, we take the 30% to 60% range for the wage premium identified by Goldin and Katz (2007), and adopt the range of 0% to 30% for a signalling effect. This combination encompasses the range of recent estimates of graduate

[5] Walker & Zhu (2008) argue that increasing participation has potentially led to a decrease in the average quality of graduates, but that the average graduate wage premium has been supported by increased demand. However, this means that the variability in graduate outcomes has increased.

wage premia for Scotland and the UK. We have settled on a constant mean wage premium of 45% as our standard case, though there clearly is uncertainty about the maintenance of the wage premium in the future, especially as the proportion of graduates in the labour force rises. The sensitivity analysis gives an indication of how the order of magnitude of the results would be affected by choosing different estimates of the wage premium.

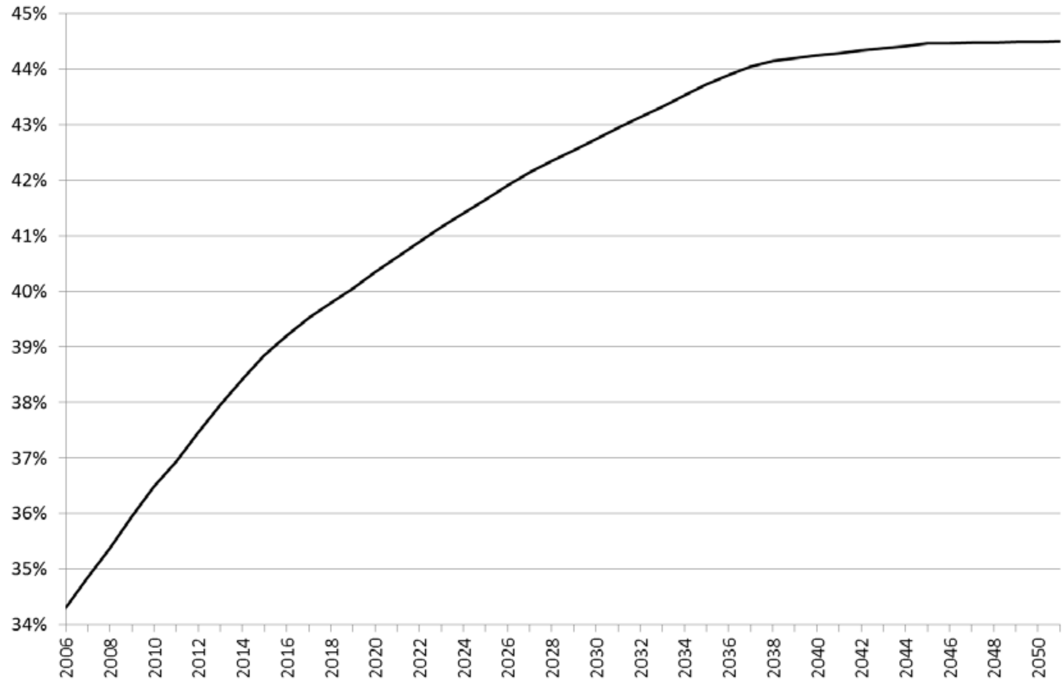
2.3 Future labour force

The baseline scenario for the future skill composition of the Scottish labour force is derived by extrapolating 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%. For new cohorts entering the labour force in the future, it is assumed that all of them achieve the 46% share of graduates by the age of 25. For those aged 20-24 it is assumed that they will 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 46% share of graduates. By 2045 all age groups over 25 will have 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.

Figure 2 plots the projected future share of graduates in the Scottish labour force. By 2051 the share of graduates in the labour force will stabilize at 44.5% (starting from just above

34% at the beginning of the period). 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 comprise 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.

Figure 2. Projected share of graduates in the Scottish labour force.



Of course, the participation rate at HEIs might change in the future, partly as a result of Government policy. At present, Scottish students do not pay fees: in the future that might change and result in a lower participation and subsequently a lower skilled Scottish workforce. On the other hand, plans to increase the pension age, together with legislation that encourages working after that age, will increase the returns to human capital and therefore might increase the HEI participation rate.[6] Responding to this uncertainty we conduct a sensitivity analysis in Section 4.2 exploring the impact of alternative participation rates.

3. Simulation strategy and the HEI-disaggregated model of the Scottish economy.

In this Section we first discuss our simulation strategy and then outline our HEI-disaggregated CGE model of Scotland. This model is then employed, in Section 5, to simulate the system-wide impacts of a growing proportion of graduates in the Scottish labour force.

3.1 Simulation strategy

The projection of the proportion of graduates in the labour force is combined with our assumptions about the future graduate wage premium and the strength of the signalling effect to calculate a series of productivity-adjusted labour force estimates. The total productivity-adjusted labour force is calculated as the sum of non-graduates and graduates weighted by their productivity difference (measured by the graduate wage premium reduced by the effect of signalling). The productivity-adjusted labour force can be represented as:

non-graduates + graduates x {1+[graduate wage premium x (1-signalling effect)]}

This means , for example, that a 30% wage premium in the presence of a 10% signalling effect implies graduates are 27% more productive. We assume that although the size of any

[6] We are indebted to an anonymous referee for this suggestion.

cohort will fall as it ages, the proportion of that cohort that are in the labour force and the proportion that are graduates does not change.[7]

The size of the labour productivity shock for each year of the simulation is calculated as the proportionate change in the productivity-adjusted labour force since 2006 divided by the proportionate change in the size of the working-age population during the same period. The productivity-adjusted labour force varies as the size and/or the skill composition of the labour force change. Because we are primarily interested in the effect of the latter, we hold the former, the total labour force, constant.[8] This allows us to focus exclusively on the effect of the changing skill composition on the productivity of the labour force.

The purpose of the simulations is to identify the likely system-wide consequences of the productivity improvement implied by our projections of the increasing share of graduates in the labour force. The stimulus is introduced as an increase in the labour productivity across all 25 sectors of the model; it takes the form of labour-augmenting, or Harrod-neutral, technical progress. In a partial equilibrium context, the determinants of the employment impact of such a change have been understood since Hicks' (1932) identification of the laws of derived demand. The present general equilibrium context complicates matters in that the

[7] This will tend to underestimate the impact of human capital because graduates are more likely than non-graduates to remain in the labour force as they age.

[8] Formally the proportionate change in labour productivity is given as $\left[\left(\frac{p_t}{p_{2006}}/\frac{n_t}{n_{2006}}\right)-1\right]$ where p_t and n_t and the productivity adjusted labour force and the working age population for year t.

key wage-elasticity of demand for labour reflects a responsiveness to all of the effects of wage changes, including income and compositional effects.

In all of the simulations presented below there is no net migration. This means that there is no inflow or outflow of labour to Scotland generated by the change in the returns on labour. Because our goal is to isolate the impact of the increased productivity of the labour force due to the rise in the graduate share, we preclude endogenous population adjustment.

3.2 The HEI-disaggregated CGE Modelling Framework

To simulate the system-wide impact of increases in the share of graduates in the Scottish labour market we employ a computable general equilibrium (CGE) model, AMOS, which is explicitly disaggregated to accommodate a separate HEI sector. AMOS is a CGE modelling framework parameterised on data from Scotland.[9] Essentially, it is a fully specified, empirical implementation of a regional, inter-temporal, general equilibrium variant of the Layard, Nickell and Jackman (1991, 2005) model. It has three domestic transactor groups, namely the household sector, corporations and government; and four major components of final demand: consumption, investment, government expenditure and exports. The model has 25 sectors, of which the Scottish HEI sector is one.

In this version of the model, consumption and investment decisions reflect inter-temporal optimization with perfect foresight (Lecca *et al*, 2010, 2011). However, for comparative

[9] AMOS is an acronym for *A M*acro-micro Model *O*f *S*cotland.

purposes we also report the results of the myopic version of the model, which has a recursive dynamic structure, since this yields some interesting differences in terms of the short-run employment responses to productivity enhancements. Real government expenditure is exogenous. The demand for Scottish exports to the rest of the UK (RUK) and the rest of the World (ROW) is determined via conventional export demand functions where the price elasticity of demand is set at 2.0. Imports are obtained through an Armington link (Armington, 1969) and therefore relative-price sensitive with trade substitution elasticities of 2.0 (Gibson, 1990). We do not explicitly model financial flows, our assumption being that Scotland is a price-taker in financial markets.

It is assumed that production takes place in perfectly competitive industries using multi-level production functions. This means that in every time period all commodity markets are in equilibrium, with price equal to the marginal cost of production. Value-added is produced using capital and labour via standard production function formulations so that, in general, factor substitution occurs in response to changes in relative factor-prices. Constant elasticity of substitution (CES) technology is adopted here with elasticities of substitution of 0.3 (Harris, 1989). In each industry intermediate purchases are modelled as the demand for a composite commodity with fixed (Leontief) coefficients. These are substitutable for imported commodities via an Armington link, which is sensitive to relative prices. The composite input then combines with value-added (capital and labour) in the production of each sector's gross output. Cost minimisation drives the industry cost functions and the factor demand functions.

In the simulations reported in this paper, the labour market is characterised by a regional bargaining function, in which the real wage is inversely related to the unemployment rate.

The bargaining function is parameterised using the regional econometric results reported in Layard, Nickell and Jackman (1991, 2005). Detailed discussion of the model and underlying algebraic structure are available in Harrigan *et al* (1991) for the myopic variant and in Lecca *et al* (2010, 2011) for the inter-temporal version of AMOS. The model is calibrated to a purpose-built, HEI-disaggregated IO table and Social Accounting Matrix (SAM) for 2006. The process of constructing the HEI-disaggregated IO table is described in Hermannsson *et al* (2010c).

It is important to recognise that in the simulations reported below, the only exogenous change that is introduced into the model is the increased labour productivity due to the growing share of graduates in the labour force. The results should therefore be interpreted as deviations from what would have occurred if labour productivity had remained unchanged. For simplicity, we make the standard assumption in the CGE literature that the simulations start in steady state equilibrium.

4. Results

4.1 Standard case

The standard case assumes a gradual rise in the proportion of graduates in the labour force to 44.5% and an accompanying long-run stimulus to labour productivity of 3.6%. Of course, the economic effects build up through time, reflecting the gradual increase in the proportion of graduates in the labour force, as depicted in Figure 2. When we simulate the impact of this using our HEI-disaggregated CGE model of the Scottish economy, we obtain the long-run results reported in Table 1. In the present context the long-run refers to a position where all capital stocks have fully adjusted, and all current cohorts have been replaced, so that the proportion of graduates in the Scottish labour force stabilises at 44.5%.

As we would expect for a large beneficial supply-side disturbance of this type there is a substantial stimulus to gross regional product (GRP) of 3.7%, and a downward pressure on prices. A key transmission mechanism is from improved regional competitiveness, through a stimulus to trade, with exports to RUK and ROW increasing by 3.1% and 2.8%. Importantly, we are assuming no changes in the economy of the rest-of-the UK.

Table 1. Long-run impacts of a 3.6% increase in labour productivity (% changes from base).

Gross Regional Product	3.7
Consumption	0.9
Investment	3.3
Employment	0.3
Unemployment rate	-4.6
Nominal wage	-1.3
Real wage	0.5
Consumer Price Index	-1.8
Exports to RUK	3.1
Exports to ROW	2.8
Capital Stock	3.3

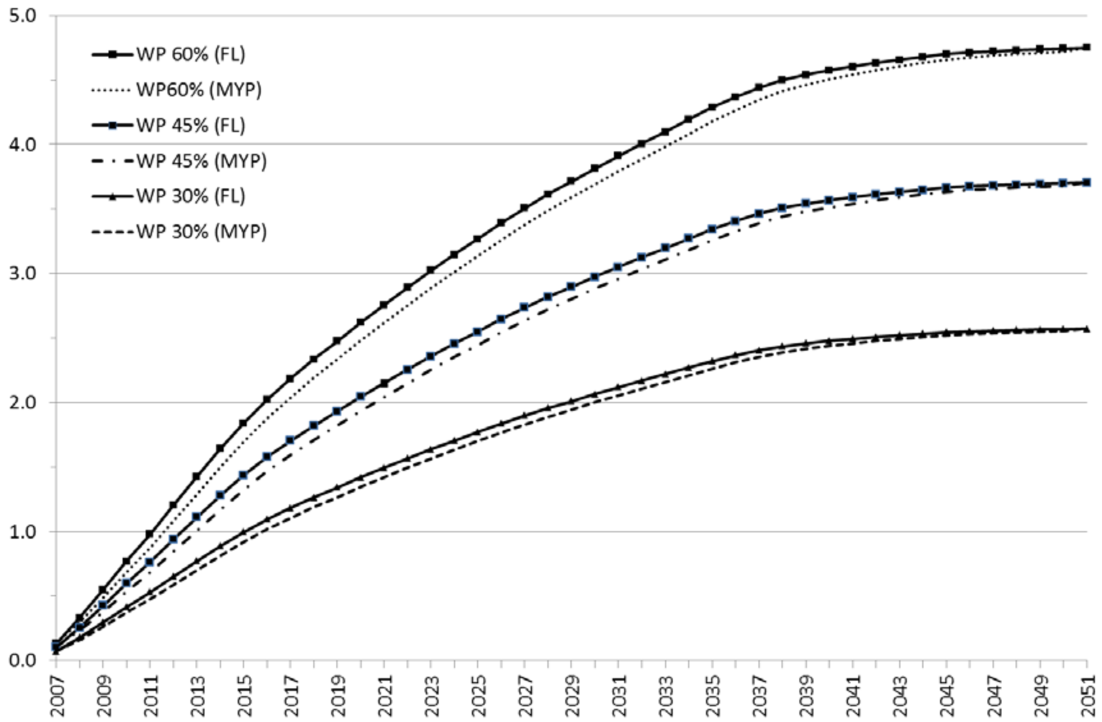
Notice that in this simulation employment increases in the long run: over this time interval, the stimulus to output from improved competitiveness and real income effects dominate the fact that any given level of output can now be produced with a smaller labour input. As argued earlier, the fall in the price of an efficiency unit of labour stimulates the demand for labour, measured in the same units. But, in general, employment measured in natural units can fall and, as illustrated in Figure 4, it does so in the initial periods of all the simulations reported here in which transactors are myopic.

In the long run, the proportionate increase in employment measured in efficiency units (which exceeds the change in actual employment by the size of the labour productivity shock) is greater than the proportionate change in value-added, which in turn is greater than the proportionate change in the capital stock. The increase in GRP exceeds the labour productivity increase because both employment and capital stock are endogenously increasing. Also whilst the ratio of efficiency units of labour to capital increases, the proportionate change in employment is less than that in capital, so that the capital/labour ratio rises.

The increase in the demand for labour pushes up the real wage. However, the overall domestic prices level falls in the long run because of the increased labour efficiency, and the nominal wage and capital rental rates decline too. While the real wage rises, it does so by less (0.5%) than the stimulus to productivity (3.6%), so that the wage in efficiency units falls, and the unskilled wage is squeezed as a consequence.

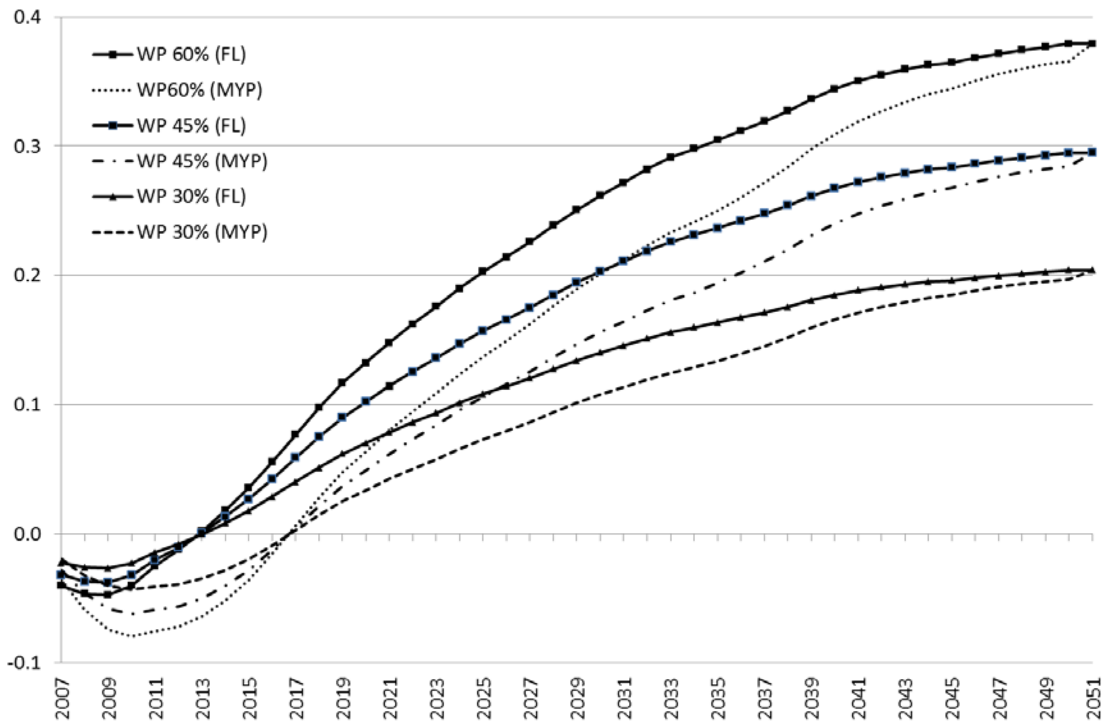
Notice that the competitiveness effect is conditional on our assumption that labour efficiency is improving in Scotland relative to the rest of the UK and the rest of the World. If other regions are experiencing similar increases in productivity the competitiveness advantages would of course be muted, but offsetting, at least partly, what would otherwise be a decline in Scottish competitiveness.

Figure 3. The impact of the increasing graduate composition of the labour force on Scottish GRP (% change from base year values). WP indicates the wage premium. FL and MYP indicate forward looking and myopic agents, respectively.



It is instructive to examine the time path of the simulated response of the Scottish economy to the projected increase in the proportion of graduates in the labour force. Figure 3 plots the GRP response to this increase. The middle two lines of the graph relate to the standard case where the increase in overall labour productivity is 3.6%. As we have seen in Table 1, GRP ultimately rises in this case by 3.7%. In both the myopic and forward-looking cases, GRP approaches its long-run equilibrium level gradually, reflecting the projected build-up in the proportion of graduates in the labour force. Adjustment is more rapid when assuming forward looking behaviour of agents than in the myopic case as consumers and investors correctly anticipate the expansion and bring forward expenditures. The long-run equilibrium impact is, however, identical in each case (Lecca *et al*, 2011). The other cases depicted in Figure 3 differ from the standard case only in respect of the wage premia and hence the scale of the impact.

Figure 4. The impact of the increasing graduate composition of the labour force on Scottish employment (% change from base year values). WP indicates the wage premium. FL and MYP indicate forward looking and myopic agents, respectively.



The corresponding adjustment paths for employment are shown in Figure 4. The standard case is represented by the two lines that meet in the middle of the right-hand-side of Figure 4, at a 0.29% increase in the long-run equilibrium employment level. In the myopic case, employment is below its base year (2006) value for ten years. This result reflects the various factors that make the general equilibrium labour demand curve inelastic in the short run. In the myopic case, investment responds partially to rental rate changes and very gradually impacts on the capital stock, and consumption is income-constrained. In the forward-looking case investors anticipate yet higher profitability in the future and consumers anticipate higher wealth, leading both to bring spending forward relative to the outcome under myopia. In effect, the short-run general equilibrium elasticity of employment demand with respect to the real wage is raised by the presence of forward-looking transactors. In practice, neither the purely myopic, nor the perfect foresight case is likely to be realistic, but the two paths give an indication of the likely range of possible outcomes.

4.2 Sensitivity analysis

While we motivated our standard case scenario on what we believe are the most plausible assumptions given the available micro-econometric evidence, clearly there is considerable uncertainty concerning our assumptions about various issues. In this section we provide a brief summary of the impact of varying some of these key assumptions.

First, we explore the impact of alternative assumptions about the strength of the signalling effect and its interaction with different assumptions about the graduate wage premium. Table 2 shows the long-run increase in Scottish GRP attributable to the changing skill composition of the labour force under different combinations of wage premia and signalling. We consider the impact of three different signalling effects: 0%, 10% and 30%, and as before three potential levels of the long-run graduate wage premium: 30%, 45% and 60%. The long-run change to GRP varies between 2.04% (30% wage premium and 30% signalling effect) and 5.19% (for a 60% premium with no signalling effect).

Table 2. The long-run increase in Scottish GRP in response to the productivity stimulus.

Graduate wage premium	Signalling		
	0%	10%	30%
30%	2.83%	2.57%	2.04%
45%	4.06%	3.70%	2.96%
60%	5.19%	4.75%	3.82%

The adjustment paths for GRP for the three scenarios with a 10% signalling effect can be seen in Figure 3, and the corresponding paths for employment are plotted in Figure 4. The adjustment paths are similar in all cases although, of course, the long-run equilibrium impacts differ as we would expect given the different scales of the productivity stimulus.

Table 3. The long-run Scottish GRP increase for alternative retention rate assumptions.

Graduate wage premia	Retention rates			
	UK net retention rate		Scottish local retention rate	
	Productivity increase	GRP increase	Productivity Increase	GRP increase
30%	2.52%	2.57%	1.91%	1.95%
45%	3.62%	3.70%	2.75%	2.81%
60%	4.64%	4.75%	3.52%	3.60%

Second, we vary our assumptions about graduate retention rates. The actual value of the retention rate is likely to be sensitive to policy variables. For example, it has been argued that if Scotland adopted a student loan scheme similar to the UK's, the retention rate would fall as students emigrate to defer paying back the loan. On the other hand, the Scottish Government has introduced direct policy interventions, through the Fresh Talent initiative, to retain foreign students with the offer of a work permit if they stay. The base line scenario is constructed around the share of graduates as revealed in the Annual Population survey. Implicit in the survey data is a UK net retention rate that, in addition to Scottish graduates, includes the net flow of graduates from other UK regions. This essentially means that our simulations are providing a measure of the impact of UK HEIs on the Scottish economy. In this sensitivity scenario we explore the impact of HEIs using the Scottish gross retention rate. This rate only takes into account the retention of graduates from the Scottish HEIs that were working in Scotland 6 months after graduation. So it excludes the net inflow of graduates from RUK that is included in the simulations reported in previous section. We calculate estimates for these different definitions of the retention rate and use these to scale the share of graduates in the new cohorts, $\%G_{25}^{\partial R}$, using the following formula:

$$\%G_{25}^{\partial R} = \%G_{25}^{BC} \frac{R_{Sco}}{R_{UK}}$$

where $\%G_{25}^{BC}$ is the share of graduate at age 25 in the standard case, R_{Sco} is the alternative retention rate and $R_{UK}$is the retention rate used for the standard case.

Focussing on the Scottish gross retention rate implies a lower stimulus to productivity which is reduced by between 0.61 and 1.12 percentage points. As indicated in Table 3, this generates a stimulus to GRP which is lower than the standard scenarios reported in Section 4.1 by between 0.62 and 1.15 percentage points. The differences in these GRP estimates provide a measure of the contribution of HEIs in the rest of the UK to the Scottish economy.

Table 4. The impact of alternative participation rate assumptions.

Graduate wage premia	Participation rate			
	Current 46%		50%	
	Productivity Shock	GRP increase	Productivity Shock	GRP increase
30%	2.52%	2.57%	2.92%	2.98%
45%	3.62%	3.70%	4.20%	4.29%
60%	4.64%	4.75%	5.38%	5.51%

Third, we analyse the consequences of different participation rates in higher education. Again as we have argued in Section 2.3, the participation rate is subject to policy influences, particularly concerning the payment of fees. The central assumption of the standard simulations is that all future cohorts will reach the same share of graduates as the highest age-specific share attained in recent years. As one alternative to this scenario we calculate the effect of increase in the maximum age-specific graduate share from the current 46% to 50%. This level is chosen because it has recently been a Scottish Government target for HEI participation. In this scenario participation increases by 1 percentage point a year starting from 2011 and reaches 50% by 2014. The incremental long-run stimulus to GRP (Table 4) varies from 0.40 (30% wage premium) to 0.76 percentage points (60% wage premium) compared to previous scenario.

These scenarios provide a wide range of results, reflecting a number of alternative "what if" simulations. However, the general message is unambiguous: there is a substantial GRP impact ranging from 1.95% at one end of the spectrum and up 5.51% at the other.

5. Conclusions

In this paper we seek to address a lacuna in the existing literature on the regional impacts of HEIs. This is the absence of any systematic attempt to assess the scale of the impact on regional economies that HEIs generate through the enhanced productivity of their graduates. Of course, this mechanism is widely recognised, and its potential importance often emphasised, but there have been no attempts to measure the scale of the impacts using a structural model that identifies explicit transmission mechanisms from HEI activity to macroeconomic outcome. Our "micro-to-macro" approach uses existing micro-econometric evidence on the scale of the graduate wage premium and the strength of any signalling effect to identify the differential productivity stimulus of graduates relative to non-graduates. We then project the share of graduates in the labour force, compute the implied productivity stimulus (given regional graduate retention rates) and simulate the system-wide impact of this using a purpose-built, HEI-disaggregated CGE model of Scotland.

Our results strongly suggest that HEIs exert a significant impact on regional economies through the additional human capital accumulated by their graduates. This generates significantly larger GDP impacts than the demand-driven expenditure effects of HEIs when considered on a comparable basis (Hermannsson *et al*, 2010a, b). In our work on the same data set we identify the full expenditure impact of Scottish HEIs and their students as 2.6% of GRP. In the present paper we calculate the supply-side effects of the increased proportion of graduates in the labour force resulting from maintaining that level of HEI expenditure. This increases Scottish GRP by 3.7%. But this is not measuring the supply-side impact of all graduates in the Scottish labour force but rather the impact of increasing the proportion from 34% to 44.5%.

The approach to modelling the regional impacts of HEIs here can be extended in a number of directions, for example: relaxing the assumed constancy of the wage premium and the graduate retention rate; extending the analysis to other regions and to the UK as a whole; accommodating interregional interactions in an explicitly multi-regional context; incorporating other supply-side transmission mechanisms, notably those coming through innovation and knowledge spillovers (e.g. Harris *et al*, 2010a, b), and through social returns and non-market private returns (McMahon, 2009); exploring the impact of the origin of graduates as well as their employment destination, and allowing for heterogeneity among graduates (and HEIs); disaggregation of labour market effects. The basic framework could also be extended to explore the different higher education funding regimes that are developing across regions of the UK as a consequence of devolved governments' quite different judgements about the importance of social, as compared to purely private, returns to HEIs.

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