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THE SYSTEM-WIDE IMPACTS OF THE EXTERNAL BENEFITS TO HIGHER EDUCATION ON THE SCOTTISH ECONOMY: AN EXPLORATORY "MICRO-TO-MACRO" APPROACH

BY

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Abstract

The private market benefits of education, i.e. the wage premia of graduates, are widely studied at the micro level, although the magnitude of their macroeconomic impact is disputed. However, there are additional benefits of education, which are less well understood but could potentially drive significant macroeconomic impacts. Following the taxonomy of McMahon (2009) we identify four different types of benefits of education. These are: private market benefits (wage premia); private non market benefits (own health, happiness, etc.); external market benefits (productivity spillovers; and external non-market benefits (crime rates, civic society, democratisation, etc.). Drawing on available microeconometric evidence we use a micro-to-macro simulation approach (Hermannsson *et al*, 2010) to estimate the macroeconomic impacts of external benefits of higher education. We explore four cases: technology spillovers from HEIs; productivity spillovers from more skilled workers in the labour market; reduction in property crime; and the potential overall impact of external and private non-market benefits. Our results suggest that the external economic benefits of higher education could potentially be very large. However, given the dearth of microeconomic evidence this result should be seen as tentative. Our aim is to illustrate the links from education to the wider economy in principle and encourage further research in the field.

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

JEL Codes: I23, E17, D58, R13.

The system-wide impacts of the external benefits to higher education on the Scottish economy:

An exploratory "micro-to-macro" approach.

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1. Introduction

We are on the cusp of a major "natural experiment" in the UK, where potentially radically different funding mechanisms for Higher Education look likely to be deployed across the regions of the UK. The proposals for England largely reflect the recommendations of the Browne (2010) report. It emphasises the private benefits that graduates receive and argues that it is therefore reasonable that individuals should be expected to pay for these benefits through higher fees. In the case of Arts and Social Sciences, at least, there is to be no continuing public subsidy (although the loans will be subsidised). From an economics perspective, such a proposal would only be socially efficient if the external benefits of higher education in these subject areas were precisely zero (at least in England), 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 either.[1] Again, from an economics perspective this would be the socially optimal solution only if the anticipated future public/private distribution of costs of HE exactly reflects the excess of external over private benefits of higher education. It would be purely fortuitous if either implicit judgement about the external benefits of HE was correct.

In this paper four different types of returns to (or benefits of) education are differentiated (see Table 1.1): private market returns, private non-market returns, external market returns and external non-market returns to education. Private market returns to education are the labour market benefits enjoyed by individuals who possess a higher level of education. They manifest themselves in higher earnings and lower unemployment rates. Private non-market returns to education are the benefits enjoyed by people with a higher level of education outside of the labour market. They include positive effects on health, longevity, happiness and many other benefits (for detailed discussion see McMahon, 2009, chapter 4). External returns to education (or externalities) refer to benefits enjoyed by the wider society if its members chose to acquire higher level of education. External market returns are expressed in terms of higher wages and higher profits and are reflected in GDP per capita, but they are not "internalised" by graduates or HEI institutions and are enjoyed by other agents in the

[1] Of course, this raises concerns about a possible "funding gap" of HE in Scotland as compared to England. Estimates of the scale of this gap are provided in the Expert Group Report (2011).

economy. Examples would include the higher productivity and wages of non-graduates generated by working with graduates and HEIs' contribution to R&D and innovation (of a public good nature). External non-market returns improve quality of life, but are not necessarily directly translatable into pecuniary benefits. Examples would include any HE-induced: reduction in crime levels; improvements in public health, democratisation and political stability.

Table 1.1 Classification of returns to education

	Who benefits	
Type of benefit	*Private market returns* Higher wages Higher employment Lower unemployment	*External market returns* Higher productivity of other workers (productivity spillovers) Higher TFP due to knowledge spillover
	Private non-market returns Better own health Longer life expectancy Improvement in happiness	*External non-market returns* Lower crime Democratisation Civic society

There exist numerous studies of the private market benefits of education in general and higher education in particular, which are reviewed, for example, by Blundell *et al* (1999) and Psacharaopoulos and Patrinos (2004). While the results of these studies do vary depending on data sets, chosen control variables and specific econometric methods, there is no doubt at all that higher education yields substantial private market benefits in the form of increased earnings over the lifetime of a graduate, often expressed in terms of a private rate of return to higher education. Among the most influential studies in a UK context are Blundell *et al* (2000, 2005) and in a US context Heckman *et al* (2000, 2008). Estimates of the UK wage premium often mention estimated rates of return of around 10%, but significantly higher returns have been reported (Psacharopoulos and Patrinos, 2004). Furthermore, there is evidence these returns have been increasing, not decreasing, in the face of the dramatic increase in the HE participation rates in the UK and elsewhere, suggesting that demand for graduates' skills is increasing at an even greater rate than the supply of them (e.g. Machin and McNally, 2007).

Unfortunately, however, there are few, if any, studies of the scale of external benefits of HE in the regions of the UK, or indeed to the UK as a whole (though see McMahon and Oketch, 2010). This is unfortunate, since for the appropriate formulation of policy, from the perspective of society as a whole, it is the total costs and benefits generated by HE that really matter. If total rates of return to higher education are higher than private rates this suggests underinvestment in higher education by society as a whole. The solution would be to induce greater investment in higher education, and *vice versa* if the opposite were to hold. Furthermore, it is widely recognised that private individuals' higher education investment decisions should, in principle, be based on their total returns from higher education, including any non-market returns. If the latter are positive, as seems clear from what we know of the links from education to health and longevity (e.g. Grossman, 2005), these returns (or rather those elements of them that do not overlap with market returns) should be added to the private market benefit. If private non-market returns are not taken into consideration, the suggestion is that there may be private underinvestment in higher education.

Few researchers in this area go beyond simply acknowledging the potential importance of non-market and external returns. This is understandable: it is extremely difficult to obtain accurate estimates of the earnings differentials attributable to higher education *per se* from thorough analysis of large microeconomic databases; but it is even more difficult to arrive at convincing estimates of the external returns to education. There is a natural tendency to focus on those effects that are easier to measure. Furthermore, there is undoubtedly scepticism among conventional neoclassical economists about the likely scale of externalities from higher education. As McMahon (2009) argues, perhaps this is in part due to a tendency to, in effect, "control away" some of the possible external impacts of HEIs.[2] Yet the potential policy significance of these external impacts of HEIs is such that it seems essential to explore this systematically, and consider whether mainstream scepticism is justified by the available evidence.

In Section 2 of the paper, we briefly review the methods that have been used in attempts to estimate the external benefits of education in general and higher education in particular. This includes a discussion of the approach that has tended to dominate in the UK focussing on the "macroeconomic returns" to education from growth studies that include human capital measures. Essentially, these are regarded as returns inclusive of aggregate externalities, from which microeconomic estimates of private

[2] The judgment is that some researchers incorporate control variables (such as occupation) that effectively absorb part of the contribution that may in fact be attributable to higher education.

(market) returns can be deducted to reveal the existence, scale and sign of any externalities. This "macro-*less*-micro" approach is not the only one, however, and we briefly review others, including the Wolfe and Haveman (e.g. 2003) household-production-function-based method and McMahon's (e.g. 2009) dynamic simulation method.

In Section 3 we apply the "micro-*to*-macro" approach to identifying the system-wide consequences of the external returns to higher education that we applied in our analysis of private market benefits of higher education in Hermannsson *et al* (2010). In that study we explore the system-wide impacts of micro-econometric estimates of private market returns to higher education by incorporating these as stimuli to labour productivity in a purpose-built, HEI-disaggregated, computable general equilibrium (CGE) model of Scotland. In the present study we adopt a similar approach, but here use the (predominantly) micro-econometric estimates of particular examples of external returns to higher education to explore their likely system-wide impacts. We also briefly illustrate the importance of the scale of overall external returns to higher education.

Given the comparative dearth of micro-econometric evidence of external returns in the UK, we are compelled to draw on evidence that is not Scottish (and, in some instances, not even UK based) in order to implement our approach. Furthermore, some of the evidence that we draw on is itself controversial, reflecting the difficulties that beset attempts to measure accurately the external returns to education, and the comparatively limited body of research that has been devoted to this to date (in comparison to the research on the private market returns to education). Despite the difficulties, this analysis has substantial potential importance for policy. Moreover, part of the motivation for this work is more clearly to identify the gaps in our knowledge of the external impacts of higher education in the UK and its regions. Future research will have to close these gaps if it is to provide the kind of evidence base that would be required to inform fully education policy in the UK.

Given these qualifications the results of our model simulations must be regarded as exploratory and somewhat speculative. We illustrate our approach by (1) analysing the impact of technology spillovers from HEIs to firms in Scotland drawing on evidence from Harris *et al* (2011, 2012), (2) considering the likely system-wide effects of productivity spillovers from graduates to non-graduates based on Moretti (2004) and (3) estimating potential system-wide effects from reduction in property crime based on Machin *et al* (2011). Finally, we briefly investigate the likely scale of system-wide impacts of overall external returns to higher education of the magnitude identified by McMahon (2009) and calculated using the "macro-*less*-micro" approach.

The micro-to-macro approach to the external impacts of higher education should prove capable, in principle at least, of analysing the system-wide ramifications of any individual higher education externality or any combination of externalities, so that, for example, any interactions among them can be revealed. However, to be convincing the implementation of the approach must ultimately be based upon a range of micro-econometric studies of higher education externalities in the UK that is comparable in quality to those that currently exist for the private market returns. In our brief conclusions in Section 5 we therefore focus primarily on the further research that would be required to allow a full micro-to-macro analysis of the external (and private non-market) returns to higher education in Scotland and the other regions of the UK.

2. Approaches to valuing the externalities associated with higher education.

This section of the paper provides a brief review of each of the main approaches to measuring (and valuing) the external and private non-market returns to higher education. The review can be brief because an extensive account is available in McMahon (2009).

One approach is based on the macroeconomic growth-accounting literature, which was the original source of the famous "residual" in GDP per capita growth that could not be explained by labour or capital growth and was interpreted as reflecting "technical change". The approach can be straightforwardly extended to incorporate the impact of education (see e.g., Stevens and Weale, 2004). While the accounting attribution approach is interesting, it cannot resolve the issues of causality.

The most widely used approach, which at least in principle overcomes many of the limitations of the growth accounting approach is what we term the "macro *less* micro" approach (Topel, 1999; Heckman and Klenow, 1997). Here macroeconomic growth models (either neoclassical growth models with disaggregated labour input or one of the variants of endogenous growth models) are estimated and interpreted as capturing the total (private plus external) market returns to education in general, or higher education in particular. There exist a number of relevant reviews here, including one on the macroeconomic returns to education (Sianesi and Van Reenen, 2003) - though there is rather less research on higher education *per se* - and on the potential role for higher education within endogenous growth models (Gemmell, 1996). Conventional micro-econometric estimates of private market returns (such as those reported in Blundell *et al,* 2000, 2005) are subtracted from the macroeconomic returns estimated from macroeconomic growth models (with disaggregated labour input) to yield estimates of external returns.

The literature is valuable, but the 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 yet of whether human capital impacts on the levels of per capita GDP or its growth rate. UK evidence suggests positive externalities, US evidence is less clear cut (with a suggestion perhaps of signalling effects and negative externalities) (Benhabib and Spiegel, 1994; Krueger and Lindahl, 2001; Sala-i-Martin, 1995; Sianesi and Van Reenen, 2003). Furthermore, this approach can at best provide an estimate of aggregate externalities that are reflected in GDP (i.e., external market returns), with no identification of the source of these. Nor can it hope to identify transmission mechanisms or indicate the scale of private and external non-market returns.

A third approach brings an element of macro into micro, through e.g. the incorporation of some measure of average "system-wide" human capital (which is external to the individual or firm) into augmented Mincerian earnings functions, directly reflecting Lucas's (1988) variant of endogenous growth. Examples include Moretti (2004), in which there is positive productivity spillover from graduates to non-graduates. The basic idea here is that productivity can be enhanced through human capital externalities arising from the interaction of graduates with non-graduates and other graduates. 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. More detailed description of this approach is provided in Section 3.

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

In the regional literature by far the biggest focus, in terms of HEI externalities, has been on estimating the scale of HEI spillover effects in knowledge production functions. The approach began by incorporating spatial effects more effectively into a knowledge production function in which the impact of HEIs is separately identified (Jaffe, 1989)[3]. In a wider context, studies of the knowledge economy encompass a broad range of typically more descriptive, case-study-based approaches, though the generality of their results is questionable (see e.g. Goldstein, 2009).[4] Many of these analyses are microeconomic in orientation, but in principle the estimates of spillovers could be calibrated as a productivity shock in a system-wide model to simulate likely aggregate effects. In fact, here we draw on new micro-econometric evidence for the UK (Harris *et al*, 2011, 2012) to calibrate a total productivity impact.

McMahon (2009, chpt 4) discusses private non-market benefits of higher education notably: own health; longevity; child health; child education; husband's health; fertility; happiness; consumption and saving; job and location amenities; lifelong learning; consumption benefits. Haveman and Wolfe (1984) develop a general "willingness to pay" method for valuing the non-market private benefits of education. The basis is a model of household production in which marginal conditions are used

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[3] See Anselin et al (1997) and Varga (1998) for early examples. Acs (2009) provides a review of these and subsequent developments of this approach.

[4] There is recent UK evidence that strongly suggests that the "bugs and drugs" conception of "knowledge transfer" that has often been the focus of this literature is unwarranted: active knowledge exchange occurs across a very wide range of subject areas. See Abreu *et al*, (2010).

to value non-market elements that enter the household production function, most notably health. This approach is predicated upon some quite strong assumptions but proves to be very useful and allows progress to be made in challenging areas. McMahon (2009) details methods and sources for a range of non-market private benefits (including only studies that have income and education in the equation, so that income-equivalent benefits can be computed). He estimates that the non-market benefits to the individual are 122% of the earnings increase. This is huge, with obvious implications for the incentive for individuals to invest in higher education provided they have access to the relevant information. However, we do not pursue the analysis of non-market private benefits further in this paper, although our approach can, in principle, accommodate these impacts.

3. A "micro-to-macro" approach

Here we adopt a "micro-to-macro" approach to assessing the possible system-wide impacts of higher education externalities. The approach is straightforward in principle. Firstly, we select relevant micro-econometric evidence of the external returns to higher education. Secondly, we use this evidence to inform the specification of an HEI-disaggregated CGE model of Scotland, and to calibrate the nature and scale of the external benefits of higher education. We initially applied this approach to the private market benefits of higher education in Hermannsson *et al* (2010), by introducing appropriately scaled labour productivity increases in response to projected increases in the share of graduates in the labour force. In this section we briefly motivate our approach in the present context and outline the CGE model of Scotland, which we then use, in Section 4, to simulate the system-wide impacts of the external benefits of higher education in Scotland.

3.1 The motivation for our approach

Our "micro-to-macro" approach, at least in principle, has a number of advantages over the "macro-*less*-micro" approach that characterises most past attempts to quantify external effects. Firstly, we can identify the system-wide ramifications of any particular external benefit of higher education, or any group of such benefits, for which there exists micro-econometric evidence. This would also allow an analysis of any interdependencies that may characterise the impact of particular external benefits.

The "macro-*less*-micro" approach assumes that the totality of external impacts is correctly measured by the estimated macro (growth) equation. The "macro-*less*-micro" approach therefore can at best only identify *aggregate* higher education externalities that are reflected in GDP, since it is assumed that the difference between the macroeconomic estimates and private market returns reflects the presence and extent of the totality of externalities.

Secondly, the micro-to-macro approach can, in principle, be used to measure the system-wide impacts of the *non-market private* benefits of higher education. McMahon (2009, chpt. 4) reviews and integrates this literature, and also notes that the "macro *less* micro" approach cannot, by its nature, shed any light on the scale of such benefits.

Thirdly, the transmission mechanism from the externality to the wider economy can, again in principle, be captured by the model, at least in broad-brush terms. And the causal sequence is clear in any subsequent simulations of impacts.

Fourthly, in one sense the micro-to-macro approach is a more coherent and transparent approach since it is not bedevilled to the same extent by the unavoidable problems of interpretation of models based on varying theories, methods, assumptions and databases as are the two elements of the "macro-*less*-micro" approach. Of course, such studies remain extremely useful, but there is merit in exploring all approaches to assessing the scale of social benefits given the limited work in this area, including, we believe, further development of the micro-to-macro approach developed here.

Fifthly, while the "macro-*less*-micro" approach can be implemented at the regional level that is our present focus, this is not straightforward given the quality and availability of regional data generally, which has limited the application of economic growth models in a UK regional context. However, the modelling framework that makes the "micro-to-macro" approach feasible can readily be implemented at the level of the regions, provided an appropriate input-output table exists, as we illustrate here with an application to Scotland.

Finally, the estimated total external effects calculated based on "macro-*less*-micro" approach can be used to inform scenarios in "micro-*to*-macro" approach. We do this in the last section using Topel's (1999) results for the macro component and

Psacharopoulos and Patrinos's (2002) for the micro element as reported in McMahon (2009).

While we believe the advantages of our general approach to be important, we would emphasise the illustrative nature of this particular application, given that there currently exists very little relevant Scottish (or indeed UK) evidence on external returns to higher education. We are therefore compelled to draw on evidence from elsewhere to determine the nature, and calibrate the scale, of at least one of the external benefits that we explore in order to illustrate the implementation of our approach. Furthermore, we are not comprehensive in our coverage of external effects, although we do attempt to provide some indication of the possible overall scale of the external benefits of higher education. In this paper we consider the evidence of three examples of positive externalities of higher education, and then consider external benefits as a whole based on "macro-*less*-micro" approach.

3.2 AMOS: A macro-micro model of Scotland

AMOS is a CGE modelling framework parameterised on the data from Scotland.[5] Essentially, it is an intertemporal, multisectoral, general equilibrium, empirical implementation of a Layard, Nickell and Jackman (1991, 2005) model of a regional economy. 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. There are twenty five commodities/activities.

Consumption and investment decisions reflect intertemporal optimization with perfect foresight (Lecca *et al*, 2010).[6] Real government expenditure is equal to its base year level. The demand for Rest of the UK and Rest of the World exports is determined via conventional export demand functions for which 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).

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[5] AMOS is an acronym for a macro-micro model of Scotland. The model is calibrated using a Social Accounting Matrix based around the 2006 Scottish Input-Output Tables.
[6] The details are given in Appendix 1. The intertemporal dimension of the model is based on Abel and Blanchard (1983).

In all of the simulations in this paper we impose a single Scottish labour market characterised by perfect sectoral mobility. All sectors are taken to be perfectly competitive and produce using multi-level CES production functions with elasticities of substitution of 0.3 (Harris, 1989). The model is characterised by a multi-level production structure. At the highest level gross output in each sector is produced by a Leontief production function of value-added and intermediate inputs. The value-added is a CES function of labour and capital inputs, and technical change can augment labour, capital, or both. In implementing the simulations based on results reported in Harris *et al* (2011, 2012) we apply the shock to total factor productivity, so it takes the form of Hicks-neutral technical change. In all the other simulations we shock only labour productivity, as in a Harrod-neutral technical change. We do not explicitly model financial flows, our assumption being that Scotland is a price-taker in the competitive UK financial markets.

As regards demographic developments, we assume no natural population change and no migration to isolate the effect of HEIs from the effect of changing size of the labour force. Wage setting is determined by a regional bargained real wage function that embodies the econometrically derived specification given in Layard *et al* (1991), . In this function the real wage is negatively related to the level of unemployment in the region, reflecting labour's lower bargaining power in such circumstances.

4. Simulation strategy and results

We illustrate our approach by focussing on three individual effects with clear transmission mechanisms: the stimulus to total factor productivity as a consequence of establishments' interaction with HEIs, the impact of graduates on the productivity of non-graduates (and other graduates) and the impact of increased investment in higher education as a result of public saving due to a crime reducing effect of education. Later we make an attempt to estimate an aggregate effect of external returns to education.

4.1 The impact of HEIs on total factor productivity

Simulation strategy

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

$$y_i = \alpha + \beta_E e_i + \beta_K k_i + \beta_x x_i + \beta_{ATT} HEI_i + \varepsilon_i \qquad (1)$$

where: lower case letters indicate logarithms, E_i is employment in firm *i*, K_i is 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 in 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, and we interpret this coefficient here as indicating the presence of a positive externality of HEIs on total factor productivity. But it has to be noted that since the precise nature of the co-operation is not known it may be that some part (or all) of this is internalised (e.g., in the form of research grants). When estimated on all industries in Great Britain, with a matched sample based on propensity score matching, Harris *et al* (2011) find that β_{ATT} is positive and statistically significant, and indicates that collaborating with HEIs is associated with TFP that is around 12% higher, given all the control variables included. The impact is slightly reduced, however, when a dummy variable indicating the presence of an innovation over the period is introduced (which itself has a positive and statistically significant impact). This is as the authors expected, since the direct impact of HEIs is captured by the dummy variable, but HEIs also exert an indirect impact through innovation, as captured here through the introduction of the innovation dummy (Arvanitis *et al*, 2008). In this context it seems more appropriate to use the estimate of impact which is not "corrected" for innovation, otherwise we are effectively "controlling away" one of the mechanisms through which HEIs in fact exert their impact.[7]

The impacts were based on the 2007 CIS, so we regard the results as relating to 2006 and interpret them as implying that the presence of HEIs increases TFP by 12% in firms reporting cooperation with HEIs, *ceteris paribus*. There are a number of problems involved in trying to deduce what Hicks neutral technical change shock should be introduced into our CGE model to reflect the Harris *et al* (2011) results. First, the estimated impact, of course, only applies to those establishments that actually report collaboration with HEIs (i.e. only to those establishments that indicated that they had either sourced knowledge or cooperated on innovation-related activities in the CIS). In 2006, based on weighted CIS data, 30.1% of GB establishments (in output terms) collaborated with HEIs, although this varied significantly by firm size (and by sector). Accordingly, if we are looking at the economy as a whole the scale of the impact on TFP on the basis of the GB estimate is 3.6% (i.e., 30.1% of 12%).

Second, this estimate is, because of the necessary dummy variable ("all or nothing") characterisation of the impact of HEI activity (given the nature of the CIS questions on HEI collaboration), effectively a measure of the impact of a "hypothetical extraction" of HEIs on TFP. It reflects the *total 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 HEIs: we could simulate the impact of extraction of HEIs on TFP (103.6 to 100 or a 3.5% reduction in TFP), although, of course, this may not be that informative if we are interested in the likely impact of marginal changes in HE policy. Nonetheless, it gives some feel for the scale of what are likely to be research-induced supply-side changes on the Scottish economy, if Scottish establishments respond like those in GB as a whole (though note that the regional origin of the HEIs with which links exist is not identified).

[7] The authors also report the result of including the percentage of the firm's workforce that are graduates. This consistently has a positive and statistically significant coefficient throughout. The authors report that a 10% increase in the percentage of graduates leads to between a 0.6% and 1.4% increase in TFP depending on sector and model. However, we regard this as simply reflecting a disaggregation of the labour input into graduate and non-graduate employment, not indicating the presence of a productivity spillover.

In fact, in a subsequent paper Harris *et al* (2012) report significant differences in the link between HEIs and establishment-level TFP across the regions of GB. In particular, they incorporate an interactive dummy between HEI impact and foreign ownership. They find a (weakly significant) negative link between HEIs and indigenous Scottish companies, but do find evidence of a large (31%) and statistically significant positive link between collaboration with HEIs and the productivity of foreign-owned firms in Scotland. The authors interpret this as evidence supporting the assessment of the Scottish innovation system in Roper *et al* (2006), who argue that there is a lack of absorptive capacity of Scottish indigenous firms. This suggests another hypothetical extraction simulation, in which we simulate the system-wide impact of the reduction in productivity in foreign firms that the absence of HEI interaction with the foreign-owned sector implies. The equivalent stimulus to TFP (on a weighted basis) is 7.2%, but if the negative link to indigenous companies is taken to be genuine, the overall stimulus to TFP from HEIs is only 0.9%.

Simulation results

Table 4.1 presents the long-run equilibrium results of hypothetical extraction, in which we remove the estimated impact of a technology spillover on the Scottish economy (assuming Scottish establishments are like GB establishments), through a reduction of a Hicks neutral kind of 3.5%. In the long-run equilibrium all capital stock and population adjustments are complete.

Table 4.1 TFP shock of 3.5%. Long-run percentage change.

GDP	4.9
Consumption	1.7
Investment	2.3
Total Employment	1.0
Unemployment Rate	-15.6
Nominal wage	-0.1
Real wage	1.6
CPI	-1.7
Export RUK	4.9
Export ROW	4.8
Capital Stock	2.3

Since we are here simulating the impact of a hypothetical *extraction* of the (positive) impact of HEIs on TFP, the impacts on GDP and employment are negative. To avoid confusion we present the positive numbers here. The simulation results suggest that, in a system-wide context HEIs, through their interaction with GB plants, stimulate GDP by 4.9%. Of course, this is not an impact at the margin, but indicates the total impact of HEIs (captured by a dummy variable in the econometric analysis).

A key feature of the stimulus to TFP that the presence of HEIs implies is the beneficial impact that it has upon competitiveness (reducing CPI by 1.7%) and stimulating Rest of the UK and Rest of the World exports by 4.9% and 4.8% respectively. However, the impact on employment (1.0%) and capital stocks (2.3%) are significantly lower than the stimulus to TFP, with the upward pressure on the real wage serving to limit the scale of the expansion in employment.

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

Simulation strategy

In this section we take an example of results from the general approach that includes some indicator of the average (external) level of human capital in earnings equation, and interprets the coefficient on that variable as indicating the scale of spillover effect on the individual/ group whose earnings are captured in the dependent variable. The example that we are using is Moretti (2004), who estimates an earnings function in which external effects are measured through the incorporation of an external, city-wide, measure of human capital, namely the share of college graduates.

We are interested in the external impact of 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, but they have long been recognised as potentially important (Marshall, 1890), and are the most direct way, at the comparatively disaggregated level, of testing for the effects that are the core of the Lucas (1988) variant of endogenous growth theory. The area is controversial, in particular in respect of the appropriate estimation and interpretation of the coefficient of the proxy for average human capital in the earnings equation. A number of researchers have adopted this approach, mostly in a US context. The empirical evidence is mixed. For example, Rauch (1993) finds evidence of significant externalities, using earnings and rental rate equations, while Acemoglu and Angrist (2000) find apparent evidence of such effects for schooling using OLS, which largely disappear under IV estimation. Moretti (2004), reports significant impacts, and his work seems most relevant here in that he estimates external effects for groups with different education levels, high school drop outs, high school graduates and college graduates. Moretti (2004, 2006) suggests that the difference from Acemoglu and Angrist (2000) is down to: his inclusion of a time period in which returns grew; his focus on returns at the higher end of the earnings spectrum; his analysis being of city-level rather than state-wide effects (which he finds to be lower in his sample). This pattern of results, as Moretti (2004) notes, is broadly consistent with Kreuger and Lindhal's (2000) argument that the external benefits to education at lower levels of the education system impact largely through reduced crime and benefit claimants, whereas at the upper levels they impact through technology and productivity.

Lange and Topel (2006) argue that Moretti's (2004) estimates must be regarded as upwards biased, given that they believe the notion of spatial equilibrium implies human capital intensities of cities may be demand driven (although Moretti (2004) tries to correct for that). 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 here given a lower degree of labour mobility in the UK. As far as we are aware we have no comparable UK studies.

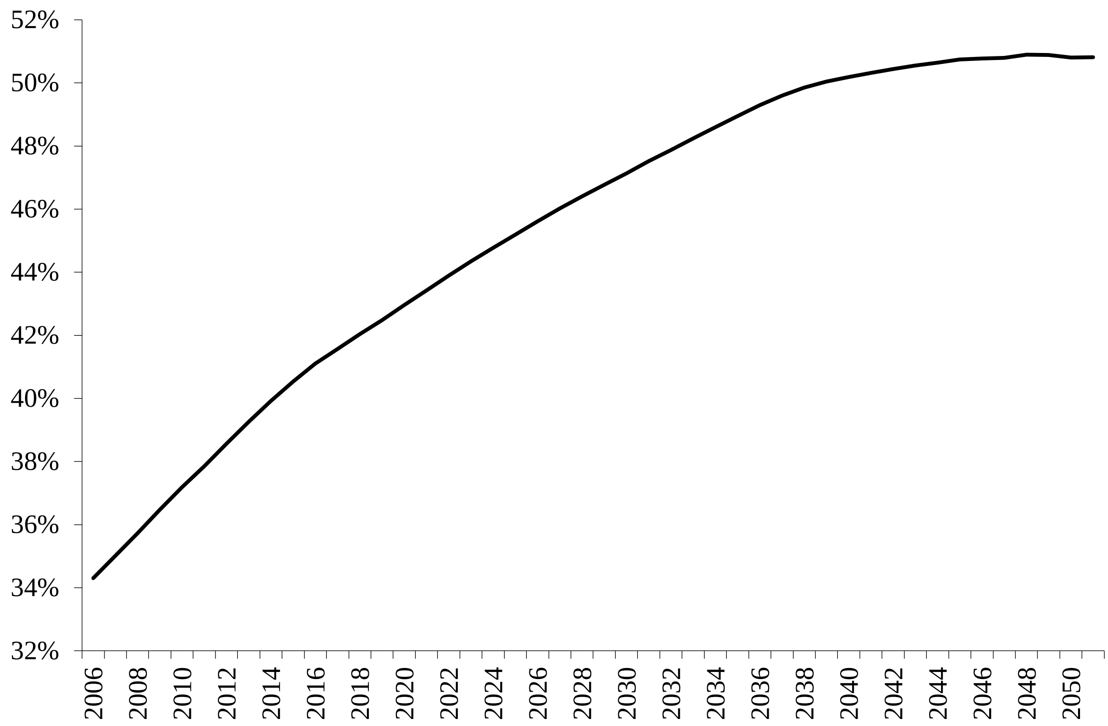
Despite the problems, we base our estimate of the externality on Moretti's (2004) estimate of a 1.6% hike in earnings for non-graduates and 0.4% for graduates for every 1 percentage point increase in the proportion of graduates in the labour force. However, the only component of this change that clearly 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 we estimate the second conservative scenario in which we take 0.4% as a measure of the external effect on graduates and non-graduates alike. While this is a conservative interpretation of Moretti's (2004) estimated externality, the qualifications to our analysis are nonetheless substantial: the Lange and Topel (2006) critique of upward bias remains; the fact that the scale of these effects tends to be bigger the smaller the spatial scale, and that the estimates were based on US cities, while we are here dealing with a UK region. The reservations concerning the estimates are such that our simulations have to be regarded as illustrative of the ability of the micro-to-macro approach to capture the impact of this externality, given our assumption that these wage differentials fully reflect genuine productivity effects.

To determine the scale of the productivity spillovers we first have to determine the projected share of graduates in the Scottish labour force. It will increase even with an unchanged higher education participation rate (given demographic processes and the higher participation rate for recent cohorts). After that we apply the external effects to determine the resultant changes in productivities 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.

We use here our own projection of the future Scottish labour force composition described in Hermannsson *et al* (2010). The central assumption is that the number of graduates from the Scottish universities after the 2006/07 academic year will change proportionately to the number of people aged 20-25 and that the retention rates of graduates within the regional labour force will be constant. The original skill composition is calculated based on age-specific shares of graduates from the Annual Population Survey as reported by NOMIS and 2006 population age structure. The future size and age structure of the potential labour force (population age 20-64) are taken from the 2010-based ONS principal population projection. The resulting projected share of graduates in the Scottish labour force is presented on Figure 4.1.

The increasing proportion of graduates reflects the fact that older cohorts have smaller proportions of graduates than is true of the recent cohorts. Gradually younger cohorts with high proportion of graduates replace older cohorts with lower proportion of graduates.

Figure 4.1. Projected share of graduates in the Scottish labour force



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

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

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 (1.6% or 0.4% depending on scenario). Based on these calculations, by 2051 the cumulative shock reaches 12.4% or 4.6%, depending on scenario.

Simulation results

The long-run results of the positive shock to labour productivity associated with the external effect of graduates on productivity of non-graduates and other graduates are presented in Table 4.2.

Table 4.2. Simulation results. Long-run percentage change.

	Base scenario	Conservative scenario
Labour productivity shock	17.9	6.6
GDP	18.5	8.8
Consumption	4.4	1.6
Investment	16.2	6.0
Total Employment	1.6	0.6
Unemployment Rate	-25.2	-9.6
Nominal wage	-1.7	-0.8
Real wage	3.3	1.1
CPI	-4.8	-2.0
Export RUK	18.2	6.9
Export ROW	18.4	6.9
Capital Stock	16.2	6.0

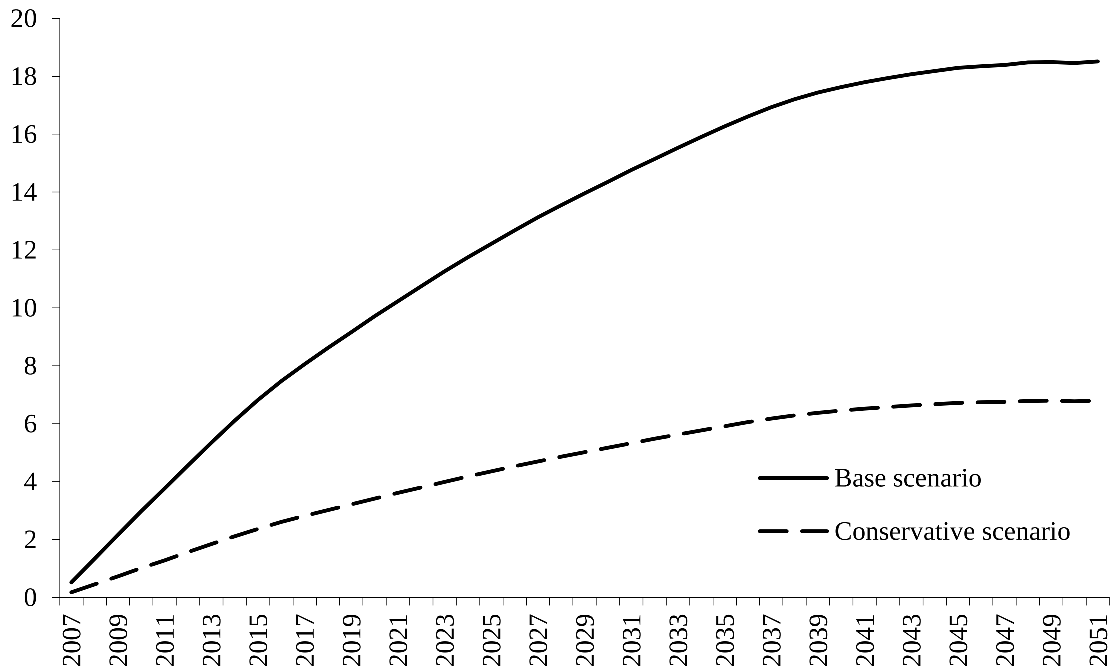
The stimulus to the productivity of labour, as a consequence of the increasing proportion of graduates over the period ultimately raises GDP substantially by 17.9% in the base scenario or by 6.6% in the conservative scenario and puts downward pressure on prices by -4.8% and -2.0% respectively. A major part of the impact here is through the stimulus to regional competitiveness, which results in a substantial increase in interregional and international exports. Of course, this reflects our assumption that the proportion of graduates is unchanged in RUK and ROW. There is a significant reduction in unemployment (-25.2% or -9.6%) and increase in the real wage (3.3% or 1.1%). Employment does rise in the long-run (1.6% or 0.6%) so that the general equilibrium demand curve for labour is wage-elastic over this interval. Of course, the fall in the price of an efficiency unit of labour (percentage change in real wage – labour productivity shock) stimulates the demand for labour in efficiency units, but in general employment can fall (and does in the short-run – see below). The increase in GDP exceeds the labour productivity increase because both employment and capital stock are increasing.

The reduction in the wage per efficiency unit of labour stimulates the demand for value-added through its impact on prices, via a competitiveness and real income effect, and this in turn stimulates the demand for both labour and capital services. However, the reduction in the relative price of an efficiency unit of labour stimulates the demand for it relative to capital, through a substitution effect, and the ratio of efficiency units of labour to capital increases. Nonetheless, the change in employment is less than that in capital. The capital/worker ratio increases, reflecting the greater efficiency of workers.

The increase in the demand for labour and capital pushes up the real wage and the real rental rate. However, the overall level of domestic prices is falling because of the competitiveness effect, and the nominal wage and rental rates decline too. While the real wage rises, it does so by less than the stimulus to productivity, which means that the wage in efficiency units falls, so that the unskilled get squeezed as a consequence.

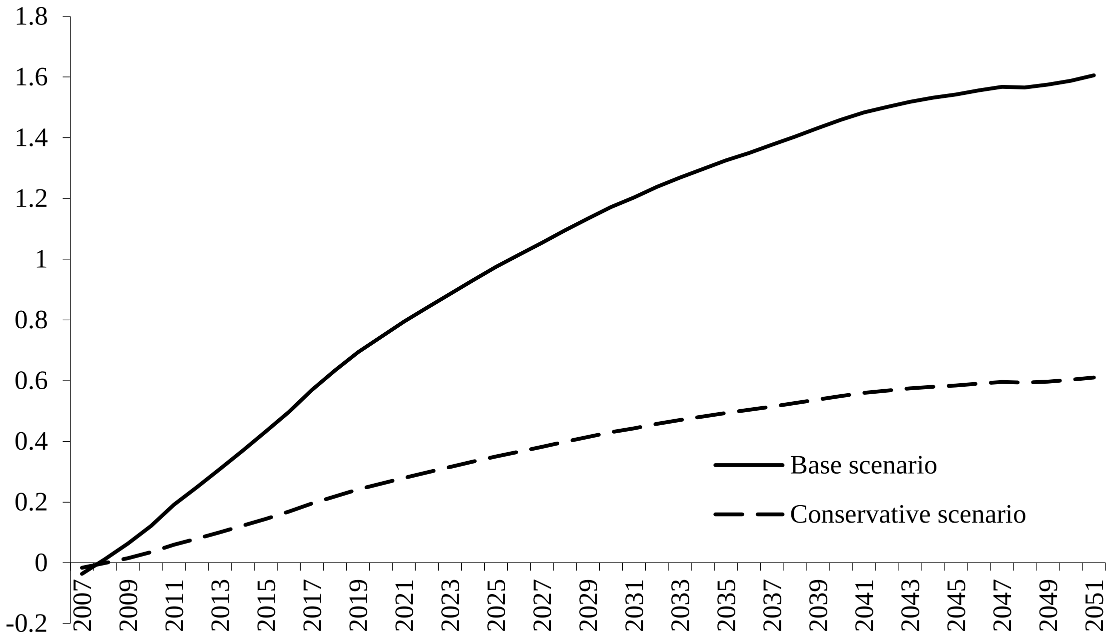
It is instructive to examine the adjustment path of the simulated response of the Scottish economy to the projected increase in labour productivity associated with positive external effect of graduates on productivity of non-graduates and other graduates. Figure 4.2 plots the GDP response to this increase. The two lines represent results for two scenarios.

Figure 4.2. The adjustment path of GDP in response to labour productivity increase



The adjustment paths for employment are shown in Figure 4.3. Notice that employment actually falls in the first period, reflecting the various factors that make the general equilibrium wage elasticity of employment demand lower in the short-run, including the fixed sectoral capital stocks in the first period.

Figure 4.3. The adjustment path of employment in response to labour productivity increase



4.3 The crime-reducing effect of education

Simulation strategy

There is a small but growing literature on the crime reducing effect of education (Haveman and Wolfe, 1984; Lochner and Moretti, 2001; Lochner, 2004; Machin et al, 2011). The authors identify several factors that explain the negative relationship between the level of education and criminal activity. Firstly, education increases opportunity cost of criminal activity by both increasing the returns from legal work and increasing the cost of potential incarceration. Secondly, time spent in education reduces time available for participation in criminal activity. This is especially important for teenagers. Thirdly, education may reduce the chances of involvement in criminal activity by increasing patience and risk aversion. And finally, if we believe in humanistic role of education, it may change preferences and make crime a less attractive activity on moral grounds.

We base our analysis of the macroeconomic impact of a crime-reducing effect of education on a recent paper by Machin et al (2011). They estimate a causal education impact on crime using as an instrument an increase in the compulsory school leaving age from 15 to 16 in England and Wales in 1972. This law generated a discontinuity in the average age left school and proportion with no qualification for men aged 18-40 who were born 1950-1965[8]. Simultaneously they observe a drop in the conviction rates[9] for men leaving school after the school leaving reform.

The biggest challenge in estimating the effect of education on crime participation is the correlation between unobservables influencing education choices and those affecting the decision to get involved in criminal activity. To overcome this difficulty Machin et al (2011) use a school leaving age dummy as an instrument for education as it is a strong predictor of education and is not correlated with the unobservables that are correlated with both education and involvement in crime. They estimate crime and education reduced form equations:

$$O_{at} = \beta_0 + \beta_1 SLA_{at} + \sum_j \phi_j X_{jat} + \nu_{at}$$

$$E_{at} = \delta_0 + \delta_1 SLA_{at} + \sum_j \varphi_j X_{jat} + \vartheta_{at}$$

and crime structural form equation, that is used for causal estimates:

$$O_{at} = \theta_0 + \theta_1 E_{at} + \sum_j \sigma_j X_{jat} + \varepsilon_{at}$$

where O_{at} is a measure of offending by cohort *a* in year *t*, E_{at} is an education variable, SLA_{at} is a dummy variable that take value 1 for the cohorts that are affected by the new school leaving legislation, X_{jat} is a set of other explanatory variables.

In the regression that we use for our scenario formulation the dependent variable is log of property crime convictions per 1000 population, and education variable is share with no qualification. The data on offending from the Offenders Index Database is aggregated by age, gender and broad crime type (property and violent). The offending rates are calculated using population data from the Office of Nation Statistics (ONS)

8 Based on General Household Survey data for 1972-1996.

9 From Offenders Index Database for 1972-1996.

and matched with education and other characteristics from the General Household Survey.

The coefficient on the "no qualification" variable in a structural form equation is 0.851 if the standard sample is used and 0.999 if the sample with inverse distance weighting, that gives more weight to the observations nearer to the discontinuity point, is employed. The interpretation is as follows: if the share of population without qualification declines by 1% the level of convictions for property offences (which is used as a proxy for all property offences) reduces by 0.851 or 0.999 per cent. We use both of these estimates to construct two scenarios.

Our approach is to use the coefficients estimated by Machin et al (2011) as estimates of the reduction in crime that will be achieved as the share of graduates in the Scottish labour force increases. Given the lack of evidence for the crime reducing effect of higher education qualifications we adopt the estimates of Machin et al (2011) as proxies even though they are based on secondary education. We realise the limitation of the proposed approach but argue that it is justifiable for two reasons. First, the factors that are responsible for the crime reducing effect of secondary education are still at play with higher education. Second, the presented evidence is based upon the effect of a one year's increase in education participation, while it takes three years to complete an undergraduate degree. That is to say, by using the same coefficients we are effectively applying one third of the effects estimated by Machin et al (2011).

The authors also estimate the social benefits from the crime reducing effects of education by doing a cost-benefit analysis. They use the Home Office report by Dubourg et al (2005) for estimates of crime cost and the British Crime Survey for the estimates of the number of property crimes. We also start by using the estimates of crime cost from Dubourg et al (2005) but apply them to Scottish criminal statistics from the 2008 Scottish Criminal and Justice Survey (SCJS). There are two differences between our approach and that of Machin et al (2011): we use crime by category, while they use average cost of all property crimes; and we only include "defensive expenditures" and "cost to the criminal justice system", while they also take into account "insurance administration" and "cost as a consequence of crime" (cost of crime for the victim). The rationale for not including the latter two categories of cost is that we are trying the estimate the public savings as a consequence of reduced crime and not the total savings (that include private savings). The calculations of public savings associated with the crime reducing effects of education are presented in Table 4.3. Total savings rage from £ 4.0 to 4.7 millions.

To convert these savings into a potential macroeconomic effect from crime reduction we propose a hypothetical scenario, in which savings from reduced crimes are used to finance additional places at Scottish HEIs. We estimated that in 2005/06 academic year one FTE student costs £5,315 of public money (based on the data from Higher Education Statistics Agency (HESA) on teaching grants to Scottish HEIs and total number of FTE students). This means that one graduate costs £15,945, as it takes three year to graduate with a first degree. Money saved from crime reduction would allow the funding of 252 to 296 graduates (depending on which estimate of the crime reducing effect we use) per 1% increase in the share of graduates in the labour force. For the percentage increase in the share of graduates in the labour force we use the same projections that were described in the previous section. We apply a UK net retention rate[10], which in 2005/06 was 89%, to calculate the number of additional graduates who will stay in Scotland. Then we add them to the base line scenario of the projected number of graduates in Scotland described in Hermannsson et al (2010) with a three year lag to account for the time it takes to acquire a degree. As a result by 2051 the total cumulative number of additional graduates that would stay in Scotland would be equal to 4,531 or 5,507, depending on the scenario.

[10] Retention rates are calculated based on the HESA Destination of Leavers from Higher Education Survey (DLHE) for 2002-07. "UK net retention rate" is calculated as the total number of UK graduates employed in Scotland 6 months after graduation divided by the total number of UK graduates that graduated from Scottish universities. The retention rate therefore takes into account the retention of students from Scottish universities as well as the net inflow of graduates from other UK regions.

Table 4.3. Savings from crime reducing effect of education

Classification in SCJS	Classification in HO report	Number of crimes	Cost in anticipation, £	Cost to the criminal justice system, £	Total cost, £ thousands	Public savings from reduction of crime, £ thousands	
						Estimate = 0.851%	Estimate = 0.999%
Vandalism	Criminal damage	350,376	13	126	48,702		
All motor vehicle theft	Theft of vehicle	69,709	546	199	51,933		
Housebreaking	Burglary	25,485	221	1137	34,609		
Other household theft	Theft non vehicle	172,856		301	52,030		
Personal theft (incl. robbery)	Robbery	109,793		2601	285,572		
Total property crimes		728,219			472,845	4,024	4,724

We formulate the scenarios in terms of long-term (45 years from 2006 until 2051) increases in labour productivity attributable to the effect of increased human capital accumulated by the Scottish labour force due to higher number of graduates. This effect is expressed as a labour-augmenting productivity shock. As an indicator of the productivity differential between graduates and non-graduates we use the graduate wage premium, allowing for a signalling effect equal to 10% of the wage premium (Lange and Topel, 2006). For simulations presented in this paper we use the baseline estimate of graduate wage premium from Hermansson *et al* (2010) – 45%. For justification of the selected level of wage premium and discussion of the link between the graduate wage premium and productivity, signalling effect and sensitivity analysis see Hermansson *et al* (2010).

The scale of the productivity adjustment for graduates is calculated according to the following formula:

$K=(1-sig)*(1+wp)$

where: K is a productivity scaling factor of graduate relative to non-graduate, sig is signalling effect, wp is the graduate wage premium.

The total productivity-adjusted labour force is calculated as the sum of non-graduates and graduates weighted by their productivity scaling factor. The size of the labour productivity shock for each year of the simulation is calculated as a growth rate in the productivity-adjusted labour force between 2006 and the corresponding year[11].

Simulation results

The long-run results of the simulations demonstrating the potential macroeconomic impact of the crime reducing effects of education are presented in Table 4.4. In these simulations the increase in labour productivity is driven only by the increasing number of graduates in the labour force.

[11] To eliminate the scale effect of the change in population, the series is divided by the change in the size of the working-age population during the same period.

Table 4.4. Simulation results. Long-run percentage change.

	Estimate = 0.851%	Estimate = 0.999%
Labour productivity shock	1.31	1.56
GDP	1.35	1.61
Consumption	0.32	0.38
Investment	1.18	1.42
Total Employment	0.12	0.14
Unemployment Rate	-1.87	-2.23
Nominal wage	-0.14	-0.17
Real wage	0.24	0.28
CPI	-0.37	-0.46
Export RUK	1.34	1.60
Export ROW	1.36	1.62
Capital Stock	1.18	1.41

The labour productivity shock associated with a growing number of graduates funded by savings from public spending on crime produces a large positive impact on the level of GDP (1.3% or 1.6%). This mainly operates through an improvement in competitiveness (CPI decrease by 0.4% or 0.5%) which drives an increase in exports to the Rest of the World and the Rest of the UK (1.3% or 1.6%). In the long run, the overall level of employment increases (0.1%) because the stimulus to employment from improved competitiveness (competitiveness effect), dominates the efficiency effect that is caused as any given level of output can now be produced with less labour input.The increase in demand for labour and capital pushes up the real wage (0.2% or 0.3%) and the real rental rate. However, the overall level of domestic prices is falling because of the competitiveness effect, and the nominal wage (-0.1% or -0.2%) and rental rates decline too.

The time paths of GDP and employment in response to the discussed shocks are presented in Figures 4.4 and 4.5. the two lines represent two different scenarios.

Figure 4.4. The adjustment path of GDP in response to labour productivity increase

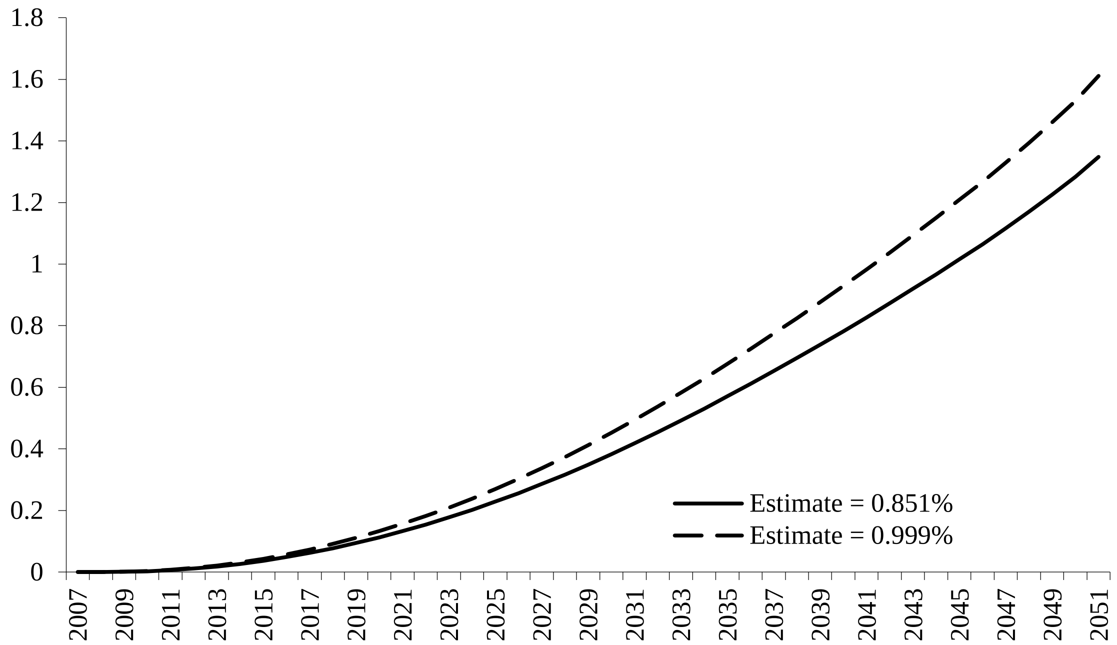
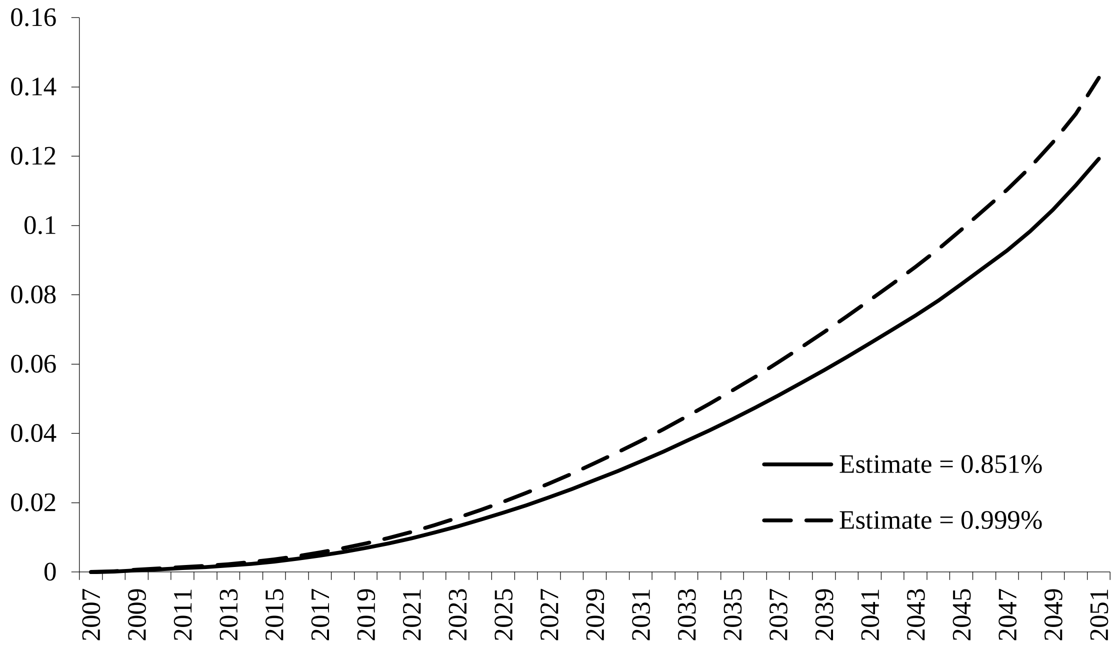


Figure 4.5. The adjustment path of employment in response to labour productivity increase



It is interesting to note that unlike the previous labour productivity scenarios based on Moretti (2004) there is no sign of the effect reaching its equilibrium after 45 years. The reason is that in this case the effect is self-stimulating – larger share of graduates leads to lower crime, which leads to greater savings and financing of more graduates, which in turn increases the share of graduates.

4.4.The aggregate social benefits of higher education

Simulation strategy

So far we have focussed on only two of the possible externalities associated with higher education. However, the scale of the problem associated with trying to identify and quantify each and every externality is daunting, although McMahon (2009, chs 4 and 5) has attempted to do just that and McMahon and Oketch (2010) report their most recent estimates for the US and the UK. We do not have the resources or space to attempt a comprehensive analysis here. However, in order to give a flavour for how important the overall social impacts identified by McMahon (2009) may be, we explore this issue from a slightly different perspective. In particular, we ask what effect the overall social impacts identified by McMahon (2009) would have if they were expressed in terms of an *equivalent* stimulus to the *private market* returns to higher education (expressed in terms of higher earnings, which we assume indicates higher productivity). The impacts are those that would be associated with a stimulus to graduate productivity of a sufficient scale to produce the same total of private market plus social returns to higher education reported by McMahon (2009). Of course, this does not capture the transmission mechanism for all externalities. Some researchers do, in fact, argue that the flow of graduates is critically important to some dimensions of HE impacts. For example, Faggian and McCann (2006) find that the spillover effects from HEIs to innovation occur via the flow of new graduates, and can find no evidence of an independent effect of the type considered above. However, none would argue that this is the only possible transmission mechanism for HEI impacts. We are not, though, arguing that this approach accurately captures all transmission mechanisms, but rather that it merely provides some indication of the potential importance of the overall social benefits of higher education.

The measure of social benefits is taken from McMahon (2002, 2004, 2009). The productivity increase that would be required to raise private rates of return to the same overall level can then be identified and used as the basis of a series of productivity shocks to indicate the scale of overall social plus private returns to higher education.[12]

We use the same projection of Scottish labour force composition as in the previous section, together with evidence of graduate productivity differentials, to simulate the system-wide impact of the increased proportion of graduates operating through conventional private market returns to higher education. We then express the social returns to HE in terms of an *equivalent* labour productivity stimulus, to explore the scale of the system-wide impacts that would be implied if the social plus private market returns were captured in this way.

We begin by considering the impact of private market returns that we employ as a comparator. The basic principle of shock formulation is the same as in the previous section. The scenarios are formulated in terms of long-term (45 years from 2006 until 2051) increases in labour productivity attributable to the effect of increased human capital accumulated by the Scottish labour force owing to growing participation in higher education over the past 50 years. This effect is expressed as a labour-augmenting productivity shock. And again we use the same wage premium of 45% as a measure of graduates higher productivity, allowing for a 10% signalling effect (for detailed discussion see Hermansson *et al*, 2010).

The scale of the productivity adjustment for graduates is calculated according to the following formula:

$$K=(1-sig)*(1+wp)/(1-s)$$

where: *K* is a productivity scaling factor of graduate relative to non-graduate, *sig* is signalling effect, *wp* is the graduate wage premium and *s* is the share of social benefits in total return to education (private market returns + social returns). Non-graduates' productivity is assumed to remain constant.

We estimate upper and lower bounds for the social rate of return. The upper bound is from combining Topel's (1999) total rate of return to education from cross-country

[12] While McMahon (2009 pp 240-244) also examines the value of social benefits using his dynamic simulation model of endogenous development, the attribution of results to higher education *per se* requires some judgemental input. However, he reports impacts of a similar order of magnitude to those obtained using the Haveman and Wolfe (1984) approach.

output per worker regressions – 23%, with Psacharopoulos and Patrinos (2002) estimate of the private returns to education based on individual earnings data and Mincer regressions – 9% for OECD. For OECD countries the size of externalities turns out to be (23%-9%)/23%=61% of the total returns. The lower bound of 37% is from McMahon (2002), which is the result he obtained for the USA[13]. However, it should be noted that Heckman and Klenow (1997) find no evidence of significant social returns when they control for life expectancy. As we have seen other papers also find no evidence of social returns when they control for a wide range of factors. McMahon's (2009) response is that often these controls remove a part of the return that should be attributed to higher education (including improvement in longevity).

It should be kept in mind, however, that we are ignoring the private non-market returns to higher education in our analysis, although again in principle, it is possible to extend the micro-to-macro approach to accommodate these (while it is not possible to do so, using some other methods, including the "macro less micro" method).

Simulation results

Here we compare the results we obtain by shocking productivity to reflect only the private market returns from higher education with the impacts implied for two estimates of social returns, expressed in terms of an equivalent additional stimulus to private market returns. Table 4.5 presents the long-run effects for three scenarios.

The first column shows the results for the scenario which assumes that there are no external benefits of higher education. The increase in labour productivity is driven only by the increasing proportion of graduates in the labour force and their higher productivity. It has a large positive impact on the level of GDP (6.0%), which mainly operates through improvement in competitiveness (CPI decrease by 1.8%) resulting in growing Rest of the World and Rest of the UK exports (6.1% and 6.2). The overall level of employment increases in the long run (0.5%) because the stimulus to employment from improved competitiveness (competitiveness effect), dominates the fact that any given level of output can now be produced with less labour input (efficiency effect). The increase in the demand for labour and capital pushes up the

[13] In fact, the estimates obtained by valuing each external benefit individually using the Haveman and Wolfe (e.g.1984) approach (McMahon (2009, chpt. 5)), imply that the total social benefits to higher education account for 47% of the private market return to higher education.

real wage (1.0%) and the real rental rate. However, the overall level of domestic prices is falling because of the competitiveness effect, and the nominal wage (-0.8%) and rental rates decline too.

Table 4.5. Effect of total returns to education. Long-run percentage change.

	External benefits		
	0%	37%	61%
Labour productivity shock	5.9%	8.7%	12.6%
GDP	6.0%	9.0%	13.0%
Consumption	1.4%	2.1%	3.1%
Investment	5.3%	7.9%	11.4%
Total employment	0.5%	0.8%	1.2%
Unemployment rate	-8.5%	-12.5%	-18.1%
Nominal wage	-0.8%	-1.1%	-1.4%
Real wage	1.0%	1.5%	2.3%
CPI	-1.8%	-2.5%	-3.6%
Exports to RUK	6.1%	9.0%	13.0%
Exports to ROW	6.2%	9.1%	13.1%
Capital stock	5.3%	7.9%	11.4%

The second and third columns present the results for simulations with positive external benefits of higher education. The direction of results is the same but magnitude is larger. For example, GDP is growing in the long run by 8.7% in case if external benefits represent 37% of total benefits of education and by 12.4% if they account for 61% of total returns. It is important to remember that the results presented in the table show the total impact of higher education over 45 years, i.e. private market and external effects combined. Thus, the external benefits of higher education in the long run represent the difference between the second/third columns and the first column. For example, the long-run impact of external benefits of higher education on GDP is 2.8% is case if external benefits constitute 37% of total benefits and 6.5% if they constitute 61% of total benefits.

The adjustment paths for GDP to long-run values, presented in Table 4.5, are shown in Figure 4.6. The lowest line shows the transition path for the scenario without external benefits of higher education, the middle line for scenario with external benefits comprising 37% and the top line for scenario with external benefits comprising 61% of total benefits. GDP approaches its long-run equilibrium level gradually, reflecting the projected build-up in the proportion of graduates in the labour force.

Figure 4.6. The total impact of the increasing proportion of graduates in the Scottish labour force on GDP.

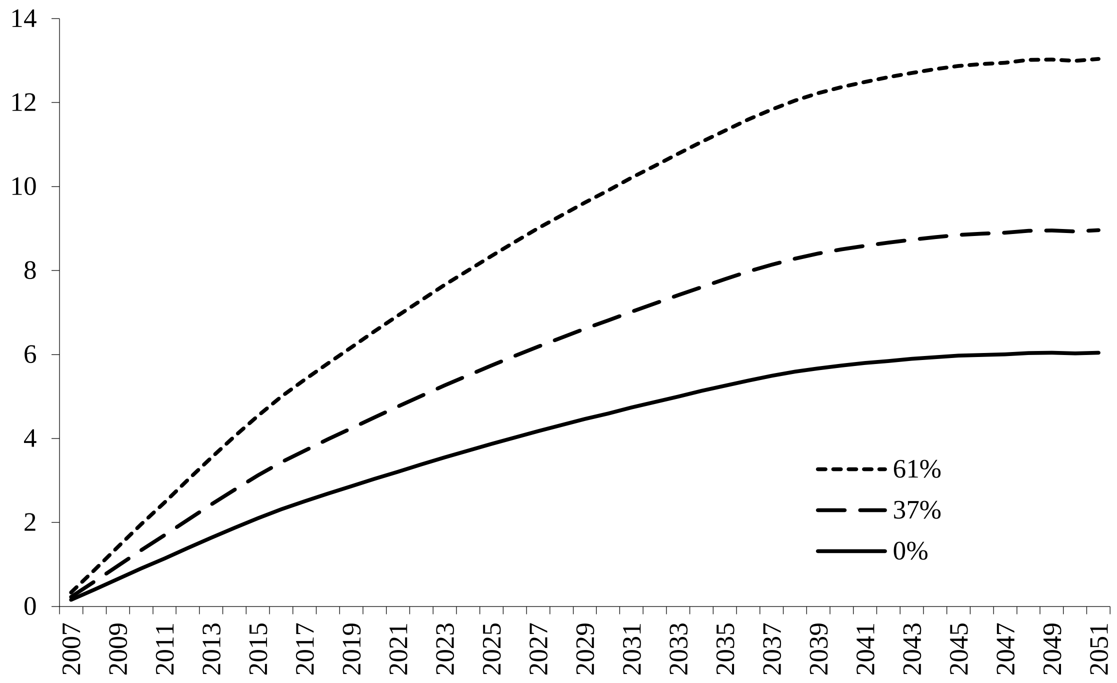
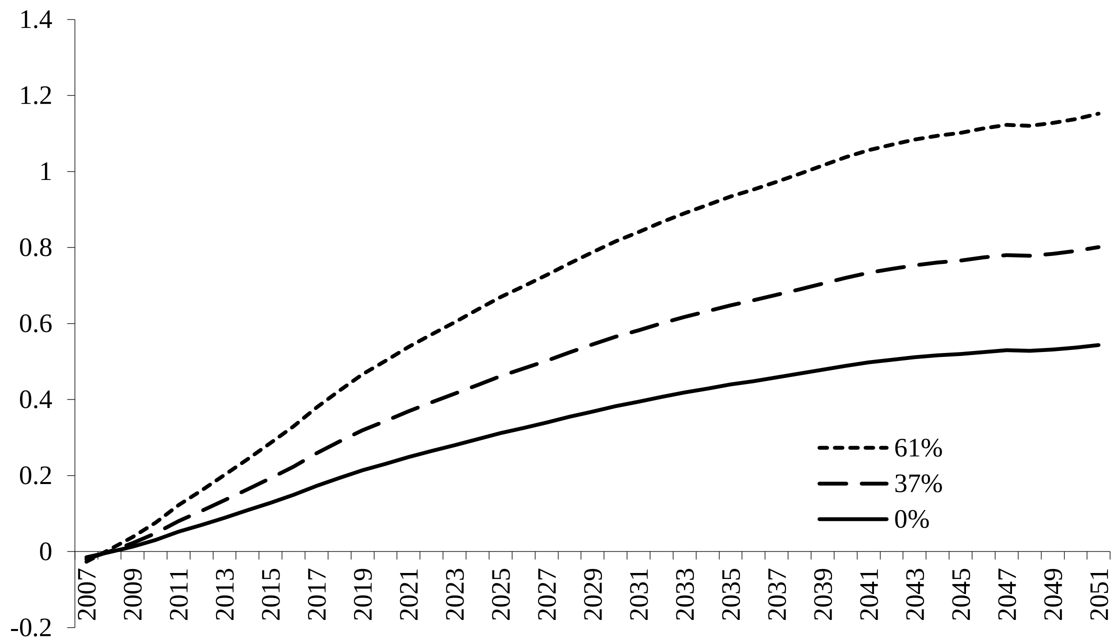


Figure 4.7. The total impact of the increasing proportion of graduates in the Scottish labour force on employment.



The adjustment paths for employment are shown in Figure 4.7. In the first period increase in labour productivity has a small but negative effect on employment. In this period the efficiency effect dominates the competitiveness effect. However, starting from the second period the aggregate effect becomes positive. Investors anticipate higher profitability in the future and consumers anticipate higher wealth, leading both to bring spending forward and increase aggregate demand.

Finally, note that we have not addressed the issue of the scale and valuation of the private *non-market* benefits of higher education that would have to be included in any comprehensive assessment of the total costs and benefits associated with HEIs. McMahon's (2009, chpt 4) estimate that these are equivalent to over 120% of the private market return (of which a very substantial portion are health-related), suggests that they at least merit further rigorous investigation. If these impacts seem surprisingly large, McMahon (2009) would argue that this is an indication of a significant information failure, rather than an estimation problem (though there are, indeed, many of those to be overcome), with clear policy implications.

5. Conclusions

In this paper we adopt a "micro-*to*-macro" approach for assessing the external returns to higher education. In principle, the HEI-disaggregated CGE modelling framework that we develop allows us to assess the system wide impacts of individual external benefits or of non-market private benefits (or groups of either or both), in addition to the more intensively researched private market benefits of higher education. Furthermore, the transmission mechanisms from HEIs to economic activity are identified and causality is clear within the simulation framework. The approach therefore offers some potential advantages relative to the "macro *less* micro" approach that characterises much of the literature in the UK, in which macroeconomic returns to education are used to identify externalities when compared to microeconometric 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) and cannot be used to explore the non-market private benefits that higher education may convey.

However, our analysis also demonstrates the importance of the "in principle" qualification in the preceding paragraph: implementation of the micro-to-macro approach on Scottish data is problematic, given the very limited range and depth of existing microeconometric analyses of higher education externalities. Firstly, we have not generally been able to use Scottish-specific estimates of social returns to education, for the simple reason that they typically do not exist. Secondly, some of the studies of social returns to higher education that do exist are themselves exploratory. There is no counterpart to the breadth and depth of studies of the estimates of the private market returns to higher education, in the analysis of social or private non-market returns for any country or region. Thirdly, we have not exploited the full possibilities of the micro-to-macro approach in that here we do not attempt a comprehensive coverage of social benefits of higher education; rather, because of the limited evidence, we simply try to provide an illustrative analysis of three types of externalities, and then an indication of the overall scale of social benefits if expressed in terms of "equivalent" private market returns. Fourthly, we do not attempt to assess the private non-market benefits of higher education, although the micro-to-macro framework offers this possibility.

Clearly, the nature of an illustrative study of this kind is that the list of further research is challenging: indeed part of the motivation in attempting to implement the micro-to-macro approach is to reveal the extent of the current gaps in our knowledge. Firstly, and most crucially, there is a need for further microeconometric studies of HEI externalities in a UK-wide and regional context. While there are major issues to be resolved here, it is difficult not to believe that 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. Secondly, 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. Thirdly, within the basic framework it would be comparatively straightforward to offer a finer analysis of impacts that distinguished, for example, among graduates by subject area and allowed for possible industry-specific effects. Fourthly, the analysis can be applied to other regions and nations: certainly the CGE modelling framework can be implemented for the main country-regions of the UK. Fifthly, there are issues relating to the issue of full spatial equilibrium that should be further investigated in a UK context, especially given that labour mobility among UK regions is significantly lower than in the US. Sixthly, but closely related, is the need for an explicitly interregional framework that can accommodate the interdependencies of the regional higher education systems of the UK, and of their host regions through trade and factor flows. Finally, the complexity of spillovers in the context of a system of multi-level governance raises issues of the appropriate coordination of higher education and other policies across UK regions. The impending funding challenges for higher education add to the urgency of research into these key policy issues. However, the potential scale of externalities presents a particular challenge for those who support HE funding policies that appear to be predicated on an implicit assumption that the external benefits of HE are negligible.

Appendix 1: Forward Looking Consumption and Production

A1.1 Consumer Preference

The decision problem for the representative consumer is to choose a sequence of consumption that maximizes the present value of utility, as summarized by the lifetime utility function:

$$\int_0^\infty U(C_t)e^{\rho t}dt\,;\quad U(C_t)=\frac{1}{1-\sigma}C_t^{1-\sigma}\,; \qquad \text{(A1.1)}$$

discounted by the consumer's rate of time preference ρ and with constant elasticity of marginal utility σ. The present value of consumption $\sum_t^\infty \mu(t)Pc_tC_t$ must not exceed total wealth, *W*; where $\mu(t)=\prod_t(1+r_t)^{-1}$ and r_t is the interest rate which is kept constant over time. In our configuration we distinguish between financial wealth (FW) and non financial wealth (NFW), such that $W_t = NFW_t + FW_t$ and in which:

$$NFW_t(1+r_t) = NFW_{t+1} + (1-\tau_t)L_t^s\cdot(1-u_t)\cdot w_t + \sum_h\sum_{dngins} TRSF_{h,dngins,t} + \sum_h TRG_h\cdot P + \sum_h REM_h\,\varepsilon - \sum_{dngins}\sum_h TRSF_{dngins,h,t} \qquad \text{(A1.2)}$$

The variables $L_t^s, w_t, TRSF_{h,dngins,t}$, u_t and τ_t are respectively working population, nominal wage rate before tax, the transfer matrix between households (*h*) and domestic no-governmental institutions **(***dngins*), the unemployment rate and the rate of income tax. The transfer from the Government (*TRG*), remittance (*REM*) and the exchange rate (ε) are fixed.

Financial Wealth (FW) evolves as follows:

$$FW_t(1+r_t) = FW_{t+1} + \Pi_t - S_t \qquad \text{(A1.3)}$$

where Π_t and S_t are respectively capital income and saving. In the model saving can be obtained as a function of the current level of income and interest rate (which is the default closure)

Once the optimal path of consumption is obtained, the aggregate consumption is allocated within each period for the *i* commodities and for five different groups of income. Household demand for regional and imported goods is the result of the intra-temporal cost minimization problem.

A1.2. Technology

A1.2.1 Production. Intermediate inputs (*VV*), labour (*L*) and capital (*K*) constitute the production inputs of the model. *L* and *K* are combined in a CES production function in order to produce value added, *Y*, allowing for substitution among primary factors of production while Leontief technology between *VV* and *Y* is imposed. Intermediate goods produced locally or imported are considered as imperfect substitutes.

A1.2.2 Investment. The decision problem of the representative firm is to choose the path of investment that maximize the present value of its cash flow given by profit, π_t, less investment expenditure, *I* subject to the presence of adjustment cost $g(x_t)$ where $x_t = I_t / K_t$:

$$Max \int_0^t [\pi_t - I_t(1 + g(x_t))] e^{-\int_0^t r_v dv} \quad \text{subject to} \quad \dot{K}_t = I_t - \delta K_t \qquad \text{(A1.4)}$$

The solution of the dynamic problem gives us the law of motion of the shadow price of capital, λ_t and the time path of investment related on the tax-adjusted Tobin's *q* and an adjustment cost parameter z:

$$\frac{I_t}{K_t} = \frac{1}{z}\left[\frac{\lambda_t}{Pk_t} - (1 - b - \tau k)\right]; \qquad \dot{\lambda} = \lambda_t(r + \delta) - rk_t - Pk_t\left[\frac{I_t}{K_t}\right]^2 g^{'}(I_t / K_t); \qquad \text{(A1.5)}$$

where *Pk* is the replacement cost of capital, *rk* is the rate of return to capital and *b* is a calibrated parameter.

The model calibration process assumes the economy to be initially in steady state equilibrium. The parameters of the models are obtained from the Scottish SAM for the year 2004 by means of the usual calibration method. The value of adjustment cost parameter *z* in equations (XX) is assigned values 1.5. The world interest rate is set to 0.04, the rate of depreciation to 0.15 and the constant elasticity of marginal utility σ is equal to 0.9. Given the value of total investment, *J*, through the capital matrix, $KM_{i,j}$, the equality condition with total investment by origin in the SAM holds true. The price of capital goods, *Pk*, is set equal to unity since the benchmark prices on the consumption side are set equal to unity. *W* corresponds to the discounted flow of current income, *NFW* to the discounted flow of net labour income, and *FW* is obtained by maintaining asset equilibrium.

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