Research Policy 44 (2015) 748–764

Contents lists available at ScienceDirect

Research Policy

journal homepage: www.elsevier.com/locate/respol

Economic impact of entrepreneurial universities' activities: An exploratory study of the United Kingdom

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ARTICLE INFO

Article history:
Received 21 November 2013
Received in revised form 13 October 2014
Accepted 28 October 2014
Available online 26 November 2014

Keywords:
Entrepreneurial universities
Economic impact
Entrepreneurial economy
Knowledge transfer
Endogenous growth theory
United Kingdom

ABSTRACT

Throughout economic history, institutions have established the rules that shape human interaction. In this sense, political, socio-cultural, and economic issues respond to particular forces: managed economy or entrepreneurial economy. In the entrepreneurial economy, the dominant production factor is knowledge capital that is the source of competitive advantage, which is complemented by entrepreneurship capital, representing the capacity to engage in and generate entrepreneurial activity. Thus, an entrepreneurial economy generates scenarios in which its members can explore and exploit economic opportunities and knowledge to promote new entrepreneurial phenomena that have not been previously visualised. In this context, the entrepreneurial university serves as a conduit of spillovers contributing to economic and social development through its multiple missions of teaching, research, and entrepreneurial activities. In particular, the outcomes of its missions are associated with the determinants of production functions (e.g. human capital, knowledge capital, social capital, and entrepreneurship capital). All these themes are still considerate potentially in the research agenda in academic entrepreneurship literature. This paper modestly tries to contribute to a better understanding of the economic impact of entrepreneurial universities' teaching, research, and entrepreneurial activities. Taking an endogenous growth perspective, the proposed conceptual model is tested using data collected from 2005 to 2007 for 147 universities located in 74 Nomenclature of Territorial Units for Statistics-3 (NUTS-3) regions of the United Kingdom. The results of this exploratory analysis show the positive and significant economic impact of teaching, research, and entrepreneurial activities. Interestingly, the higher economic impact of the United Kingdom's entrepreneurial universities (the Russell Group) is explained by entrepreneurial spin-offs. However, our control group composed by the rest of the country's universities, the highest economic impact is associated with knowledge transfer (knowledge capital).

1. Introduction

Throughout economic history, institutions have established the societal rules that shape human interaction (North, 1990) and have contributed to the configuration of the main sources of growth during the process of economic change (North, 2005). This fact explains why political, socio-cultural, and economic issues respond to particular forces: the managed economy and the entrepreneurial economy. According to Audretsch and Thurik (2001), in the managed economy there are many products (bulky ones in the lower parts of the production chain) and services (distribution and communication networks) that can be best offered in a routinised and predictable approach. On the other side, the entrepreneurial economy is not confined to the role of small businesses and business owners, but also it is the pervasive socio-economic mindset of thinking in terms of opportunities rather than in terms of resources. It is based upon ideas and knowledge rather than on investments that create more of the same. It is based upon persons rather than on organisations (Bonnet and Van Auken, 2010). Therefore, while the central theme of the entrepreneurial economy is the exploration of entrepreneurial opportunities (based on knowledge inputs/outputs and characterised by uncertainty, government enabling, the economies of diversity, and small enterprises), the managed economy focuses on the exploitation to transform traditional inputs (land, labour, capital) into manufactured products (characterised by certainty, governmental control, the economies of scale, and large corporations).

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http://dx.doi.org/10.1016/j.respol.2014.10.008
0048-7333/

Following this perspective, in each economic model, institutions facilitate the activity that serves as the driving force underlying economic growth and prosperity. In particular, the main focused of this paper is the entrepreneurial economy, where the dominant production factor is knowledge capital as the source of competitive advantage, which is complemented by entrepreneurship capital, representing the capacity to engage in and generate entrepreneurial activity (Audretsch, 2007). Thus, an entrepreneurial economy generates scenarios in which its members can identify and exploit economic opportunities and knowledge to promote new entrepreneurial phenomena that have not been previously visualised (Mueller, 2007; Shane, 2005). An increased importance of the university, in terms of its impact on the economy, is observed within the entrepreneurial economy (Aldrich, 2012; Audretsch, 2012). For these reasons, universities become more entrepreneurial in order to compete, and they become more productive and creative in establishing links between education and research (Kirby et al., 2011). Moreover, an entrepreneurial university can provide new alternatives to the university community, which typically identifies entrepreneurial opportunities (Guerrero and Urbano, 2012). As a consequence, the economic impact of universities has gained the attention of academics, governments, and policymakers around the world, who in turn are making efforts to encourage these universities.[1]

Given the complexity of university functions, previous studies have evidenced the economic impact of university teaching, research, or entrepreneurial activities by adopting different theoretical approaches and methodologies (Drucker and Goldstein, 2007). Traditionally, in the 1980s, the analysis focused on the impact via the labour force supported on the foundations of a managed economy, and research was conducted using descriptive input–output analysis at the university level (Elliott et al., 1988). In the 1990s too, the methodology of choice to measure the economic impact of university research activities was input–output analysis (Goldstein, 1990; Jaffe, 1989). Later, in the 2000s, more sophisticated methodologies were employed (i.e. productivity, total factor productive analysis, return of investments analysis, quartile regression analysis, etc.) to explore the direct impact of specific research activities or the indirect impact of knowledge spillover (Audretsch et al., 2005; Bessette, 2003; Guerrero and Urbano, 2014; Martin, 1998; Roessner et al., 2013; Siegel et al., 2003). However, the natural role of universities in economic development is less well understood than is often presumed (Bramwell and Wolfe, 2008). According to the microeconomic foundation of endogenous economic theory (Lucas, 1988; Romer, 1986), investments in knowledge and human capital generate economic growth. However, beyond generating commercialisable knowledge (patents, licenses, and agreements) and qualified research scientists (graduate students), universities produce other impacts, such as the generation of and attraction to new ventures, jobs, talent, and collaborations with local, regional, and international agents. According to Audretsch (2012, p. 7), the role of entrepreneurial universities is broader than only generating and transferring knowledge; an entrepreneurial university contributes and provides leadership for the creation of entrepreneurial thinking, actions, institutions, and what he refers to in his previous studies as 'entrepreneurship capital'. Under this scenario, entrepreneurial universities have emerged as central actors playing an active role in promoting teaching, innovation, knowledge transfer, and entrepreneurship (Urbano and Guerrero, 2013).

There are still some themes to be covered in the research agenda of academic entrepreneurship such as appropriate measures and method to study this phenomenon (Grimaldi et al., 2011, p. 1053). Based on that, our main objective is to contribute to a better understanding of the economic impact of entrepreneurial universities' activities (teaching, research, and entrepreneurial). With this objective, our conceptual framework fundamentally adopts the Endogenous Growth Theory with the understanding that the main forces of economic growth—in particular, investment in human capital, knowledge, and entrepreneurship—are endogenous (Audretsch and Keilbach, 2004a,b). The endogenous growth theory primarily holds that the long-run growth rate of an economy depends on policy measures such as subsidies, support measures, or incentives, to increase the growth rate (Romer, 1986). For this reason, Mustar and Wright (2010) argued that the creation of new start-ups could be explained by the convergence or path-dependent effect of policies fostering entrepreneurship. Methodologically, this exploratory study tests the proposed model of the economic impact of entrepreneurial universities with a structural equation analysis, using data from 2005 to 2007 from the Higher Education Statistics Agency (HESA) and the Centre for International Competitiveness in the United Kingdom. The modest contributions of this study are twofold. We propose a theoretical framework to understand the economic impact of each entrepreneurial university's core activity (teaching, research, and entrepreneurship) on the entrepreneurial economy. We also explore a new way to test this phenomenon and overcome the shortcomings of other techniques, such as input–output analysis (i.e. the economic impacts of universities extend well beyond the types that can be accounted for in this analysis).

We begin our paper by putting into context entrepreneurial universities and the range of social economic impact. In doing so, we highlight previous approaches that have been taken to measure the impact of universities, using descriptive or financial analysis, input–output modelling, and total factor productivity modelling. We then describe our conceptual framework adopting the determinants of production functions (human, knowledge, and entrepreneurship capital). Later, we describe the data collection, proxies, and methodology used in the paper. We conclude by presenting our results, implications for policy and practice, and the limitations of the study. We also suggest some areas for future research.

2. Entrepreneurial universities' activities and economic impacts: an endogenous growth perspective

2.1. Economic impact of universities: previous measures

Methods to empirically investigate universities' economic impacts have advanced since the 1980s. Today, more robust measures and more sophisticated analytical methods are applied to explore these impacts. The unit of analysis has also grown from being single campus-based studies to a system-wide university analysis (see Table 1). The main focus of these studies has been input-output relationships rather than the economic impact. They measured outputs in terms of contributions via the labour force (Bessette, 2003; Chrisman et al., 1995; Elliott et al., 1988), revenues obtained from patents, R&D collaborations (Siegel et al., 2003), spillover effects (Audretsch and Lehmann, 2005), or total university earnings (Goldstein, 1990). On the other hand, the main inputs were associated with direct expenditures incurred to develop the inputs (Bessette, 2003; Goldstein, 1990) and total factor productivity (Martin, 1998; Roessner et al., 2013; Siegel et al., 2003;

[1] According to the ISI Web of Knowledge (Thomson Reuters), the results for the search term 'economic impact of university activity' show that approximately 317 papers analysing the economic impact of universities were published during the last 20 years (1994–2013). Interestingly, more than 50% of these papers were published in the last five years (2009–2013) alone.

Table 1
Selection of previous empirical studies that measured the economic impact of universities.

Author	Year	Journal	Analysis	Unit of analysis	Variables	Key findings
Elliott et al.	1988	Research in Higher Education	Descriptive analysis (university community survey)	Universities located in Illinois	• Contribution to local workers' skills • Relationship between research and local industry • Effects on business location	An analytical framework for evaluating performance
Jaffe	1989	The American Economic Review	Times series analysis of the spillover effect of university research	Times series data of research by US universities	• Dependents: corporate patents, corporate R&D, industry research • Independents: funding, number of public/private universities, population	The significant effect of university research on corporate patents and the indirect effect on local innovation
Goldstein	1990	Planning for Higher Education	Regional input–output analysis	The University of North Carolina	• Inputs: direct expenditures • Outputs: total earnings	A powerful estimation of the economic impact of universities, but with several limitations
Chrisman et al.	1995	Journal of Business Venturing	Descriptive analysis	University of Calgary	• Spin-offs (profit and not profit) • Jobs created • University community's perceptions about the role of the university	The contribution of these new ventures in the generation of new jobs in Alberta
Martin	1998	Research Policy	Total factor productivity	R&D by Canadian universities	• GDP • Total factor productivity (human capital, knowledge capital, and other production factors)	The relevance of university R&D when it is translated into economic growth via a dynamic approach
Siegel et al.	2003	Research Policy	Productivity analysis	Five US research universities	• Cobb–Douglass function • Outputs: agreements or revenues by licenses • Inputs: invention disclosure, staff, and legal expenditures	Technology Transfer Office activity is characterised by constant returns to scale and variations in performance are explained by environmental and institutional factors
Bessette	2003	Journal of Technology Transfer	Return on investment (ROI)	Case study of one US university and three US companies	• Output (total economic output of sponsored projects (products, licenses, training, start-ups, knowledge spillovers, jobs created and retained, etc.)) • Cash operating cost • Investment (public and private universities)	A possible method for a public funding agency to quantify and tabulate research outputs such that economic impacts are reported as a percent return on investment or ROI
Audretsch et al.	2005	Research Policy	Quantile regression analysis	German universities and firms	• Spillover mechanisms of research • Spillover mechanisms of human capital • Proximity of the firms to the university	Spillover mechanisms as well as the type of spillover are heterogeneous
Simha	2005	Tertiary Education and Management	Descriptive analysis	Eight Boston universities	• Exploitation of patents and licenses • Talent/labour force • Funding sources	E economic activity is concentrated in the universities' regions
Bramwell and Wolfe	2008	Research Policy	Descriptive analysis	University of Waterloo, Canada	• Spin-off companies and employment created • University-industry relationships • Talent attraction and retention	Illustrated the manner in which the university has contributed to growth and innovation
Daim and Ozdemir	2012	Journal of Knowledge Economy	Impact of economic crisis	US research universities	• University R&D input: expenditures • University R&D outputs: spin-offs, patents, educated work force, product, and product innovations	An increase in government investments, but the result is not statistically significant
Roessner et al.	2013	Research Policy	Input–output analysis	Licensing data from US universities	• Changes in income (GDP) • Expenditures (salaries, equipment, costs, etc.) • Expenditure or research (R&D investments)	Estimates of the economic impact of university licensing income based on a range of product substitution rates

Source: Authors.

Urbano and Guerrero, 2013). Only a few studies related the economic impact to the change in the gross domestic product (GDP) (Martin, 1998; Roessner et al., 2013).

While previous studies provide interesting insights about the role of universities on economic development, the main limitations are posed by the complexity and dynamic characteristics of university outcomes and their transformation into economic impacts. Based on the variables and methods used, most previous studies considered the role of the university under a managed economy, where the traditional core activities of universities are linked to teaching and research. In other words, in the managed economy, the force is large-scale production, reflecting the predominant production factors of capital and unskilled labour as the sources of competitive advantage, while in the entrepreneurial economy, the dominant production factor is knowledge capital as the source of competitive advantage, which is complemented by entrepreneurship capital, representing the capacity to engage in and generate entrepreneurial activity (Audretsch and Keilbach, 2004b). Therefore, the economic contribution of universities should be studied within an entrepreneurial economy. In particular, it is vital to investigate how entrepreneurial universities' activities could be transformed into predominant production factors contributing to social and economic development in the long term (Guerrero and Urbano, 2014; Guerrero et al., 2014; Urbano and Guerrero, 2013).

2.2. Entrepreneurial universities: characteristics, missions, and contributions to economic growth

An entrepreneurial university is characterised by organisational adaptation to environmental changes (Clark, 1998), its managerial and governance distinctiveness (Subotzky, 1999), new activities oriented to the development of entrepreneurial culture at all levels (Kirby, 2002), its contribution to economic development with the creation of new ventures (Chrisman et al., 1995), or the commercialisation of research (Jacob et al., 2003). Applying these parameters, the entrepreneurial university has the ability to innovate, recognise, and create opportunities, work in teams, take risks, and respond to challenges (Guerrero and Urbano, 2012). Moreover, it can devise a substantial shift in organisational character to take on a more promising posture for the future (Clark, 1998). In general, these universities provide adequate environments for their students, academics and staff to explore/exploit entrepreneurial activities. Following this perspective, in the entrepreneurial economy, the role of the university is considerably broader than simply facilitating technology transfer (Audretsch, 2012). More concretely, the entrepreneurial university is required to fulfil three missions simultaneously, which otherwise might be at odds with one another: teaching, research, and entrepreneurship (Fig. 1).

Through the outcomes of those missions, directly or indirectly, universities contribute to the economic development of the city/region/country where is localised. More concretely, the most basic proposition of growth theory is that in order to sustain a positive growth rate of output per capita in the long run, there must be continual advances in technological knowledge in the form of new goods, new markets, or new processes (Aghion et al., 1998). For neoclassical economists, knowledge has been an independent variable in the sense that it is considered external to the economic system; that is, in the production function, technical change is taken as the residual that could not be explained directly by the key input factors of capital and labour. Nevertheless, by the beginning of the 1980s, most economists started to interpret technology as an endogenous variable to be explained by the economic conditions of production, which for neoclassical thought is already becoming the systematised theory of "endogenous economic growth" (Corona et al., 2006). Audretsch and Keilbach (2004a,b) also introduced a new factor, entrepreneurial activity, and linked it to output in the context of a production function model. It explains how some contexts generating a high propensity for economic agents to start new firms can be characterised as being rich in entrepreneurial activity, while other contexts, where the start up of new firms is inhibited, can be characterised as being weak in entrepreneurial activity. Entrepreneurial activity therefore can contribute to output and growth by serving as a conduit for knowledge spillovers, increasing competition, and by injecting diversity. Therefore, the endogenous economic growth model introduced a new factor, knowledge (technology), rather than leaving it as an undetermined residual, the "invisible hand" as had been the case in Solow's neoclassical model (Romer, 1986; Lucas, 1988).

In this scenario, the role of university has been understood as a provider of knowledge (technology), with its innovative context as an important source of economic growth. Also, similar to a business life-cycle, universities also experience several stages of entrepreneurial evolution (Guerrero and Urbano, 2012). Indirectly or directly, the evidence of this issue is observed in the main differences of budget distribution and in the university indicators or university rankings across countries (Aghion et al., 2010; Hazelkorn, 2007; McCormack et al., 2014). Universities in different environments may face varying challenges in the development of successful spin-off companies involving the transfer of technology and knowledge from universities (Wright et al., 2007). Under this perspective, measuring the impacts of universities has become more complex. Despite such challenges, there has been some progress. For example, in US several authors have examined and corroborated the impact of public higher education on national and regional economies (Feldman and Desrochers, 2003; Lendel, 2010; Vogel and Keen, 2010). Undoubtedly, the entrepreneurial university generates several direct outcomes from teaching, research, and entrepreneurial activities. Concretely, these outcomes could be transformed into a determinant of economic development based on the endogenous growth theory (Audretsch and Keilbach, 2004a,b; Coleman, 1988; Lucas, 1988; Romer, 1986; Solow, 1956), and later, they could produce positive impacts on the economy and society of a specific region. For instance, teaching activities have been the universal function of universities (Kirby et al., 2011). Universities educate and train students, who become jobseekers or job creators after graduation (Schulte, 2004). Hence, entrepreneurial universities could have an impact on economic notions about human capital. Human capital, considered a factor of production by Lucas (1988), refers to the stock of competencies, knowledge, abilities, and skills gained through education and training (Becker, 1993). Therefore, entrepreneurial universities could contribute to economic impacts through the generation, attraction, and retention of talented human capital and entrepreneurs (Bramwell and Wolfe, 2008; Ghatak et al., 2007; Simha, 2005).

H1. *The outcomes of entrepreneurial universities' teaching activities have a positive effect on economic development.*

According to Wright et al. (2007), the nature of universities is changing as reduced public funding reflects a public debate about their role in society. A relevant point of discussion is an increasing emphasis on the commercialisation of university research, in particular bringing the development of commercialisation beyond the traditional focus on licensing of innovations (Thursby and Thursby, 2002). Greater attention is now being applied internationally to the creation of new ventures that involve the spinning-off of technology and knowledge generated by universities. Following the traditional focus of academic entrepreneurship, within the new knowledge-based economy, research activities are another legitimate university function. This function has been identified as the generation, transfer, and commercialisation of new knowledge (Romer, 1986; Solow, 1956). Examples of traditional mechanisms to commercialise knowledge include copyrights, patents, licenses,

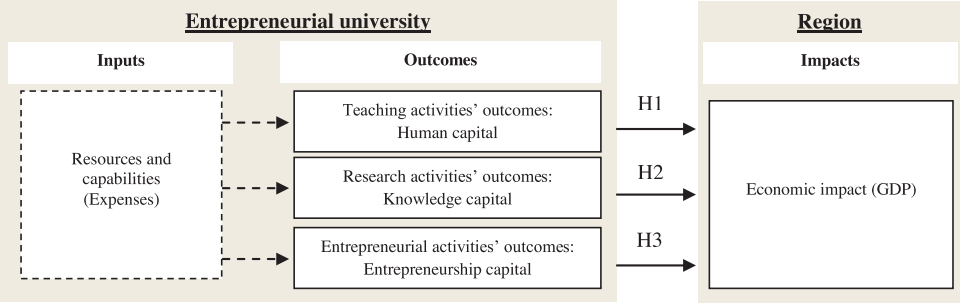

Fig. 1. Proposed conceptual framework. *Note:* [ ], Not tested in this study.

and trademarks. Several authors identify this phenomenon as academic entrepreneurship occurring at the boundaries of different scientific and professional backgrounds, creating a need for support mechanisms to transcend those boundaries (Cunningham et al., 2014; Urbano and Guerrero, 2013). In US, this phenomenon has been evident for 30 years since the enactment of the Bayh–Dole Act that is linked with the entrepreneurial and economic development activities of the universities. While some member countries of the Organisation for Economic Co-operation and Development (OECD) have reformed legislations related to academic entrepreneurship along these lines, several research opportunities remain untapped at the system, university, and individual levels (Grimaldi et al., 2011). Thus, the economic and social impact of entrepreneurial universities could be associated with the generation, attraction, and retention of prestigious researchers (Bramwell and Wolfe, 2008), who facilitate innovation and knowledge transfer (Passhe, 2005).

H2. *The outcomes of entrepreneurial universities' research activities have a positive effect on economic development.*

Moreover, following the modern focus of academic entrepreneurship, entrepreneurial activities focus on the creation of new companies that could enhance local job growth and regional development by promoting partnerships in key regional clusters that identify and meet needs (Porter, 2007). As a result, entrepreneurship is a phenomenon observed at all university levels: university management, academicians, researchers, and potential entrepreneurs among the undergraduate and postgraduate students. According to Audretsch and Keilbach (2004a,b), entrepreneurship is another element in the production function, because entrepreneurship contributes to output and growth by serving as a conduit for knowledge spillovers, increasing competition, and injecting diversity. Thus, an entrepreneurial university could attract or generate new enterprises that promote competition and diversity (Clarysse et al., 2005; Shane, 2005; Vohora et al., 2004; Wright et al., 2007). Consequently, these impacts could produce several externalities in terms of demography, economy, infrastructure, culture, mobility, education, and society challenges that will later be reflected in productivity, competitive advantages, regional capacities, regional networks, regional identity, and regional innovation (Goldstein and Renault, 2004; Passhe, 2005; Porter, 2007; Powers and McDougall, 2005).

H3. *The outcomes of entrepreneurial universities' entrepreneurship activities have a positive effect on economic development.*

3. Measuring the economic impact of entrepreneurial universities

3.1. Data

Given the nature of our study, one of the challenging aspects of measuring the economic impact of entrepreneurial universities is data for teaching, research, and entrepreneurial activities as well as its quality, particularly when the impact of these activities would be not evidenced in the same year. Martin (1998) recognised the relevance of static and dynamic approaches for measuring the economic impact of universities' activities. However, these types of analyses require panel data that allow for identification of effects during several points in the time. Unfortunately, obtaining data on entrepreneurial universities' activities at the university level is not an easy task (Audretsch and Lehmann, 2005). An alternative adopted in research collaboration studies is using 2–5 year time lags between the development of the entrepreneurial university's activities and its effects (Berman, 1990). To tackle the situation, we developed an exploratory study to analyse the economic impacts of entrepreneurial universities using university-level data of universities in the United Kingdom. We collected secondary data from several official databases, namely, the Higher Education Funding Council for England (HEFEC), HESA, and the Centre for International Competitiveness. The sample was integrated for 147 public universities in the United Kingdom for the period 2005–2007, as the required information was available for all the variables being analysed. Adopting the European Nomenclature of Territorial Units for the United Kingdom (NUTS)[2] we identified that the 147 universities are located in 74 of the 139 NUTS-3 regions of the country.

According to McCormack et al. (2014, p. 5), in UK there are 158 universities that have degree-awarding powers. Most of these universities are not-for-profit, and although they all undertake both research and teaching, the balance between these activities varies. Traditionally, UK universities are divided into "old universities" (founded pre-1992), which are typically more research-focused, and "new universities," which have been granted university status post-1992 as part of a government drive to increase participation in degree-level education. Arguably, however, there is also a further divide between the 24 most research-intensive older universities (known as "the Russell Group," which account for around 15% of the sector but 75% of all research income) and other groups (i.e., older/newer universities and former polytechnics) offering higher diplomas and degrees, often in more technical subjects, that are governed and administered at the national level (Aghion et al., 2010; McCormack et al., 2014). We adopted a criterion to identify entrepreneurial universities in this paper: the university must be part of the Russell Group[3,4] which represents the leading UK

[2] Based on the European NUTS-2, the United Kingdom is divided into 12 major economic regions (NUTS-1), 37 basic regions for the application of regional policies (NUTS-2), and 139 small regions (NUTS-3). For further information, please visit http://epp.eurostat.ec.europa.eu/portal/page/portal/nuts_nomenclature/introduction.

[3] For further information, visit http://www.russellgroup.ac.uk/home/.

[4] These universities are also listed in the Times Higher Education World Ranking, which is designed to categorise a broad range of university activities, from teaching (learning environment) and research (income, reputation, and research influence) to knowledge transfer (innovation), into 13 separate

universities with the commitment to maintain higher standards of education and learning, world leading research, wealth of the nation through unrivalled links with the business/public sector, and a huge impact on the social, economical, and cultural well-being of their regions. In general, this group of universities covers the criteria used to identify entrepreneurial universities in previous studies (Clark, 1998; Di Gregorio and Shane, 2003; Guerrero and Urbano, 2012; O'Shea et al., 2007; Shane, 2005; Wright et al., 2007). In particular, the university must promote an entrepreneurial culture by employing strategic actions that allow for adaptation to environmental changes, and it must make self-instituted efforts to change its general character by strengthening its core activities (teaching, research, and entrepreneurial initiatives). More concretely, Annex A summarises the alignment of the Russell Group of universities' commitments with the theoretical criteria by each university mission. Based on that, we believe that the Russell Group is a good proxy to identify entrepreneurial universities in UK. With this understanding, Annex B denotes our selection of entrepreneurial universities in our sample.

3.2. Variables

Previous measurement models of entrepreneurial universities employed the input-output approach, which focuses on a limited number of independent variables specifically orientated around teaching and research. We have expanded on these variables (Table 2).

Our dependent variable is Ln_GVA per capitat_{+2}, where GVA is the gross value added. The GVA per capita is a measure of the value of goods and services produced in an area of an economy linked as a measurement to the GDP, identified at the NUTS-3 level for the region within which each analysed university is located. Therefore, this proxy allows us to explore the economic effect of each entrepreneurial university's activities in the county/region it is located in, using a 2-year time lag (Audretsch, 2012; Martin, 1998; Roessner et al., 2013). The use of lagged values of the GVA per capita enables us to avoid problems of simultaneity and endogeneity between our main independent and dependent variables. This lagged relationship also reflects causality between an entrepreneurial university's activities in one period and its economic impacts in subsequent periods (Audretsch and Keilbach, 2004a). Undoubtedly, it is difficult to estimate the exact time within which the effects of the university's activities would be observed. For this reason, and to avoid additional bias produced by the current global financial crisis (2008–2011), we adopted a lag of two years. In addition, we used logarithms to reduce the possible variance that arises due to the different scales/measures used. According to Sala-i-Martin (2002), the use of logarithms in economics allows for more uniform measurement scales.

On the other hand, our independent variables were grouped according to each university's outcome: teaching, research, and entrepreneurial activities. Regarding teaching activities, the main outcome is Ln_Employment ratet_0 or the natural logarithm of the employment indicator per student and per university in the year of analysis (Bessette, 2003; Martin, 1998; Urbano and Guerrero, 2013). With respect to *research activities*, the outcomes are measured with a construct integrated by the following five variables in the year of analysis: (i) Ln_Research collaborationst_0 or the natural logarithm of the total value of research collaborations per staff (Bramwell and Wolfe, 2008), (ii) Ln_Research contractst_0 or the natural logarithm of the total value of research contracts per staff (Bessette, 2003), (iii) Ln_Consultancyt_0 or the natural logarithm of the total value of research consultancy per staff, (iv) Ln_Facilitiest_0 or the natural logarithm of the total income from facilities services per staff (Clark, 1998) and (v) Ln_Intellectual propertyt_0 or the natural logarithm of the income from all intellectual property agreements per staff (Klofsten and Jones-Evans, 2000; Roessner et al., 2013; Siegel et al., 2003).

For entrepreneurial activities, the outcomes are measures with a construct integrated by the following four variables in the year of analysis: (i) Ln_Spin-offs with university ownershipt_0 or the natural logarithm of the ratio of active spin-offs owned by the universities to the country's population, (ii) Ln_Spin-offs without university ownershipt_0 or the natural logarithm of the ratio of active spin-offs not owned by the universities to the country's population, (iii) Ln_Spin-offs with staff ownershipt_0 or the natural logarithm of the ratio of active spin-offs owned by the staff to the country's population and (iv) Ln_Spin-offs with graduated ownershipt_0 or the natural logarithm of the ratio of active spin-offs owned by graduates/alumni to the country's population(Bessette, 2003; Bramwell and Wolfe, 2008; Chrisman et al., 1995).

Our main control variable was Ln_Expensest_0 or the natural logarithm of the total expenditure of all university activities per student. This variable encompasses the salaries of university staff and the operating expenses associated with the outcomes for a particular year (Daim and Ozdemir, 2012; Elliott et al., 1988; Landry et al., 2006; O'Shea et al., 2005). Based on the resource-based view approach, this variable serves as a proxy for the internal factors (resources and capabilities) that contribute to generate the entrepreneurial university's outcomes (Wernerfelt, 1995). Finally, we included Ln_GVA per capitat_{-1} to control the inverse relationship between entrepreneurial universities' activities and economic impact (Audretsch and Keilbach, 2008; Audretsch et al., 2008). By including this variable, we can control the possible effect of the level of GVA on the university's budget/expense for each core activity. For this variable, we consider a lag of one year before the period of analysis, because universities estimate their budgets a year ahead based on the funds they expect to receive.

3.3. Statistical analysis

University impacts have been measured through flexible econometric studies, targeted and well-designed surveys administered simultaneously at many organisations, and input–output analysis of the inter-industry impacts of university expenditures (Drucker and Goldstein, 2007). In this study, given the nature of the data and taking into account previous studies (Audretsch et al., 2008), we adopted structural equation modelling (SEM) to analyse the results at the university level. SEM pinpoints causal relationships among the variables that integrate the proposed model of antecedents and consequences of entrepreneurial universities. This statistical technique has been widely used in behavioural sciences during the last decade (Shook et al., 2004), because it allows the examination of a set of relationships between one or more independent or dependent variables, either continuous or discrete (Tabachnick and Fidell, 1996). This statistical technique also allows continuous time modelling of panel data, longitudinal growth modelling, and two-step modelling. Unfortunately, our sample size is not the most adequate for us to attempt these types of modelling. Therefore, we developed two different models using time lags (see Annexes C and D). The models are useful in that they helped us to control the causation effect between the GDP and entrepreneurial universities' activities (Model A) and vice versa (Model B). This is a common problem observed in studies that have explored the impact of entrepreneurship on economic growth, and it may be tackled using two-step models via instrumental variables (Audretsch et al., 2008). Furthermore, the construct satisfied the parameters of reliability and

indicators. For further information, please visit http://www.timeshighereducation.co.uk/world-university-rankings/. Keeping in mind that international ranking systems influence a university's strategic direction and decisions (see Hazelkorn, 2007).

Table 2
Description of variables and descriptive statistics.

Type	Construct	Variable	Mean	SD	Data source	Theoretical support
Dependent variable	Economic impact	Ln_GVA per capitat_{+2}	9.61	1.15	Centre for International Competitiveness: Indicators of United Kingdom's local competitive index	Audretsch et al. (2008), Drucker and Goldstein (2007), Martin (1998), Roessner et al. (2013)
Independent variables	Teaching activities Research activities	Ln_Employment ratet_0	−4.39	1.52	HESA: Destinations of Leavers from Higher Education (DLHE) Longitudinal Survey	Audretsch and Keilbach (2008), Bessette (2003), Daim and Ozdemir (2012), Martin (1998), Urbano and Guerrero (2013)
		Ln_Research collaborationst_0	−1.11	1.44	HESA: Higher Education-Business and Community Interaction Survey	Audretsch and Keilbach (2008), Bessette (2003), Bramwell and Wolfe (2008), Jaffe (1989), Siegel et al. (2003), Tijssen (2006), Urbano and Guerrero (2013)
		Ln_Research contractst_0	−0.91	1.31		
		Ln_Consultancyt_0	−0.83	1.36		
		Ln_Facilitiest_0	−1.63	1.79		
		Ln_Intellectual propertyt_0	−1.65	1.96		
	Entrepreneurial activities	Ln_Spin-offs with HEI ownershipt_0	−1.97	1.96	HESA: Higher Education-Business and Community Interaction Survey	Audretsch and Keilbach (2008), Bessette (2003), Bramwell and Wolfe (2008), Colombo et al. (2010), Daim and Ozdemir (2012), O'Shea et al. (2005), Urbano and Guerrero (2013)
		Ln_Spin-offs without-HEI ownershipt_0	−1.23	2.07		
		Ln_Spin-offs with staff ownershipt_0	−1.16	1.95		
		Ln_Spin-offs with graduated ownershipt_0	−1.19	1.70		
Control variables	Expenditures	Ln_Expenditurest_0	1.85	1.32	HESA and Higher Education Funding Council for England: Financial statements	Bessette (2003), Daim and Ozdemir (2012), Elliott et al. (1988), Landry et al. (2006), O'Shea et al. (2005)
	Influence of GDP on expenditures/university activities	Ln_GVA per capitat_{-1}	9.49	1.12	Competitiveness: Indicators of United Kingdom's local competitive index	Audretsch et al. (2008)

Source: Authors.
Note: t_0 = period of analysis; t_{-1} = one year before the period of analysis; t_{+2} = two years after the period of analysis.

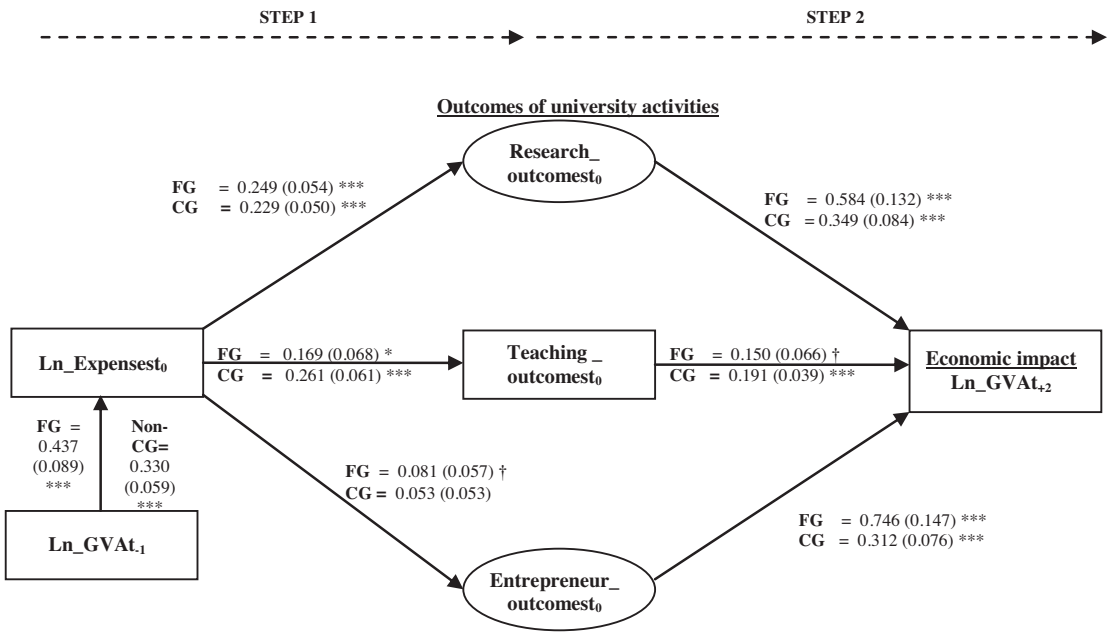

Fig. 2. Structural equation path. *Note*: Focus group (FG): the Russell group of UK universities used as a proxy of entrepreneurial universities; Control group (CG): rest of UK universities, t_0 = period of analysis, t_{-1} = one year before the period of analysis, t_{+2} = two years after the period of analysis. Level of statistical significance: $^{***}p \leq 0.001$, $^{**}p \leq 0.01$, $^{*}p \leq 0.05$, $\dagger p \leq 0.10$.

convergent analysis suggested by Shook et al. (2004).[5] The structural analysis was performed using the SPSS 18.0 and AMOS 18.0 software packages.

4. Exploring the economic impact of United Kingdom's public universities

Based on Audretsch and Keilbach (2008), the first step was to test the influence of the GVA per capita ($GVAt_{-1}$) on the universities' activities (see Annex C). The parameters of Model A were x^2 normalised [3.437], Comparative Fit Index (CFI) [0.708], Goodness of Fit Statistics (GFI) [0.886], and Root Mean Square Error of Approximation (RMSEA) [0.043] and are (close) in the cut-off values that indicate a reasonable fit.[6] In other words, the estimated model fits to the saturated model in the population (RMSEA) and presents ad-hoc measures of the descriptive adequacy (GFI) and statistical distribution (x^2 normalised). In this case, the results indicate a positive and significant effect of Ln_GVAt_{-1} on the total expenses $Ln\_Expenses t_0$, which include the salaries and operative costs of activity development for the coming year [0.338; $p < 0.001$]. The evidence from the indirect effect analysis suggests a positive, but lower, effect on research and teaching outcomes. Interestingly, the same effect is evidenced when we analysed the relationship between $Ln\_Expenses t_0$ and the ratio of teaching $outcomes t_0$ to research $outcomes t_0$. However, when we controlled the sample by type of university, surprisingly, there was no evidence of a significant effect for the focus group of entrepreneurial universities (the Russell Group universities); except in the case of entrepreneurial activities [0.362; $p < 0.010$]. The second step was to test the effect of the universities' activities on Ln_GVAt_{+2} (see Annex D). The parameters of Model B show a good fit of this model based on x^2 normalised [2.405], CFI [0.891], GFI [0.948], and RMSEA [0.031]. In this case, the evidence shows positive and significant impacts of teaching [0.183; $p < 0.001$], research [0.399; $p < 0.001$], and entrepreneurship activities [0.380; $p < 0.001$] on the economy. Particularly, the impact of research outcomes is higher than that of the other activities. Our analysis of the results by type of university confirms our expectations for our focus group (the Russell Group universities); the economic impact of entrepreneurial activities is not only higher [0.663; $p < 0.001$] than the impacts of the teaching and research activities, but it is also higher than that of the control group (rest of UK universities). Based on these previous models, Fig. 2 presents the structural equation path. In general, Model C presents significant coefficients and adequate parameters [x^2 normalised, 3.677; CFI, 0.837; GFI, 0.815; and RMSEA, 0.04].

Table 3 shows the results for the focus group of entrepreneurial universities analysed between 2005 and 2007. The results show

[5] Regarding the measures to corroborate the reliability, based on previous studies (Fox, 1980; Sobel, 1982; Shook et al., 2004), we adopted the confirmatory factor analysis, which helps us to ensure the measurement properties of the constructs and the test reported values of 0.70. High values close to 1.0 generally indicate that a factor analysis may be useful, but if the value is less than 0.50, the results of the factor analysis will probably not be very useful (Greene, 2003). The Cronbach's alpha (α) used to calculate a measure of internal reliability based on the average covariance among items in a scale and the test reported values of 0.70. A high alpha (0.70 and higher) represents that all scale items are measuring the same construct (Greene, 2003). Both constructs research activity (KMO 0.700; χ 2175.745; Sig. 0.000; Cronbach's alpha 0.700 and KMO 0.700; χ 2323.522; Sig. 0.000; Cronbach's alpha 0.700) presented a good fit respectively.

[6] Regarding the model specification, Fox (1980) and Shook et al. (2004) argue that a good fit is shown when: (i) the Root Mean Square Error of Approximation (RMSEA) represents the mean of the covariance residuals—the differences between corresponding elements of the observed and predicted covariance matrix. It is an estimate of fit of the model relative to a saturated model in the population. Small values of the RMSEA indicate that the model fits nearly as well as a saturated model. According to some researchers, RMS should be less than 0.08 (Browne and Cudeck, 1993) and ideally less than 0.05 (Stieger, 1990); (ii) the Comparative Fit Index (CFI) and Goodness of fit index (GFI) are ad hoc measures of the descriptive adequacy of the model. Specifically, compare the fit of a target model to the fit of an independent model—a model in which the variables are assumed to be uncorrelated. In this context, fit refers to the difference between the observed and predicted covariance matrices, as represented by the chi-square index. These indices are not constrained to the interval 0–1, and several rough cut-offs for the GFI and AGFI have been proposed (i.e., at least 0.80 or higher). A general theme is that they should be close to 1; lower than 0.50 represents a not good fit; and the x^2 normalised is equal to the chi-square index divided by the degrees of freedom. This index might be less sensitive to sample size. It is used most commonly to test the nature of a statistical distribution from which some random sample is drawn. The criterion for acceptance varies across researchers, ranging from less than 2 (Ullman, 2001) to less than 5 (Schumacker and Lomax, 2004).

Table 3
Economic impact of entrepreneurial universities' activities.

H	Relationships	All years	Controlled by year			Controlled by university type	
			2005	2006	2007	Focus group	Control group
Step 2							
H1	Ln_GVAt_{+2} ← Teaching_Outcomest_0	0.175 (0.036)***	0.175 (0.058)*	0.200 (0.063)***	0.211 (0.053)**	0.150 (0.066)†	0.191 (0.039)***
H2	Ln_GVAt_{+2} ← Research_Outcomest_0	0.456 (0.080)***	0.456 (0.208)*	0.502 (0.153)***	0.359 (0.114)**	0.584 (0.132)***	0.349 (0.084)***
H3	Ln_GVAt_{+2} ← Entrepreneurship outcomest_0	0.408 (0.079)***	0.408 (0.200)*	0.538 (0.164)***	0.307 (0.109)**	0.746 (0.147)***	0.312 (0.076)***
Step 1							
	Teaching_Outcomest_0 ← Ln_Expensest_0	0.154 (0.054)**	0.154 (0.025)*	0.220 (0.087)*	0.165 (0.084)*	0.169 (0.068)*	0.261 (0.061)***
	Research_Outcomest_0 ← Ln_Expensest_0	0.260 (0.044)***	0.260 (0.180)**	0.314 (0.078)***	0.201 (0.076)**	0.249 (0.054)***	0.229 (0.050)***
	Entrepreneurship_Outcomest_0 ← Ln_Expensest_0	0.026 (0.044)	0.026 (0.052)	−0.028 (0.063)	0.033 (0.066)	0.081 (0.057)†	0.053 (0.053)
	Ln_Expensest_0 ← Ln_GVAt_{-1}	0.338 (0.054)***	0.338 (0.170)***	0.279 (0.088)***	0.332 (0.099)***	0.437 (0.089)***	0.330 (0.059)***
N		441	147	147	147	72	369

Note: Focus group: the Russell Group of UK universities used as a proxy of entrepreneurial universities; *Control group*: rest of UK universities. t_0 = period of analysis; t_{-1} = one year before the period of analysis; t_{+2} = two years after the period of analysis.
Source: Authors.
Level of statistical significance:
† $p \leq 0.10$.
* $p \leq 0.05$.
** $p \leq 0.01$.
*** $p \leq 0.001$.

a positive impact of teaching [0.150; $p < 0.100$], research [0.584; $p < 0.001$], and entrepreneurship [0.746; $p < 0.001$] activities on economic development. These findings support hypotheses H1–H3, which state that the outcomes of entrepreneurial universities' activities have a positive effect on economic development. Most importantly, the highest impact is associated with the creation of spin-offs (entrepreneurship capital). Interestingly, for the control group of the United Kingdom's universities that are not part of the Russell Group of universities, the highest impact is associated with knowledge transfer (knowledge capital). Undoubtedly, the majority of the United Kingdom's universities undertake considerable research (Daim and Ozdemir, 2012; Siegel et al., 2003; Simha, 2005), which outstrips their entrepreneurial activities (Guerrero and Urbano, 2012). For instance, in this case, the relationship between expenses and universities' activities is positive and significant only for teaching and research activities. Intuitively, a possible explanation for these results could be attributed to the higher education policy implemented in the United Kingdom. In other words, by adopting a model of managed economy, institutional support has been oriented to promote teaching and research outcomes. However, there exist other environmental (organisational and governance structures, attitudes of the university community, role models, and university policies) and internal (human resources, physical resources, commercial resources, capabilities, and social resources) factors that could explain why some universities are more entrepreneurial than others (Di Gregorio and Shane, 2003; O'Shea et al., 2005; Shane, 2005; Urbano and Guerrero, 2013; Wright et al., 2007).

Regarding the inverse relationship between economic growth and entrepreneurial universities' activities, we observe that while the effect of Ln_GVAt_{-1} on Ln_Expensest_0 is significant and positive, it is lower than the impact of each entrepreneurial university's activities on Ln_GVAt_{+2}. Conversely, the control group of UK universities record also a higher influence of Ln_GVAt_{-1} on Ln_Expensest_0. A possible explanation could be the dependence of the United Kingdom's universities on public funding. Also, it is interesting to note the lower total effect of Ln_GVAt_{-1} on Ln_GVAt_{+2} (see Annex E). While significant entrepreneurial activities by universities can be expected to be conducive to economic growth, the inverse relationship can be expected to hold as well: economic growth is conducive to entrepreneurial universities' activities (Audretsch and Keilbach, 2008).

5. Conclusions and implications

In 2011, Grimaldi et al. (2011, p. 1053) raise some themes for research agendas in academic entrepreneurship. One theme in particular focuses on measurement and methods: What are appropriate measures of academic entrepreneurship? and How can multi-level studies be designed? Inspired by these questions, our exploratory study modestly aims to contribute to the existing literature of academic entrepreneurship by providing insights about some proposed measurements and methods to analyse the economic impact of entrepreneurial universities' activities in the United Kingdom. Particularly, the role of teaching, research, and entrepreneurial activities on economic development were explored. Based on our results, one of the interesting findings of this study is that for the majority of the United Kingdom's universities, research activities have contributed the most to economic growth. However, it is also interesting to note that the entrepreneurial activities of universities contribute strongly to economic development as well. The results show that the economic impact of our control group (UK universities that are not part of the Russell Group) is evident on research, teaching, and entrepreneurial activities, with the highest impact associated with research and knowledge transfer. While Elliott et al. (1988)

recognised the necessity to expand the methodology for analysing the economic impact of universities and to change the perceptions of the role of higher education in legislatures, other authors such as Goldstein (1990) discussed the limitations of traditional models (input–output) in analysing the economic impact of universities. Martin (1998) argued in favour of measuring the economic impact of universities through the dynamic approach, in terms of an appreciable growth in GDP and employment. Accordingly, the contributions of this study are: (1) the proposed theoretical framework to understand the economic impact of each entrepreneurial university's core activity (teaching, research, and entrepreneurship) in the entrepreneurial economy, and in particular, adopting the basis of the endogenous economic theory to argue how universities contribute to the main production factors of human capital, knowledge capital, and entrepreneurship capital; (2) the exploration of a new way to test this phenomenon using structural equation modelling, a powerful technique for analysing relationships among variables (exogenous and latent) and help overcome the shortcomings of other techniques such as input–output analysis (i.e. the economic impacts of universities extend well beyond the types that can be accounted for in this analysis); and (3) the empirical insights into the recognition and contribution of the United Kingdom's entrepreneurial universities during 2005–2007.

This study, however, also suffers from the following limitations. Data availability is a common limitation observed in prior studies of entrepreneurial universities. Gaining access to data from different universities is not an easy task, and this difficulty increases when you introduce the analysis contextual data at a disaggregate level (i.e., NUTS-3 regional county level). We collected information on 147 universities for three years; therefore, this sample did not allow us to apply a robust dynamic analysis (panel data or longitudinal growth modelling). Although we included some time lags to try to correct this situation, we also recognise the difficulty in estimating the specific time when the economic impact of universities is observed. In our case, we adopted a conservative period in the definition of time-lags (2-years) for two main risks: (i) because taking a higher period requires waiting more years to cover and have access to economic data; and (ii) because we also have the risk of introducing bias produced by macroeconomic conditions (i.e., financial economic crisis). For instance, at the end of 2008, Europe started to experience a rise in the unemployment rate, limited access to financing, a reduction in the demand of products, and the decline of gross domestic product. According to the Organisation for Economic Co-operation and Development (OECD, 2012) and the Innovation Union Scoreboard (European Union, 2014), these conditions could also affect (positively or negatively) innovation performance and investments in innovation mechanisms (i.e., reduced public financing of R&D, education, and a sluggish evolution of demand). However, we believe that not only are the results reliable for the United Kingdom's universities, but also that the methodology could be duplicated in other countries in which their economies are based on innovation and entrepreneurship in light of the endogenous growth theory (i.e., Germany, Nordic countries, and the USA, among others). It would nevertheless be worthwhile to continue collecting data from these universities, which might then be applied to more complex analytical methods in the future. As in previous studies, this exploratory study tried to operationalise using a "proxy of entrepreneurial university" to measure an ideal-type to understand this complex phenomenon. However, we recognise that there could be other ways to operationalise it; generating an interesting research opportunity for future venues. In this sense, future research could focus on handling data challenges (i.e., increase the period of analysis, access to data at a disaggregate regional county level, introduce contextual variables per university, etc.) and quality issues pertinent to building additional proxies (i.e., other measures of entrepreneurship such as entrepreneurial skills, explore in-depth the inverse relationship between university and society), which could capture the economic and social impacts of entrepreneurial universities' activities more precisely. For instance, it is necessary to explore the spillover effect by regions and the indirect effect of the global financial crisis. Moreover, with a tractable econometric model, it is also important to analyse not only the manner in which economic growth is influenced by the extent of entrepreneurial universities' activities, but also how these activities, in turn, are influenced by economic growth (Audretsch and Keilbach, 2008). Another extension could be the analysis of the internal (i.e., the identification and separation of managerial activities, resources, and capabilities by adopting the resource-based view) or environmental (i.e., policies and attitudes of the university community, supported by the institutional approach) antecedents of those activities in our focus group (the Russell Group), as well as, in our control group (the rest of UK universities).

The main implications for university management teams are some additional insights about how university activities contribute to their regional social and economic development. The challenge for university management teams how best to balance each mission aligned to the needs of region and external demands. University leaders need to give careful consideration to their knowledge transfer mechanisms and the associated contextual dynamics so as to make it more effective and to enable this activity to exert a sustainable economic impact. In terms of resource allocation and investment, the results of our exploratory research provide insights that each university activity has an economic impact. Nevertheless, each university needs to ensure that funding is allocated appropriately in order to continue supporting each activity and enhancing its organisational capabilities. Production capital underpins economic impacts. The manner in which this capital is utilised, as well as the areas supported by it to help sustain scientific excellence, varies by institution. The knowledge filters (Acs et al., 2009) adopted by universities can further reduce the barriers between knowledge investment and commercialisation for scientists (Cunningham et al., 2014; Mangematin et al., 2014).

The implications for policy makers are associated with the educational policy and the impact of the Research Assessment Exercise System on the United Kingdom's universities. The country's research system is one of the world's leading research systems (Salter and Martin, 2001). It rewards universities and departments that have achieved international scientific excellence. Several reports, such as the Lambert Review (Lambert, 2003), have highlighted the need to improve technology transfer and linkages between universities and businesses. Based on our results, entrepreneurial universities have addressed this gap, as evidenced by the modest economic impact of spin-off firms.

There is a heterogeneous approach in the responses of universities towards policies. The current Research Excellence Framework is aimed at reducing the gap between universities, business, and society. It also highlights that endogenous growth models do result in varied economic impacts across the three missions and that national education policies do shape the strategic directions within universities and their activities. For instance, recent reforms have allowed UK universities to charge differential fees and at the same time reduce the student-based subsidies provided to universities. Arguably, however, the nature of the competition varies across universities, but the most entrepreneurial universities (research-intensive) see themselves competing in international and national markets (for talented students, staff, and academics) while traditional universities focus more on local markets (Aghion et al., 2010). For the top management university teams our study highlights the needs for clear and consistent goals over time about their core mission activities (Jarzabkowski and Wilson, 2002) and within such goals to allow freedom of implementation approaches among

departments and research institutes. In summary, these experiences could be helping the development process of universities in other countries. An interesting example of the policy makers' interest is the guiding framework for entrepreneurial universities promoted by the European Union and OECD.[7]

Acknowledgements

The authors wish to acknowledge Professor Ben Martin (editor) for coordinating the review and the three anonymous reviewers for their comments and feedback that have helped shape this paper. Maribel Guerrero recognises the support of Mexico's National Council of Science and Technology (CONACYT). James A. Cunningham acknowledges funding support from the Irish Social Sciences Platform funded under the Programme for Research in Third Level Institutions Cycle 4, administered by the Higher Education Authority and co-funded by the European Regional Development Fund (ERDF). David Urbano acknowledges the financial support from the projects ECO2013-44027-P (Spanish Ministry of Economy & Competitiveness) and ECO/2663/2013 (Economy & Knowledge Department – Catalan Government).

Annex A. Criteria to identify entrepreneurial universities

University missions	Theoretical criteria	The Russell Group commitments
Teaching activities	Teaching activities have been the universal function of universities (Kirby et al., 2011). Universities educate and train students, who become jobseekers or job creators after graduation (Schulte, 2004). Hence, entrepreneurial universities could have an impact on economic notions about human capital. Human capital, considered a factor of production by Lucas (1988), refers to the stock of competencies, knowledge, abilities, and skills gained through education and training (Becker, 1993). Therefore, entrepreneurial universities could contribute to economic impacts through the generation, attraction, and retention of talented human capital and entrepreneurs (Bramwell and Wolfe, 2008; Ghatak et al., 2007; Simha, 2005).	The combination of excellent teaching and world class research across a wide range of subjects makes a Russell Group university an ideal place to study. Students interact with leading thinkers and academics at the forefront of their disciplines. Undergraduates have opportunities to engage in research themselves and undertake independent projects while learning alongside motivated and talented peers. There are also programmes for work-based learning, internships in coveted professions and tailored guidance to help students consolidate the skills which are valued by employers. This environment creates the ideal conditions for students to develop their creativity, analytical skills, problem-solving, as well as their team working and communication. These attributes are highly sought after by employers and will enable students be successful in their future lives and careers.
Research activities	Within the new knowledge-based economy, research activities are another legitimate university function. This function has been identified as the generation, transfer, and commercialisation of new knowledge (Romer, 1986; Solow, 1956). Examples of knowledge creation include copyrights, patents, licenses, and trademarks. Several authors identify this phenomenon as academic entrepreneurship occurring at the boundaries of different scientific and professional backgrounds, creating a need for support mechanisms to transcend those boundaries (Cunningham and Link, 2014; Cunningham et al., 2014; Urbano and Guerrero, 2013). Thus, the economic and social impact of entrepreneurial universities could be associated with the generation, attraction, and retention of prestigious researchers (Bramwell and Wolfe, 2008), who facilitate innovation and knowledge transfer (Passhe, 2005).	The Russell Group institutions are vibrant and dynamic organisations, actively contributing to their local communities and economies, yet influencing and achieving impact on a truly global scale. By virtue of their size and the quality of their research and teaching, Russell Group universities create and catalyse a hugely diverse range of activity which has a major impact on the economy of the UK. It is also important to remember that world-class research, in its many guises, can transform their lives and reach areas we may never have thought of. Much of the research in Russell Group universities goes on to benefit the environment, the culture, and the nation's health and quality of life. All this research activity creates a distinctive learning environment for students, where both undergraduates and post-graduates have access to academic staff who are involved in work at the cutting edge of their subjects as well as teaching.
Entrepreneurship activities	Moreover, entrepreneurial activities focus on the creation of new companies that could enhance local job growth and regional development by promoting partnerships in key regional clusters that identify and meet needs (Porter, 2007). As a result, entrepreneurship is a phenomenon observed at all university levels: university management, academicians, researchers, and potential entrepreneurs among the undergraduate and postgraduate students. According to Audretsch and Keilbach (2004a,b), entrepreneurship is another element in the production function, because entrepreneurship contributes to output and growth by serving as a conduit for knowledge spillovers, increasing competition, and injecting diversity. Thus, an entrepreneurial university could attract or generate new enterprises that promote competition and diversity (Clarysse et al., 2005; Shane, 2005; Vohora et al., 2004; Wright et al., 2007). Consequently, these impacts could produce several externalities in terms of demography, economy, infrastructure, culture, mobility, education, and society challenges that will later be reflected in productivity, competitive advantages, regional capacities, regional networks, regional identity, and regional innovation (Goldstein and Renault, 2004; Passhe, 2005; Porter, 2007; Powers and McDougall, 2005).	Russell Group universities work/collaborate extensively with businesses of all sizes, in their local regions, elsewhere in the UK and right around the world, in many different ways. Graduates of Russell Group universities are of the highest calibre, providing businesses of all sizes and sectors with the talented recruits they will need to meet the challenges of today and in the future. The universities' careers services offer employers the opportunity to advertise jobs to current students and recent graduates. Businesses looking for training and professional development for their employees can choose from a wide range of courses and bespoke services on offer at these universities. They also have a strong tradition of bringing innovations to market through the creation of high-tech spin-out companies. Organisations can work with these universities in a whole host of ways from commissioning research, or sponsoring postgraduate students to large-scale collaborative partnerships.

Source: Authors based on previous studies and the Russell Group Website [http://www.russellgroup.ac.uk/home/].

[7] It is designed to help interested universities assess themselves against statements which are organised under the following seven areas: Leadership and Governance, Organisational Capacity, People and Incentives, Entrepreneurship development in teaching and learning, Pathways for entrepreneurs, University – business/external relationships for knowledge exchange, The Entrepreneurial University as an internationalised institution, and Measuring the impact of the Entrepreneurial University. For further information, please visit http://www.oecd.org/site/cfecpr/guiding-framework.htm.

Annex B. Universities included in this study

1. Aberystwyth University
2. Anglia Ruskin University
3. Aston University
4. Bangor University
5. Bath Spa University
6. Birmingham City University
7. Bishop Grosseteste University College Lincoln
8. Bournemouth University
9. Brunel University
10. Buckinghamshire New University
11. Canterbury Christ Church University
12. Cardiff University[a]
13. Central School of Speech and Drama
14. Courtauld Institute of Art
15. Coventry University
16. Cranfield University
17. De Montfort University
18. Edge Hill University
19. Glasgow Caledonian University
20. Glyndwr University
21. Goldsmiths College
22. Harper Adams University College
23. Heriot-Watt University
24. Imperial College[a]
25. Institute of Education
26. King's College London[a]
27. Kingston University
28. Leeds Metropolitan University
29. Leeds Trinity and All Saints
30. Liverpool Hope University
31. Liverpool John Moores University
32. London Business School
33. London Metropolitan University
34. London School of Economics and Political Science[a]
35. London School of Hygiene and Tropical Medicine
36. London South Bank University
37. Loughborough University
38. Middlesex University
39. Newman University College
40. Norwich University College of the Arts
41. Oxford Brookes University
42. Queen Margaret University, Edinburgh
43. Queen Mary and Westfield College[a]
44. Roehampton University
45. Royal Academy of Music
46. Royal Agricultural College
47. Royal College of Art
48. Royal College of Music
49. Royal Holloway and Bedford New College
50. Royal Northern College of Music
51. Sheffield Hallam University
52. Southampton Solent University
53. St George's Hospital Medical School
54. St Mary's University College, Twickenham
55. Staffordshire University
56. Swansea Metropolitan University
57. Swansea University
58. Thames Valley University
59. The Arts Institute at Bournemouth
60. The City University
61. The Institute of Cancer Research
62. The Manchester Metropolitan University
63. The Nottingham Trent University
64. The Open University
65. The Queen's University of Belfast[a]
66. The Robert Gordon University
67. Royal Conservatoire of Scotland
68. The Royal Veterinary College
69. The School of Oriental and African Studies
70. The School of Pharmacy
71. The University of Aberdeen
72. The University of Bath
73. The University of Birmingham[a]
74. The University of Bolton
75. The University of Bradford
76. The University of Brighton
77. The University of Bristol[a]
78. The University of Buckingham
79. The University of Cambridge[a]
80. The University of Central Lancashire
81. The University of Chichester
82. The University of Dundee
83. The University of East Anglia
84. The University of East London
85. The University of Edinburgh[a]
86. The University of Essex
87. The University of Exeter[a]
88. The University of Glasgow[a]
89. The University of Greenwich
90. The University of Huddersfield
91. The University of Hull
92. The University of Keele
93. The University of Kent
94. The University of Lancaster
95. The University of Leeds[a]
96. The University of Leicester
97. The University of Lincoln
98. The University of Liverpool[a]
99. The University of Manchester[a]
100. The University of Newcastle-upon-Tyne[a]
101. The University of Northampton
102. The University of Northumbria at Newcastle
103. The University of Nottingham[a]
104. The University of Oxford[a]
105. The University of Plymouth
106. The University of Portsmouth
107. The University of Reading
108. The University of Salford
109. The University of Sheffield[a]
110. The University of Southampton[a]
111. The University of St Andrews
112. The University of Stirling
113. The University of Strathclyde
114. The University of Sunderland
115. The University of Surrey
116. The University of Sussex
117. The University of Teesside
118. The University of the West of Scotland
119. The University of Wales, Lampeter
120. The University of Wales, Newport
121. The University of Warwick[a]
122. The University of Westminster
123. The University of Winchester
124. The University of Wolverhampton
125. The University of Worcester
126. The University of York[a]
127. Trinity College, Carmarthen
128. University College Birmingham
129. University College Falmouth
130. University College London[a]
131. University College Plymouth
132. University for the Creative Arts
133. University of Abertay Dundee
134. University of Bedfordshire
135. University of Chester
136. University of Cumbria
137. University of Derby
138. University of Durham[a]
139. University of Glamorgan
140. University of Gloucestershire
141. University of Hertfordshire
142. University of London[a]
143. University of the Arts London
144. University of the West of England
145. University of Ulster
146. University of Wales Institute, Cardiff
147. York St John University

[a] Identified as entrepreneurial universities that are the 24 universities that integrate the Russell Group [our focus group].

Annex C. Model A

See Fig. C1, Tables C1 and C2.

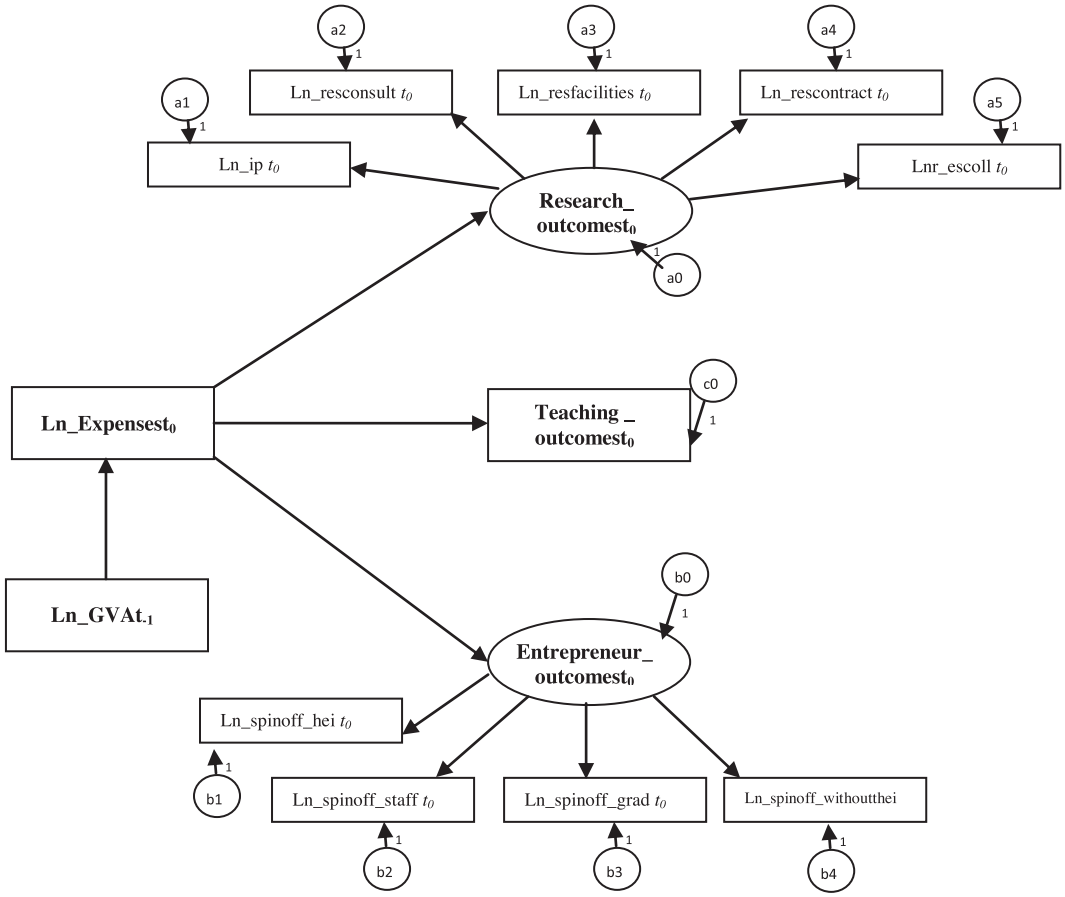

Fig. C1. Model A [x^2 normalised, 3.437; CFI, 0.708; GFI, 0.886; and RMSEA, 0.043].

Table C1
Statistical relationships observed in Model A.

Relationships	All years	Controlled by year			Controlled by university type	
		2005	2006	2007	Focus group	Control group
Teaching_Outcomest_0 ← Ln_Expensest$_0$	0.154 (0.054)**	0.086 (0.100)	0.220 (0.087)*	0.165 (0.084)	0.045 (0.038)	0.261 (0.061)***
Research_Outcomest$_0$ ← Ln_Expensest$_0$	0.262 (0.046)***	0.289 (0.078)***	0.331 (0.084)***	0.181 (0.080)*	−0.007 (0.094)	0.232 (0.052)***
Entrepreneurship_Outcomest$_0$ ← Ln_Expensest$_0$	−0.073 (0.115)	−0.021 (0.059)	−0.034 (0.060)	−0.029 (0.128)	0.363 (0.126)***	0.021 (0.046)
Ln_Expensest$_0$ ← Ln_GVAt$_{-1}$	0.338 (0.054)***	0.403 (0.092)***	0.279 (0.088)**	0.332 (0.099)**	0.277 (0.110)*	0.348 (0.061)***
N	441	147	147	147	72	369

Note: *Focus group*: the Russell Group of UK universities used as a proxy of entrepreneurial universities; *Control group*: rest of UK universities. t_0 = period of analysis, t_{-1} = one year before the period of analysis.
Level of statistical significance:
* $p \leq 0.05$.
** $p \leq 0.01$.
*** $p \leq 0.001$.

Table C2
Total effects observed in Model A.

Total effects	Ln_GVAt$_{-1}$	Ln_Expensest$_0$	Teaching_Outcomest$_0$	Entrepreneurship_Outcomest$_0$	Research_Outcomest$_0$
Ln_Expensest$_0$	0.338	0.000	0.000	0.000	0.000
Teaching_Ourcomest$_0$	0.052	0.154	0.000	0.000	0.000
Research_Outcomest$_0$	0.088	0.261	0.000	0.000	0.000
Ln_ipt$_0$	−0.014	−0.041	0.000	0.000	−0.159
Ln_resconsultt_0	0.052	0.154	0.000	0.000	0.589
Ln_resfacilitiest$_0$	0.055	0.161	0.000	0.000	0. 618
Ln_rescontractt_0	0.060	0.178	0.000	0.000	0.682
Lnr_escollt_0	0.088	0.261	0.000	0.000	1.000
Entrepreneurship_Outcomest$_0$	−0.003	−0.009	0.000	0.000	0.000
Ln_spinoff_heit_0	−0.003	−0.009	0.000	1.000	0.000
Ln_spinoff_stafft_0	−0.005	−0.013	0.000	1.543	0.000
Ln_spinoff_gradt_0	−0.003	−0.008	0.000	0.871	0.000
Ln_spinoff_withoutHEIt_0	−0.014	−0.015	0.000	1.867	0.000

t_0 = period of analysis, t_{-1} = one year before the period of analysis.

Annex D. Model B

See Fig. D1, Tables D1 and D2.

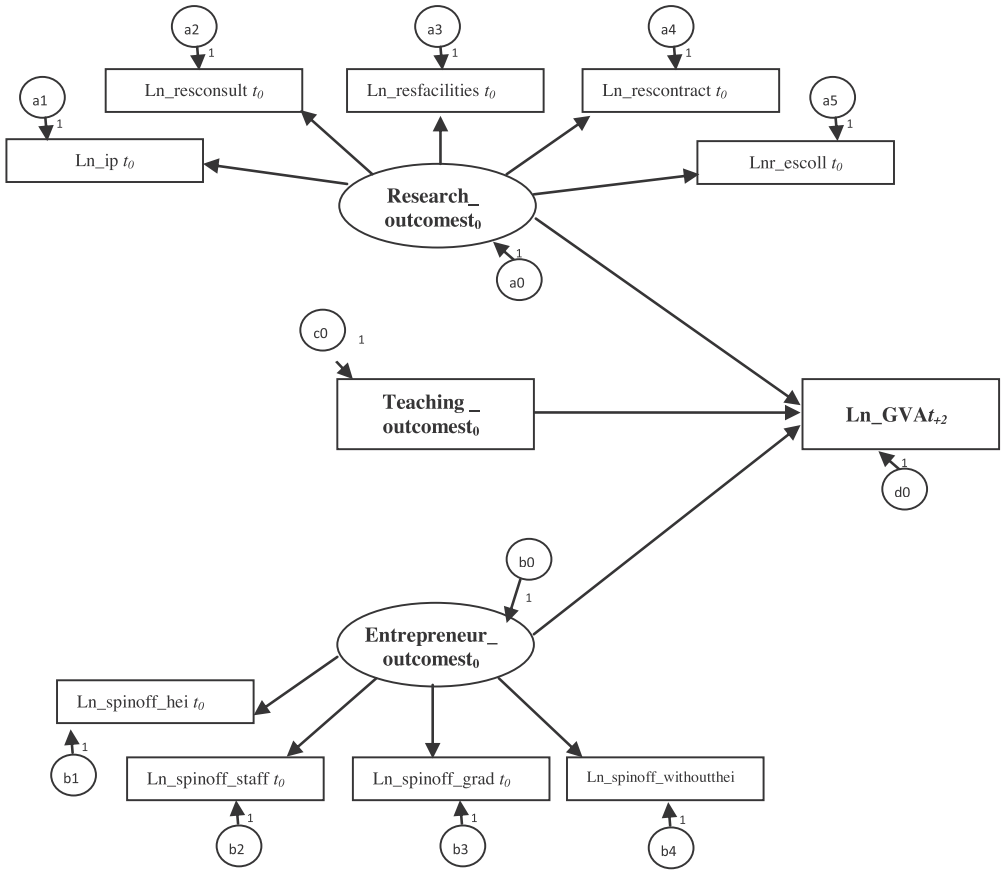

Fig. D1. Model B [x^2 normalised, 2.405; CFI, 0.891; GFI, 0.948; and RMSEA, 0.031].

Table D1
Statistical relationships observed in Model B.

Relationships	All years	Controlled by year			Controlled by university type	
		2005	2006	2007	Focus group	Control group
Ln_GVAt_{+2} ← Teaching_Outcomest_0	0.183 (0.036)***	0.191 (0.058)***	0.160 (0.070)*	0.191 (0.061)**	0.061 (0.084)	0.121 (0.054)*
Ln_GVAt_{+2} ← Research_Outcomest_0	0.399 (0.079)***	0.259 (0.120)*	0.555 (0.153)***	0.409 (0.128)***	0.659 (0.161)**	0.371 (0.103)***
Ln_GVAt_{+2} ← Entrepreneurship_Outcomest_0	0.380 (0.077)***	0.312 (0.119)**	0.427 (0.144)**	0.354 (0.124)**	0.663 (0.142)***	0.352 (0.091)***
N	441	147	147	147	72	369

Note: *Focus group*: the Russell Group of UK universities used as a proxy of entrepreneurial universities; *Control group*: rest of UK universities. t_0 = period of analysis, t_{+2} = two years after the period of analysis.
Level of statistical significance:
* $p \leq 0.05$.
** $p \leq 0.01$.
*** $p \leq 0.001$.

Table D2
Total effects observed in Model B.

Constructs	Estimate	S.E.	*p*
Ln_spinoff_withoutHEIt_0 ← Entrepre_Outcomest_0	0.661	0.125	**
Ln_spinoff_heit_0 ← Entrepre_Outcomest_0	1.000		
Ln_spinoff_stafft_0 ← Entrepre_Outcomest_0	0.636	0.134	**
Ln_spinoff_gradt_0 ← Entrepre_Outcomest_0	0.701	0.107	**
Ln_ipt$_0$ ← Research_Outcomest_0	−0.260	0.127	*
Ln_rescollt_0 ← Research_Outcomest_0	1.000		
Ln_resfacilitiest_0 ← Research_Outcomest_0	1.010	0.379	**
Ln_rescontractt_0 ← Research_Outcomest_0	0.969	0.397	**
Ln_resconsultt_0 ← Research_Outcomest_0	0.859	0.315	**

Note: t_0 = period of analysis.
Level of statistical significance:
* $p \leq 0.05$.
** $p \leq 0.01$.

Annex E. Model C

See Fig. E1 and Table E1.

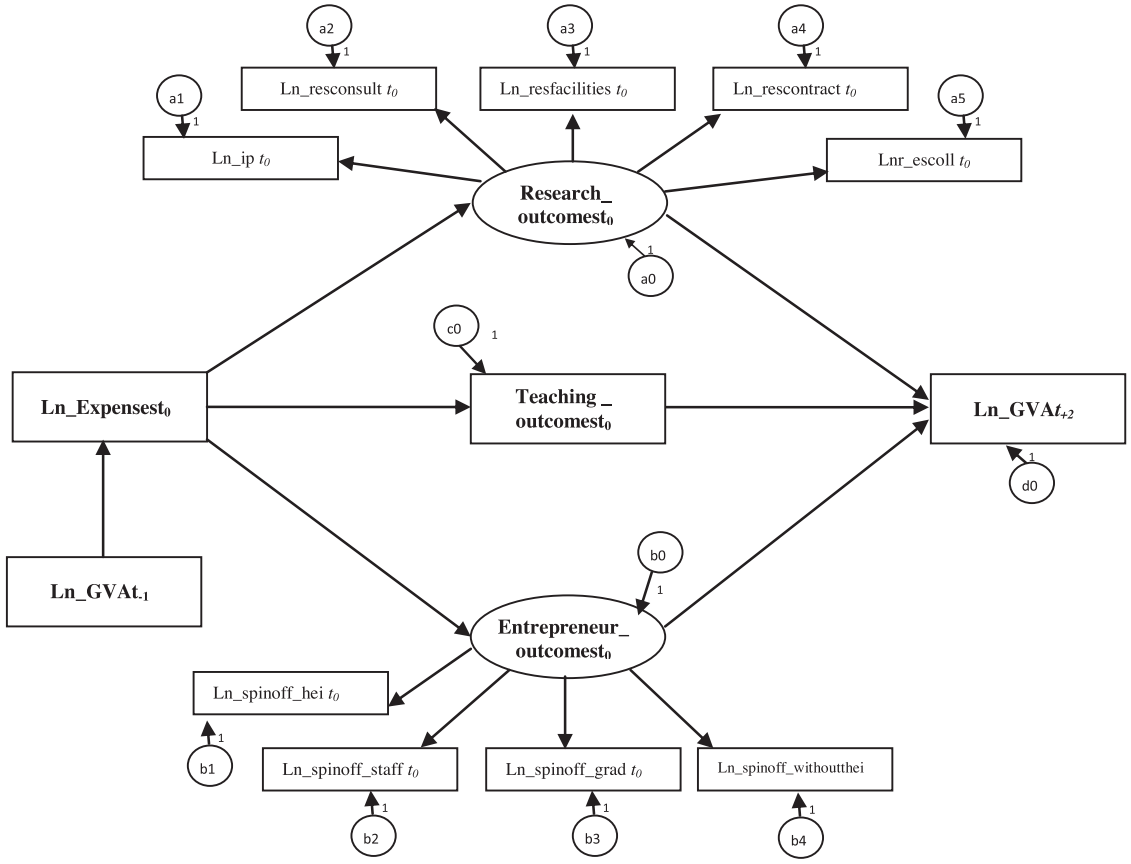

Fig. E1. Model C [x^2 normalised, 3.677; CFI, 0.837; GFI, 0. 815; and RMSEA, 0.04].

Table E1
Total effects observed in Model C.

Total effects	Ln_GVAt$_{-1}$	Ln_Expensest$_0$	Teaching_Outcomest$_0$	Entrepreneurship_Outcomest$_0$	Research_Outcomest$_0$
Ln_expensest$_0$	0.338	0.000	0.000	0.000	0.000
Teaching_Outcomest$_0$	0.052	0.154	0.000	0.000	0.000
Research_Outcomest$_0$	0.088	0.260	0.000	0.000	0.000
Ln_ipt$_0$	−0.021	−0.062	0.000	0.000	−0.238
Ln_resconsultt$_0$	0.064	0.188	0.000	0.000	0.725
Ln_resfacilitiest$_0$	0.061	0.181	0.000	0.000	0.698
Ln_rescontractt$_0$	0.078	0.230	0.000	0.000	0.885
Ln_rescollt$_0$	0.088	0.260	0.000	0.000	1.000
Entrepreneurship_Outcomest$_0$	0.009	0.026	0.000	0.000	0.000
Ln_spinoff_heit$_0$	0.009	0.026	0.000	1.000	0.000
Ln_spinoff_stafft$_0$	0.012	0.036	0.000	1.390	0.000
Ln_spinoff_gradt$_0$	0.008	0.023	0.000	0.865	0.000
Ln_spinoff_notheit$_0$	0.011	0.032	0.000	1.232	0.000
Ln_GVAt$_{+2}$	0.053	0.156	0.175	0.408	0.456

Note: t_0 = period of analysis, t_{-1} = one year before the period of analysis, t_{+2} = two years after the period of analysis.
All the total effects are significant at least at $p \leq 0.10$.

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