Indexing Third Stream Activities in UK Universities: Exploring the Entrepreneurial / Enterprising University

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Abstract

Third Stream Activity (TSA) is increasingly important to UK Universities and the wider economy, through innovation and entrepreneurship. Using data from the 2009/10 UK Higher Education Business and Community Interaction Survey (HE-BCIS) this study investigates UK universities' TSA. Through considering the data in original and logged forms, two interpretations of TSA are investigated, in relation to entrepreneurial and enterprising university concepts. Using Principle Component Analysis (PCA) on both data forms, four factors relating to universities' TSA are identified. A nascent indexing approach is employed to create sub-indexes using the identified factors, weight aggregated to produce final TSA indexes (one for each form of the data). Comparisons are then made between the ranking of universities using the two versions of TSA index, and sub-indexes, illustrating differences utilising entrepreneurial and enterprising university concepts. Important questions are raised for future government policy in terms of promoting interventions that drive towards different TSA types.

Introduction

Since the Lambert (2003) Review there have been a number of government sponsored reviews of university roles in the wider economy, part of an ongoing debate (e.g. Rodríguez-Pose and Refolo, 2003; Smith, 2007; Mueller et al., 2012; Harrison et al., 2016. The Warry Report (2006), Sainsbury Review (2007) and Wilson Report (2012), all considered universities' changing economic roles. This potential paradigm shift (Etzkowitz et al., 2000) therefore represents an ongoing government policy issue (e.g. see Youtie and Shapira, 2008; Reddy, 2011), illustrated in the UK by the increasing role of "impact" in the Research Exercise Framework (REF) (Smith et al., 2011).

Traditional university roles as teaching and theoretical research centres have been supplemented by more directly assisting economic performance of their own regional as well as national economies (Gibb et al., 2009; Etzkowitz and Leydesdorff, 1999). Higher Education Institutions (HEIs) have therefore increasingly been encouraged to take larger roles in local economic development (e.g. Lenger, 2008; Lazzeretti and Tavoletti, 2005), particularly through innovation (Benneworth, 2007).

Whilst by no means uncontested (see Sharifi et al. 2014; Badley, 2016) there has therefore been greater focus on Third Stream Activities (TSAs) (Hatakenaka, 2005). More specifically, there is increasing interest in conceptualisations of the entrepreneurial university (Etzkowitz, 2003), defined here as mainly focused on innovation-related activities of the university itself, but also the enterprising university (Woollard et al., 2007), defined here as also focused on activities such as enterprise education and graduate entrepreneurship, Jack and Anderson (1999) and Matlay (2006) noting that entrepreneurship education has climbed political agendas within industrialised and developing economies, to encourage business growth and employment (Dickson et al., 2008; Hannon et al., 2005). Holden et al. (2007) also identify the need for ongoing, more sophisticated, research in the graduate entrepreneur area.

This overlaps with ongoing university typology discussions. Hewitt-Dundas (2012) showed, for example, that LRI (Low Research Intensive) universities, typically post-92, were more focused upon engaging with regional players than HRI (High Research Intensive) universities often able to attract more national and international partners due to their higher research standing. Importantly, there appears to be increasing acknowledgement that university heterogeneity in terms of strategies, missions and activities, requires assessment based upon multiple criteria (Agasisti and Johnes, 2015; Agasisti and Bonomi, 2014).

Previous studies of university TSA, including typological, focus on a specific channel of university's commercial activity, or select few channels. Typically analysed individual activities include; patenting (Di Gregorio and Shane, 2003), licensing (Powers and McDougall, 2005; Siegel et al., 2008), creation of spin-outs (Avnimelech and Feldman, 2011; O'Shea et al., 2005; D'Este and Perkmann, 2010), other forms of engagement (Van Looy et al., 2011), or a mixture of these activities (Caldera and Debande, 2010).

This restricts the usefulness of findings when looking at roles of the university sector as a whole, specifically the lack of studies including the potentially important activity of graduate entrepreneurship amongst variables studied, particularly when considering the broader concept of the "enterprising" university. This is important, because, when graduate entrepreneurship was studied by Åstebro et al. (2012), for example, they found graduate entrepreneurship (through start-up creation) of an order of magnitude higher than the number of staff creating start-ups.

Lack of studies within this area, however, was highlighted by Åstebro et al. (2012). This study begins to address that problem through inclusion of measures of graduate entrepreneurship in this research. More broadly, because of the disparate nature of university TSA, this study aims to both identify sets of activities that can be seen to fit within entrepreneurial and enterprising university concepts, but also allow ranking of universities using those sets of activities, to better inform government policy in this area.

Such ranking of universities is increasingly popular. In 2012 alone, there were three additional ranking systems for universities, but all used the same methodologies as previous ranking systems (Soh, 2014). Having a ranking system for specific types of activities could therefore provide policy makers with a greater understanding of universities' strengths across a new range of metrics.

This can also be seen as part of broader discourse in relation to the HE-BCI survey. Rossi and Rosli (2015), for example, used the HE-BCI survey to analyse the knowledge transfer activities of universities in the UK, finding the most common knowledge transfer indicators suffering numerous limitations, including lack of testing of indicators, and focusing on a narrow range of indicators hampers universities' ability to fully represent their knowledge exchange activities. Rossi and Rosli (2015) grouped knowledge transfer activities into five broader areas, whilst Universities were also grouped into four broad categories using a hierarchical clustering algorithm. In order to undertake such a process with regard to entrepreneurial / enterprising university concepts, a different methodological approach is utilised compared to narrower approaches used previously. Principle Component Analysis (PCA), used in this study (see Hair et al., 2010), identifies four *groups of related* variables (defined as factors) and their relative importance in terms of explaining total variance. This enables university activities to be identified within statistically distinct groups, allowing broader understanding of universities' TSA, useful from a policy perspective.

To rank universities in terms of broader sets of activities, creating a framework which could measure this mixture of activities over time, it is also necessary to create an index using PCA-derived data, weighted by the differing levels of "importance" of the factors identified. In this paper two indexes are created. One uses the original HE-BCIS data (weighted by the relevant PCA analysis) to create an "Entrepreneurial University TSA Index", so named because of its statistically closer relationship to that concept. The other index utilises logged values of the HE-BCIS data (again weighted by the relevant PCA analysis), partly in order to reduce the impact of university's focusing on only one or two areas, allowing generation of an index better able to measure university activity across all four areas of activity, creating an "Enterprising University TSA index", more closely related to that broader concept, again of value to policy makers.

The indexing method undertaken follows Beynon et al. (2015), who introduced a constellation graph approach to elucidation of an index (urban-rural in their case). They utilised results from the employment of PCA, and were able to also elucidate sub-indexes (from the found factors), weight aggregated to give a final index. An important feature of the introduced approach was the ability to visualise all aspects of the indexing approach through the use of constellation graphs (including variable contribution etc.).

The next section explores the literature related to university TSA, including an evaluation of the promotion of TSA by the government and its effects on the overall aims and performance of universities, and entrepreneurial and enterprising university concepts, identifying variables of potential relevance to the study. Methods and data set used are then outlined, including those utilised in indexing. Results obtained and the two indexes created are then reviewed, followed by discussion and policy consequences. Conclusions identify the relevance of these results and future potential for research, particularly related to identification of what drives the outcomes generated here, and policy implications of this.

Literature Review

An evaluation of the promotion of TSA by the government and its effects on the overall aims and performance of universities

TSA can happen in a wide range of different ways, Abreu et al (2009) putting these under the sub-headings of "People Based", "Community Based", "Problem Solving" and "Commercialisation", only a subset of which can be defined as commercial in nature, with the majority of academics' external interactions revolving around people based activities. According to Sharifi et al (2014) globalisation and consequent government policies have, however, driven higher education systems to become increasingly entrepreneurial. Reductions in higher education spending and increasing student numbers, have also meant that universities are increasingly forced to develop third stream (external) sources of income (PACEC, 2009;

Gibb et al., 2009), such TSA activities therefore representing increasing value to the institutions themselves as the new more entrepreneurial paradigm for universities, developed in parallel, also typically involves greater focus on direct value creation and exploitation than previously (Lebeau and Bennion, 2014). Simultaneously, government policy increasingly aims to more directly commercialise university research outputs (Goldfarb and Henrekson, 2003) as a means of promoting economic growth, giving certain types of TSA a wider value to the economy. The UK Government, for example, has tried to drive this change through legislation and programs such as the Higher Education Innovation Fund (HEIF) which aims to increase collaboration between Universities and local businesses (HEIF 2012), PACEC (2009), using the HE-BCIS dataset, and finding that access to HEIF funding had a positive effect on TSA.

Consequently, TSA has become an increasingly measured (e.g. in the UK by the annual HE-BCIS survey of University activities) and analysed (Hatakenaka, 2005; Meyer and Tang, 2007; Lockett et al., 2013) set of activities, albeit not uncontested in terms of its broader value to society, for example in comparison with the pragmatic university concept (Badley, 2016). Sharifi et al. (2014) also acknowledge that concerns exist in terms of how universities can pursue the new focus set by policy and government which has not historically been part of core university activities. Specifically tensions are potentially created with teaching and theoretical research activities related to a University's traditional academic reputation and more recent regional economic development roles (Jarzabkowski, 2005). TSA which require Universities to take on a more commercial approach when compared to their previous missions, for example, can cause tensions amongst Universities and their staff (Martin and Turner 2010; Rinne and Koivula 2005; Philpott et al 2011). TSA will tend to favour applied rather than basic research as applied research is typically easier to commercialise (Etzkowitz 2003). With this difference then comes tension between departments because some departments, such as Engineering, are typically more applied research in nature whilst others (such as the Social Sciences) are often naturally more basic research focused and see their contribution being through "soft" avenues rather than "hard" (Philpott et al 2011). This tension is then often exacerbated by the skewing of government research funding towards science, engineering and technology, a skewing potentially made even worse as governments increasingly encourage TSA (Philpott et al 2011).

Martin and Turner (2010) also found that the expectation inherent in TSA to create a profit for the University was a barrier to staff engaging in entrepreneurial activities. Conversely Philpott et al (2011) argue that some Universities may not be able to make progress with regards to TSA because of institutional structures or procedural barriers that impede efforts of more entrepreneurial academics.

Another criticism of encouraging greater commercial activity at Universities, for example, is the possible negative side-effect on more traditional activities related to academic freedom and open research (Rosell and Agrawal 2006). In addition, evidence from a study by Abreu et al (2009) identified that 56% of academics are either unaware, unwilling or perceive no need to engage with their University's Technology Transfer Office. It may be therefore that it is academics themselves, rather than TTOs or official focus on TSA, that are often driving University's' linkages with local, regional and international players (Benneworth 2007).

It also needs to be recognised that the value of Universities' TSA will differ depending on the regional and sectoral context. For example, possible benefits of Universities engaging in regional development are the spillovers generated and clustering effects created (Acs et al 2007), . This clustering has occurred around many of the best research institutions in the UK, USA and around the world (Nelsen 2005; Garnsey and Heffernan 2005, Ferrary and Granovetter 2009). Conversely, industry is often wary of Universities' TSA because of misunderstandings of the role and scepticism about the value of working with public firms (Benneworth and Charles 2005), Giuliani and Arza's (2009) research showing that the value of universities' TSA can be determined by the knowledge base of those receiving university knowledge, highlighting the key importance of absorptive capacity in this debate.

Bowl (2016) also sees distinctly different approaches to TSA between higher and lower ranking universities, related to their degree of independence from government funding sources. For higher ranked universities, more financially independent of government, and having greater reserves of cultural, social and economic capital, entrepreneurial activities are more likely to be undertaken on the institution's terms, implying that whilst these universities have value for industry based on their research excellence, and will engage in partnership arrangements, this is not at the expense of institutional autonomy or other more traditional priorities, including international academic standing. Conversely, lower ranked universities, relatively more dependent on government funding, are much more explicitly seen to be responsive to business and the knowledge economy and serving regional and national economic objectives.

Universities can also be seen to engage in a range of entrepreneurial activities, some viewed as"soft", such as public lectures and consulting, or "hard", such as licensing or spin-off creation (Caldera and Debande 2010). Soft entrepreneurial activities are, according to Philpott et al (2011), less conflicting with traditional University missions and are also available to almost every HEI within the UK. The TSAs often associated with the Entrepreneurial University paradigm, however, are typically associated with "hard" activities, which can cause a number of problems for universities that may wish to engage in TSA but are not able of doing that in the stereotypical "hard" manner (Philpott et al 2011). What this also highlights is that there may be different types of TSA that may also be entrepreneurial or enterprising but may not be valued as highly by universities or the government.

This brief discussion highlights the contested value placed on TSA and the ways in which an increased focus on TSA can impact the overall aims and performance of universities, these influences differing because of a range of contexts, and with the potential for TSA activities to negatively impact on other, more traditional aims and performance measures of the university. The debates surrounding the push towards the Entrepreneurial University are likely to continue as commercial pressures upon Universities continue to grow (Philpott et al 2011), Bowl (2016) also highlighting that regardless of status there is increased use of entrepreneurial language by universities generally. Whilst it is undoubtedly true that tensions exist, however, it is also true that Governments around the world are continuing to promote TSA of Universities, forcing Universities and their staff to increasingly adapt to this new paradigm, making it an important area of study.

TSA Mechanisms and Entrepreneurial and Enterprising University Concepts

Given this, and consistent with Sharifi et al (2014) and Rossi and Rosli (2015),The TSA activities analysed within this study can be seen to fit within the broad theoretical framework encapsulated by the 'Triple Helix' (Etzkowitz et al 2000) which brings together universities, governments and industry. This framework, upon which much government policy in this area is implicitly or explicitly based, highlights the increasing role that universities play in innovation across sectors and the wider economy as a whole (Etzkowitz and Leydesdorff 1999; Gibb et al 2009). Within this the 'Entrepreneurial University' concept can be thought of as one of the focal points of the Triple Helix (Gibb et al, 2009), university development of close ties developed through on-going mutually beneficial knowledge exchange as the underpinning of the model (Etzkowitz and Leydesdorff 2000), including entrepreneurial education and innovation vehicles, such as incubators (Etzkowitz, 2008), that can be seen as entrepreneurial in nature. TSA activities then help to further university linkages with business which helps to strengthen the Triple Helix (Gibb et al 2009). In addition, the "Knowledge Spillover Theory of Entrepreneurship" (Acs et al., 2009) is also of relevance here, because it highlights that knowledge (for example created by universities) can spillover indirectly into the economy to be exploited by entrepreneurs. It is the dissemination of university knowledge therefore that is key to the role of the university within the triple helix and knowledge spillover theory of entrepreneurship.

Hewitt-Dundas (2012) and Morgan's (2002), research then identifies typological frameworks that support the notion that universities in the UK are heterogeneous in their ability to conduct TSA activities related to entrepreneurship. Morgan (2002) classified these as "elite" and "outreach" universities, whilst Hewitt-Dundas (2012) identified them as "Low Research Intensive" (LRI) and "High Research Intensive" (HRI) universities. Essentially, LRI / Outreach universities were engaged in far more human (social) capital development than HRI / elite universities, whilst HRI / elite universities were able to generate far more income from their research and were provided with far more funds for research. Building on the Hewitt-Dundas (2012) use of the HE-BCIS dataset (which was used to explore correlations between LRI and HRI Universities and TSA), this research uses the TSA activities themselves as a mechanism to identify the broad sets of activities related to entrepreneurship from which to create a typology.

There are then a range of TSA activities of relevance. Wright et al. (2004), for example, suggest a range of formal and informal mechanisms through which university knowledge creation and dissemination can be encouraged. These include traditionally utilised patenting, licensing and technology transfer, as well as more recent mechanisms such as new firm incubators, joint ventures, start-ups and spin-outs (e.g. see Berggren and Dahlstrand, 2009). Prospects Net (2007) also identify that whilst self-employment is chosen by a minority of graduates, it is a key source of overall entrepreneurial activity in the UK, offering another entrepreneurial mechanism for university knowledge commercialisation.

This identifies the potential, therefore, for universities to become more entrepreneurial in terms of exploiting their own resources for greater direct self-benefit, and / or to also have a wider enterprising agenda also of benefit to the wider economy. Evaluation of the literature identifies a number of sets of TSA that can be seen as potentially, simultaneously relevant to these overlapping concepts of what this paper classifies as the "Entrepreneurial" and "Enterprising" university. The entrepreneurial university concept is defined here as focused more on those traditional activities universities undertake to generate additional benefit for themselves, whilst the enterprising university concept is more associated with a more even distribution of university activities between those of most direct benefit to itself with those of wider advantage to the economy more generally.

This is important because, as Landry et al. (2010) found for example, after analysing a wide range of entrepreneurial activities of universities, consulting (which included contract research), patenting and spin-out creation all have significant covariances but teaching appeared to have no impact on consulting. There did not, therefore, appear to be the trade-off between the two activities that may be expected given that these types of activities are often competing for time from academics (Landry et al., 2010; Abreu et al., 2009). This potentially suggests that activities such as enterprise education need not necessarily be seen as substitutes for those that benefit the university more directly. To follow, will be an overview of the various activities that make up the TSAs of Universities in the UK. These range from contract research and consultancy, to more traditional patents to licensing, but also spinoffs of various types.

Contract Research, Consultancy Contracts and Facilities

Contract research provides a number of benefits in addition to short term monetary gain for the university. It can also enhance relationships with industry (Prince, 2007), assist spin-out creation (Van Looy et al., 2011), complement other knowledge exchange activities (Van Looy et al., 2011; Landry et al., 2010), and benefit the local region more than (inter)nationally (Schartinger et al., 2002).

Universities also provide facilities and equipment for businesses for fees, encouraging entrepreneurial behaviour with the facilities whilst also generating third stream income (Etzkowitz, 2003). Huffman and Quigley (2002) suggest one reason for the success of Silicon Valley was because firms could access facilities and equipment from Stanford University, as well as Stanford creating an industrial park on university owned land to facilitate business co-location and enhance knowledge sharing and diffusion. Indeed, many universities now have science parks and new firm incubators for these very reasons.

Patenting and Licensing

The addition of third stream missions often simply exploits universities' core existing TSA strengths, given that Universities have been centres for knowledge creation for centuries, and dedication to research is often cited within universities' vision and mission declarations (e.g. see, Cardiff, 2012; Cambridge, 2012). Patenting also forms an important component of the entrepreneurial university, protecting its intellectual property (Crespi et al., 2011) though there has been a downward trend in this activity since the turn of the 21st century (Leydesdorff and Meyer, 2010).

One way universities can then exploit their patent is through sale of licenses to firms, providing the university with a royalty income substantial in some cases, see for example

Gatorade (Gatorade, 2012). Siegel et al. (2008) show a positive and significant increase in licensing numbers from increased disclosures by a university. Licensing has also been used to analyse the entrepreneurial university (Powers and McDougall, 2005; Caldera and Debande, 2010), many studies using licensing (or licensing income) as one of the measures of a university's' knowledge transfer or economic success (Siegel et al., 2008; Caldera and Debande, 2010). Siegel et al. (2008), also suggest, however, that different types of universities require different approaches in their exploitation of knowledge, with larger, older universities often less focused on licensing, preferring alternative methods of knowledge transfer.

Spin-outs and Start-ups

Another, related, method for exploiting university research is the creation of spin-outs, various types of spin-out categorisations used by the HE-BCIS within this study. Universities have been directly creating spin-out companies for decades and university spin-out activity is increasing (PACEC, 2009). Spin-outs from universities provide many benefits; including jobs, investment, economic value, and localised impacts (Shane, 2004). These benefit not just the university, but also the region and its inhabitants, generating both entrepreneurial and enterprising outcomes.

In terms of spin-out research, however, most studies have only explored whether a university is creating a spin-out, not differentiating different *types* of spin-out. Whilst some have differentiated between sponsored and unsponsored spin-outs (Bathelt et al., 2010), or orthodox, hybrid or technological (Nicolaou and Birley, 2003), there is a lack of use of categorisations used in the HE-BCIS to analyse UK universities. Specifically noteworthy in this regard is the study by Åstebro et al. (2012) which uses graduate and staff spin-outs (start-ups). They note, however, the lack of studies including the creation of graduate start-ups when assessing universities.

Although self-employment is chosen by a minority of graduates, it is also a key source of entrepreneurial activity in the UK (Prospects Net, 2007). Hannon et al. (2005) also identified the key (enterprising university) role of the HE sector in the process of increasing levels of graduate entrepreneurship. Holden et al. (2007) therefore identify the need for ongoing, more sophisticated, research in the graduate entrepreneur area.

Methodology

This review of the literature identified a range of variables of potential use in the analysis. Specifically, different types of spin-out, both university owned but also other types related to activities such as graduate entrepreneurship, highlight different ways to look at university TSA. This could also prove interesting for university stakeholders and policy makers because the UK Government has traditionally concentrated research funds, typically those who are part of the Russell Group (DES, 2003).

Data Sources

The analysis within this paper uses the Higher Education Business and Community Interaction Survey (HE-BCIS), carried out annually by the Higher Education Statistics Agency (HESA) providing comprehensive collection of data regarding financial activities of UK universities. Whilst there have been reports of Universities providing unreliable information (Rae, 2010), which could lead to inaccurate results, the HE-BCIS, as a Government sponsored collection of data, is the most comprehensive dataset available to researchers. Rossi and Rosli (2015) also note that it is broad in scope, other countries seeking to adopt similar survey methods so they can have a greater indication of their universities' TSA.

The 2009/10 HE-BCIS included data from all 168 UK HEIs forming the basis of analysis within this paper. Information was collected from all types of commercial activities that UK universities were engaging in, including; disclosures, patenting, licensing, spin-outs generated, contract and consultancy research, provision of continuing professional development, provision of continuing education and use of facilities and equipment.

Many of these commercial activities are then broken down even further to include data relating to *type* of organisation the university engages with. For instance, licensing is broken down into six categories; software Small and Medium sized Enterprise (SME), software non-SME, software non-commercial, non-software SME, non-software non-SME and non-software non-commercial. For spin-outs four different types are identified based on ownership of the new venture; HEI Owned, non-HEI Owned, Staff Owned and Graduate Owned. Compared to other studies (e.g. Avnimelech and Feldman, 2011; Caldera and Debande, 2010), the additional variables available in the HE-BCIS dataset allow greater analysis into specific commercial activities of UK universities.

Due to the heterogeneity of HE within the UK and the inclusive nature of the HE-BCIS there was, however, also a need to identify universities not actively engaged with, or not submitting data for, their commercial activities. After analysis of the 2009/10 data it became apparent that 24 universities had insufficient data to include within this PCA based study. This left a total of 144 universities considered, see Table A1 in Appendix A for their listing.

As referred to previously, one aspect of the study is the intention to consider two forms of the same data, the original and logged forms. Logging of data is a common stage in many analyses approaches (e.g. see, Keene, 1995; Osborne, 2005; Lütkepohl and Xu, 2012), with natural log ($\log_n$) transformation employed in this study.

As noted in Osborne (2005), such data transformation reduces non-normality by reducing relative spacing of scores on the right side of the distribution more than scores on the left side. Importantly it should be used appropriately, in an informed manner (it does allow researchers to continue to interpret results in terms of increasing scores). Keene (1995) expresses that the log transformed analyses should be frequently preferred to untransformed analyses. Whilst Keene notes that analysis of untransformed data should be combined with examination of outliers, here the notion of outliers is not pertinent, it needing to be respected that there will exist universities with high variable values. Log transformation, will, however, enable more discernment in variations at small value levels across variables.

Factor Analysis

The first stage of analysis here is to consider the wide range of available variables, in terms of individual pertinence and also their ability to contribute to identification of a smaller, more descriptive set of factors. Principal Component Analysis (PCA) was identified as the most relevant method for this part of the analysis, allowing reduction of dataset size whilst keeping as much information as possible (Field, 2009). PCA also produces factors that include a number of correlated variables and account for a large proportion of the variance within that group of variables (Field, 2009). PCA has been used widely within the past for this reason, within the education domain, such as by, Croxford and Raffe (2015) and Fernandez-Sainz and Garcia-Merino (2015).

Entering a whole range of variables relating to external interactions of Universities and then allowing PCA to confirm which variables to subject to further analysis has not been used in this way before, in respect of university TSA. This method of variable based factor generation provides unique insight into statistical similarities between various variables relating to university TSA (e.g. knowledge creation, exchange and exploitation).

There is much debate amongst PCA theorists over the correct way to retain factors, the most basic to keep those with an eigenvalue above one (Hair et al., 2010). However, Osborne and Costello (2009) recommend using a scree plot to visually observe the point that eigenvalues naturally flatten. Both methods were used to identify factors to be retained (see Appendix B for numerical details). Acknowledging two forms of the variable data considered (original and logged data), 36 variables were included within the PCA at the beginning of the process, 16 variables remaining at the end, identified in Table 1.

(Table 1 about here)

The 20 individual variables omitted, some obviously important in the literature, were excluded for reasons of crossloading onto multiple factors. Omitted variables included those concerning consultancy contracts (which make up the second largest revenue stream for Universities (HE-BCIS, 2010)), all the different types of licensing (software/non-software and by the type of business), as well as firm use of university laboratories or digital media suites (HE-BCIS, 2010).

It may be that effects of omitted variables are being picked up in multiple factors, rather than these variables not being important in the debate. Given that the factors are summarising the data into four broader concepts, this approach was believed to be justified, though this also highlights the need for further research in this area (revisited in the conclusions). Additionally, those 16 variables retained during the two PCAs that were run (results in Appendix B), were, able to explain between 76.9% and 82.6% of variance depending on the (original and logged) data used.

Also shown in Table 1 are descriptive statistics associated with original and logged forms of the data. In the original data there are wide spreads of values with heavy positive skewness observed (understandable with so many zeros in the data for some variables). This skewness is lessened in the variables when considered in their logged forms.

As described in Appendix B, the PCA established four factors not identified in previous literature (though containing 16 variables widely discussed in relation to university TSA), which are not correlated with each other. Each factor consists of a number of variables, next described:-

Factor 1: University Knowledge Exploitation Activity (UKEA) (V1, V2, V3, V4, V5, V6, V8, V12, V15): This factor included a wide range of the more "traditional" university knowledge exchange and exploitation activities most closely associated with entrepreneurial universities in the literature, explaining almost half the total variance explained by the factors.

Factor 2: Staff Spin-out Activity (V10, V14, V16): This factor includes staff spin-out activity, creating companies set-up by current (or recent) HEI staff, but not based on IP owned by the university (HESA, 2012), explaining around a fifth of the total variance explained by the factors.

Factor 3: Non-HEI Owned Spin-out Activity (V9, V13): HESA (2012) define this type of spin-out activity as including companies based on IP that has originated from within the HEI, but where the HEI has released ownership through sale of shares and/or IP etc. This factor explains just over $1/6^{th}$ of total variance explained by the factors.

Factor 4: Graduate Start-up Activity (V7, V11): Defined as including new business started by recent (within two years) graduates regardless of where IP resides, and where there has been formal business/enterprise support from the HEI, making this factor most closely related to enterprise education type activities. This explains around $1/8^{th}$ of total variance explained by the factors.

Regardless of whether original or logged data is used, the same variables load onto the same factors established, though loading weights are different. Further, used in later analysis, and described more specifically then, the total variance explained values associated with each factor also differ across the two factor models (for original and logged data), the factors identified for the logged data explaining a greater percentage of variance. When using the percentage of variance explained by each factor as a proportion of overall variance explained to weight the index, however, the weights are almost identical for the original and logged data. This means that logging the data, particularly in terms of reducing the impact of a university focusing on one or two factors (particularly UKEA) to the detriment of others, explains the differences in the rankings. As will be seen this suggests the index for the original data can be more closely related to the concept of the entrepreneurial university defined in this paper, whilst the index of the logged data is more relevant to the wider concept of the enterprising university.

Index Results

This section describes results from indexing undertaken on the PCA factor analysis employed on the two forms of the data considered (original and logged). Details on the indexing approach employed are given in Beynon et al. (2015). Throughout this exposition results are presented to enable easiest opportunity to compare across original and logged forms of the data.

Sub-index university TSA

Following the index approach in Beynon et al. (2015), items (variables) making up a factor are weight-plotted across the domain of a constellation graph. This weighting is the pseudo-normalised forms of the item's loadings for a factor. To illustrate, for the factor Staff Spin-out

Activity, with three items associated with it, each of the loadings are divided by their sum. For original data, the loadings are 0.953, 0.932 and 0.829, which sum to 2.714, hence their normalised values are, 0.351, 0.344 and 0.305. For the logged data, with loadings, 0.925, 0.940 and 0.920, which sum to 2.785, hence their normalised values are, 0.332, 0.338 and 0.330.

Following the plotting approach described in Beynon et al. (2015), with this described weighting process for each university (on each form of data), a constellation coordinate (herein shortened to coordinate) is identified to represent the associated factor in the constellation graph domain. In Figure 1, the eight constellation graphs show the university's considered (labelled with code given in Table A1 in Appendix A) over each factor, University Knowledge Exploitation Activity (UKEA), Staff Spin-out Activity, Non-HEI Owned Spin-out Activity and Graduate Start-up Activity (top to bottom), and whether using original or logged data (left and right).

(Figure 1 about here)

In each constellation graph in Figure 1, one university is shown with piecemeal lines shown between points, showing the contribution of items making up that factor to that university's position in the constellation graph domain (this piecemeal line is further elucidated later when considering individual universities). Comparing across constellation graphs, the piecemeal lines describe coordinates are on the same university (labelled 17). These piecemeal lines show how the different numbers of items make up a factor and their weights of contribution.

The technical description in Beynon et al. (2015) of the formulation of a factor based sub-index value is described in the constellation graph by mapping each coordinate down to the baseline of the constellation graph (which has associated numerical scale/domain of 0 (left vertex) to 1 (right vertex)), with concomitant sub-index values shown for university labelled 17. Table 2 gives summary statistics of the four sub-indexes over the established original and logged data forms.

(Table 2 about here)

The results in Table 2, and constellation graphs in Figure 1, show that in general terms, for a factor, the original data sub-index values are on average lower than those with the logged data.

Our attention now turns to the weighted aggregation of the sub-index coordinates (note coordinates not values), for a university, over a data form, to create a final index of university TSA. From Beynon et al. (2015), the weightings used are found by pseudo-normalising the %variance associated with each factor. For original data, the % of variance are 36.905, 16.328, 14.085 and 9.628, which sum to 76.946, and so weights are 0.480, 0.212, 0.183 and 0.125. For logged data, with % of variance, 40.539, 17.985, 13.052 and 10.989, which sum to 82.565, and so weights are 0.491, 0.218, 0.158 and 0.133. Figure 2 shows the final index coordinates for universities over the original (2a) and logged (2b) data.

(Figure 2 about here)

In each constellation graph in Figure 2, each university is represented by its code (see Table A1 in Appendix A). As with the sub-indexes, the university TSA index values are found by mapping from each coordinate down to the base line (over the 0-1 baseline domain), as shown for university labelled 17. Table 3 gives a summary of the final indexes of university TSA across the two data forms.

(Table 3 about here)

With two indexes describing university TSA, based separately on original and logged data, how they compare across the individual universities can be succinctly visualised using a scatterplot, see Figure 3.

(Figure 3 about here)

In Figure 3, each university is described by a point in the scatter plot domain, with axes representing the TSA index values based on original (horizontal-axis) and logged (vertical-axis) data. Also shown in the scatterplot domain is the dashed line representing $y = x$, along which if any point was on this line it would represent the case that the same index value is found for a university across the two forms of data considered. The case of university labelled 17 is shown for demonstration purposes.

Inspection of points in the scatterplot diagram shows the index values, for those above 0.000, have the property that the index value associated with the logged data is above that of the index value associated with the original data. This was evident with comparison with the final TSA index values shown in Figure 2 (for the same university). The vertical distance of each point away from the $y = x$ line indicates how much the logged data based index values are above their respective original data based index values.

In an attempt to look more specifically at the variations in index values across the universities, across the two data forms of index values found, Figures 4 and 5 give an overall rank ordering of the 144 universities based separately on the original (Figure 4) and logged (Figure 5) based data.

(Figure 4 and Figure 5 about here)

In Figures 4 and 5, each university is described by two points, circle and triangle, joined by a straight line, these two points represent the two index values found from the original (circle) and logged (triangle) forms of data (knowing that for each university, from Figure 3, the triangle will be above the circle in value). In Figure 4 the universities are ranked based on the original data hence by the values represented by circles (on the left), then in Figure 5 the universities are ranked based on the logged data hence by the values represented by triangles (on the right).

Inspection of rank positions of universities in Figures 4 and 5 shows a number of rank changes when comparing across the two index values representing them, illustrative examples outlined in the discussion section below. First, however, follows comparisons of results for example universities across the four factors (UKEA, Staff Spin-outs, Non-HEI Spin-outs and Graduate Start-ups) and final TSA index, in order to highlight where these differences are derived from.

Individual university analysis

This section outlines the ability of this constellation graph index approach to exposit the sub-index and final index information for individual universities. Here, with two forms of the data, original and logged, two constellation graphs exist for an individual university, see Figures 6 and 7.

(Figure 6 and Figure 7 about here)

In Figures 6 and 7, each pair of constellation graphs shows the TSA information for a single university, based on the original (left) and logged (right) data. Within a single constellation graph, the constellation coordinates of the four sub-indexes, UKEA Staff Spin-outs, Non-HEI Spin-outs and Graduate Start-ups, as well as the final index TSA. Mapped down from each of these constellation coordinates onto the base line of the constellation domain are the actual sub-index or final index values (with the final TSA index in the largest font). Associated with each sub-index, in particular their associated constellation coordinate, is the contribution of the items established to make up that factor (e.g. nine items for UKEA factor and three items for Staff Spin-outs factor). Using logged and unlogged data leads to, in some cases, different rankings for these universities, for reasons discussed below.

Discussion and policy consequences

Regardless of whether original or logged data is used, individual factor rankings show a consistent pattern (see Table C1 in Appendix C). For UKEA, unsurprisingly, all the top 10 universities belong to the Russell Group. The very nature of the components of the UKEA factor suggest that this type of activity will likely be driven by research funding and research quality, dominated by the most research active and best funded universities.

In contrast, fewer Russell Group universities are represented in the Top 10 for staff spin-outs, with a likely greater variation amongst the universities with regards to their research quality and funding, as determined by REF, and focus (teaching or research). Non-HEI Owned Spin-outs also show different universities being in the top 10, including fewer Russell Group universities in this top ten. Finally, when we consider the top 10 universities for Graduate start-ups, Russell Group universities are even less common.

There are, of course, a number of universities that are very good at more than one type of entrepreneurial activity, Cambridge University, for example, appearing in the top ten for three of the four factors. Conversely, many other universities, such as Oxford and Swansea Metropolitan, are very good at driving one or two of the sets of activities but relatively less engaged in the other groups of activity.

In terms of how this is reflected in the final TSA index, there is a much higher correlation between non-UKEA factors and final overall score in the logged form index compared to the original form index (Staff: 0.65 compared with 0.52, Non-HEI: 0.62 compared with 0.42, and Grad: 0.33 compared with 0.21). The UKEA correlation, in contrast, remains at about the same level (0.89 for logged, 0.90 for original).

Unsurprisingly, the ranking of the illustrating universities show clear differences with regards to the original and logged data. Whilst Oxford University and Swansea Metropolitan University dropped down the rankings (from 1st to 8th and 43rd to 59th respectively), Cambridge University, Cardiff University and Aston University all rose (from 2nd to 1st, 11th to 3rd, and 64th to 44th respectively). The reasons for this are that Oxford's UKEA concentration is less strongly "rewarded" in the logged index, whilst Swansea Metropolitan's lack of UKEA activity is more heavily "punished". Conversely, for Cambridge University, Cardiff University, Aston University and Coventry University, their more consistent activity across all four factors are rewarded in the logged index in terms of their higher rankings.

These results support the view that using the original data will tend to better rank the entrepreneurial university concept as defined here, particularly as this will, to a greater extent, tend to reflect the strength of UKEA activities, as well as more narrowly focused universities. Conversely, logging the data creates an index reflecting the broader enterprising university concept defined here, where there is a more even spread of university activities across those associated with entrepreneurship and enterprise promotion.

The two types of indexing used, on original and logged data, crucially, allow further delineation between universities based on the concentration or dispersal of their activities across the four factors. This is also of potential relevance to policy makers when determining how to allocate resources depending on their view of the values of different types of activity.

The reasons for concentration of research funds, for example, are numerous, but the most common stated reason is that a concentration of funds allows universities to focus upon research and so attract the best talent and conduct the best research (DES, 2003). What this means for commercial activities, such as patenting or spin-out creation that rely on the creation of commercial knowledge or technologies is that universities with the most research funding are most able to conduct these types of commercial activities. This concentration of funds within the UK can also, however, cause a reinforcing feedback loop. Enhanced research funding means that a university is able to carry out more research and of a higher standard. This in turn allowed them to submit more research to the Research Assessment Exercise (RAE) (now REF) and so gain more funds, thereby completing the funding loop.

This is, conversely, detrimental to universities outside the Russell Group, affecting their ability to engage in high levels of certain commercial activities. One of the perceived strengths of many of these often post-92 universities, however, is their interaction within their local region (Hewitt-Dundas, 2012). The wider range of variables relevant to the role of universities in the economy highlighted in this research, allows the efficacy of government policy in this area to begin to be evaluated, particularly in terms of the range of mechanisms the research has highlighted (e.g. staff spinouts and graduate start ups) by which university knowledge can spillover into the economy, which government policy may also have the ability to affect. It also highlights, however. a need for further exploration of the reasons behind these results, discussed in the conclusions.

Conclusions

This study, through use of PCA and indexing, mathematically identifies dependent variables of relevance to future research. This approach allowing identification of four unique groups of entrepreneurial activities that universities are engaging in, which together can be seen as encompassing the concepts of Entrepreneurial and Enterprising Universities.

"University Knowledge Exploitation Activities" (UKEA) is the most wide-ranging, and importantly, includes many activities analysed in previous studies as separate activities Because, statistically, these variables can be grouped together into a single factor when considering the 144 HEIs across the UK included in this study, this is of real interest to policy makers trying to understand what groups of entrepreneurial activities at universities are similar, and how universities are performing in terms of these activities. The other three groups of activities identified by the PCA, "Non-HEI Owned Spin-outs", Staff Owned Spin-outs" and "Graduate Start-Ups" are all activities less associated with the Russell Group of Research intensive universities, the use of graduate start-ups when analysing entrepreneurial universities particularly so.

Possible policy implications of the findings may include a need to re-evaluate the way in which government funding is allocated, for example depending on whether entrepreneurial or enterprising university TSA configurations are favoured by government. This would also require further research to explain the reasons for the differences in TSA performance across the sector, including the identification of common and disparate policy relevant variables affecting the 4 factors identified in this study. For example, in addition to research and teaching funding and activity, university size may be potentially important, but also the structure of the university (e.g. science parks, medical schools, etc.), and nature and extent of supporting activities (e.g. Technology Transfer Offices), all obvious areas of policy related interest. Given the potential conflicts between TSA and other university aims and performance objectives identified in the literature, the impact of these other aims and objectives and related university policies are also of relevance for further research. In addition, reasons for differences in the value of TSA, related to absorptive capacity and the regional economic contexts in which universities reside, are also of relevance here.

In terms of further research, the weights associated with each sub-index for its contribution to the final index, currently comes from the percentage of variance from the factor analysis. As an alternative, expert opinion could be used to give these weights, including numbers of sets of weights if a group of experts were considered.

The authors acknowledge the exploratory nature of this study, and the need for further research. Other variables, for example, could be included (including returning to those removed in the factor analysis stage), as well as different forms of the data considered. This latter issue includes the possibility of scaling the data items in ways to take account of other external factors, which may have an appropriate associated interest.

In technical terms, the index approach employed has, however, shown a number of interesting features, i) the results from factor analysis are fully included in the indexing process, ii) the sub-indexes and final index are comparable over the same domain, and iii) how each constituent item contributes to the establishment of a sub-index and subsequent final index.

There are also pertinent developments to consider. In political/strategic terms, what variables and what forms of the variable values is usually in the hands of the researcher(s), the index approach employed here shows the transparency of the analytical process. The comparison between the results from the use of original and logged data forms also explicitly demonstrate what choices have been made in the analytics and have been fully expressed.

Appendix A (List of universities)

This appendix gives a list of the 144 universities considered in this study, see Table A1.

(Table A1 about Here)

Appendix B (PCA factor analysis results)

This appendix reports the factor analysis results on the 16 variables described in the main text summarised in Table 1. For technical description of this factor analysis approach see Hair et al. (2010). With two sets of variable values considered, namely the original values and the logged transformed set of values, two sets of factor analysis are reported.

The first stage of the factor analysis is the extraction of factors, see Table B1, where it is identified for both versions of the variables (original and logged forms).

(Table B1 about here)

Table B1 shows for both forms of the variable values four factors are identified, with associated eigenvalues above one. Collectively, nearly 76.946% (original) and 82.566% (logged) of the variance[1] in the underlying data is contained in the variables from the separate extraction of factors. Comparing these totals shows the logged model retains the most variance (this could be a feature of making the variables more normally distributed).

Once rotated using Varimax with Kaiser Normalisation, the 'percentage of Variance' contribution of the three identified components are; Original - 36.905%, 16.328%, 14.085% and 9.628% and Logged - 40.539%, 17.985%, 13.052% and 10.989%.

Following on from identification of factors, Table B2 shows the resulting loadings of the 16 variables for the separate original and logged forms of the data. These loadings estimate the level of contribution of a variable to a factor.

(Table B2 about here)

Inspection of loadings across the two models shows the largest loading (in bold) for each variable map the same variables onto each identified factor, enabling consistency in the later factor names to be employed. There is some note in terms of ordering of the sizes of the loadings within each factor across the two models. That is, for example, in Factor 1 across both models, for original data 'Number of Active HEI Owned Spin Offs' is third largest in loading value (with 0.833), but for logged data 'Number of Disclosures' is third largest in loading value (with 0.863). A number of such changes in order of loading size are apparent across within factors (though variables do not change factors across models).

The loadings in Table B2 are used to construct factor scores, values representing the factors for each university. This enables a form of data reduction. It is debateable how the loadings should be used to enable factor scores to be evaluated. There are a series of approaches to constructing factor scores for the universities (in this case). For example, Hair et al. (2010) suggest including: identification of a single variable (value) to represent each factor; aggregation of values of the variables most associated with each factor (averaged or weighted by loadings values); and 'loadings' weighted aggregation of values of all variables associated with each factor. There are advantages and disadvantages to each approach (Hair et al., 2010). For the two models here, each variable is loaded onto the factor it was most

[1] The '% of variance term' relates to what percentage of the variance in the considered 16 variables is explained by the respective number of factors (see Hair et al., 2010).

associated with (based on largest loading value) and weighted by the loading value (identified in bold face in Table B2).

Appendix C

Listings of UK universities based on sub-index results, see Table C1.

(Table C1 about here)

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Table 1. Descriptive statistics of 16 retained variables (over original and logged forms of data)

Code	Variable	Description									Factor
		Original data					Logged data				
		Min	Mean	Max	Skewness		Min	Mean	Max	Skewness	
V1	Number of Contract Research with SME	0.000	14.285	102.000	2.257		0.000	1.778	4.635	0.196	1
V2	Number of Contract Research with Non SME	0.000	69.972	738.000	2.600		0.000	2.613	6.605	0.268	1
V3	Number of Contract Research with Non Commercial	0.000	114.292	926.000	2.606		0.000	3.475	6.832	-0.416	1
V4	Number of Disclosures	0.000	27.160	342.000	3.839		0.000	2.042	5.838	0.110	1
V5	New Patent Apps	0.000	13.972	253.000	4.970		0.000	1.574	5.537	0.426	1
V6	Number of Patents Granted	0.000	5.743	121.000	5.216		0.000	0.957	4.804	1.105	1
V7	Number of Graduate Spin Offs	0.000	16.604	222.000	3.558		0.000	1.665	5.407	0.369	4
V8	Number of HEI Owned Spin Offs Survived 3yrs	0.000	5.479	68.000	3.182		0.000	1.123	4.234	0.658	1
V9	Number of Formal Not HEI Owned Spin Offs Survived 3yrs	0.000	0.972	26.000	6.046		0.000	0.356	3.296	1.942	3
V10	Number of Staff Spin Offs Survived 3yrs	0.000	1.271	21.000	3.804		0.000	0.405	3.091	1.806	2
V11	Number of Graduate Spin Offs Survived 3yrs	0.000	13.882	213.000	3.925		0.000	1.418	5.366	0.621	4
V12	Number of Active HEI Owned Spin Offs	0.000	7.313	81.000	2.879		0.000	1.279	4.407	0.541	1
V13	Number ofActive Not HEI Owned Spin Offs	0.000	1.639	43.000	5.677		0.000	0.449	3.784	1.914	3
V14	Number of Active Staff Owned Spin Offs	0.000	1.986	30.000	3.530		0.000	0.547	3.434	1.480	2
V15	Estimated Employment of HEI Owned Spin Offs	0.000	61.826	1050.000	3.922		0.000	2.025	6.958	0.564	1
V16	Estiimated Employment of Staff Spin Offs	0.000	7.028	126.000	4.317		0.000	0.711	4.844	1.711	2

Table 2. Descriptive statistics of sub-index values (for original and logged data)

Original	Min	Mean	Max	Skewness
UKEA	0.000	0.057	0.837	3.519
Staff Spin-out Activity	0.000	0.045	0.985	4.437
Non-HEI Owned Spin-out Activity	0.000	0.021	1.000	8.238
Graduate Start-up Activity	0.000	0.044	0.746	4.100
Logged	Min	Mean	Max	Skewness
UKEA	0.000	0.324	0.987	0.637
Staff Spin-out Activity	0.000	0.141	0.999	1.822
Non-HEI Owned Spin-out Activity	0.000	0.099	1.000	2.305
Graduate Start-up Activity	0.000	0.284	0.985	0.652

Table 3. Descriptive statistics of final index values (for original and logged data)

Original	Min	Mean	Max	Skewness
University TSA	0.000	0.048	0.491	2.847
Logged	Min	Mean	Max	Skewness
University TSA	0.000	0.243	0.796	0.720

Table A1. Code listing of 144 considered UK universities

No.	University	No.	University	No.	University
1	Anglia Ruskin University	49	Kingston University	97	Southampton Solent University
2	Aston University	50	The University of Lancaster	98	The University of Southampton
3	Bath Spa University	51	Leeds Metropolitan University	99	Staffordshire University
4	The University of Bath	52	The University of Leeds	100	The University of Sunderland
5	University of Bedfordshire	53	The University of Leicester	101	The University of Surrey
6	Birkbeck College(#3)	54	The University of Lincoln	102	The University of Sussex
7	Birmingham City University	55	Liverpool Hope University	103	The University of Teesside
8	The University of Birmingham	56	Liverpool John Moores University	104	Thames Valley University
9	The University of Bolton	57	The University of Liverpool	105	Trinity Laban Conservatoire of Music and Dance
10	Bournemouth University	58	University of the Arts, London	106	University College London(#3)
11	The University of Bradford	59	London Business School(#3)	107	The University of Warwick
12	The University of Brighton	60	London Metropolitan University	108	University of the West of England, Bristol
13	The University of Bristol	61	London South Bank University	109	The University of Westminster
14	Brunel University	62	London School of Economics and Political Science(#3)	110	The University of Winchester
15	Buckinghamshire New University	63	London School of Hygiene and Tropical Medicine(#3)	111	The University of Wolverhampton
16	The University of Buckingham	64	Loughborough University	112	The University of Worcester
17	The University of Cambridge	65	The Manchester Metropolitan University	113	Writtle College
18	The Institute of Cancer Research(#3)	66	The University of Manchester	114	York St John University
19	Canterbury Christ Church University	67	Middlesex University	115	The University of York
20	The University of Central Lancashire	68	The University of Newcastle-upon-Tyne	116	Aberystwyth University
21	Central School of Speech and Drama(#3)	69	Newman University College	117	Bangor University
22	University of Chester	70	The University of Northampton	118	Cardiff University
23	The University of Chichester	71	The University of Northumbria at Newcastle	119	University of Wales Institute, Cardiff
24	The City University	72	Norwich University College of the Arts	120	University of Glamorgan
25	Coventry University	73	The University of Nottingham	121	Glyndwr University
26	Cranfield University	74	The Nottingham Trent University	112	The University of Wales, Lampeter
27	University for the Creative Arts	75	The Open University	123	The University of Wales, Newport
28	De Montfort University	76	Oxford Brookes University	124	Swansea Metropolitan University
29	University of Derby	77	The University of Oxford	125	Swansea University
30	University of Durham	78	The University of Plymouth	126	Trinity University College
31	The University of East Anglia	79	The University of Portsmouth	127	The University of Aberdeen
32	The University of East London	80	Queen Mary and Westfield College(#3)	128	University of Abertay Dundee
33	Edge Hill University	81	Ravensbourne(#2)	129	The University of Dundee
34	The University of Essex	82	The University of Reading	130	Edinburgh Napier University
35	The University of Exeter	83	Roehampton University	131	The University of Edinburgh
36	University College Falmouth	84	Rose Bruford College	132	Glasgow Caledonian University
37	University of Gloucestershire	85	Royal Academy of Music(#3)	133	Glasgow School of Art
38	Goldsmiths College(#3)	86	Royal Agricultural College	134	The University of Glasgow
39	The University of Greenwich	87	Royal College of Art	135	Queen Margaret University, Edinburgh
40	Harper Adams University College	88	Royal College of Music	136	The Robert Gordon University
41	University of Hertfordshire	89	Royal Holloway and Bedford New College(#3)	137	The University of St Andrews
42	The University of Huddersfield	90	The Royal Veterinary College(#3)	138	The University of Stirling
43	The University of Hull	91	St George's Hospital Medical School(#3)	139	The University of Strathclyde
44	Imperial College of Science, Technology and Medicine	92	The University of Salford	140	UHI Millennium Institute
45	Institute of Education(#3)	93	The School of Oriental and African Studies(#3)	141	The University of the West of Scotland
46	The University of Keele	94	The School of Pharmacy(#3)	142	The Queen's University of Belfast
47	The University of Kent	95	Sheffield Hallam University	143	Stranmillis University College
48	King's College London(#3)	96	The University of Sheffield	144	University of Ulster

Table B1. Extraction of factors for original (top) and logged (bottom) forms of variable values (those shown include one beyond those retained with eigenvalues above 1)

Original	Initial Eigenvalues			Rotation sums of squared loadings		
Component	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	6.651	41.567	41.567	5.905	36.905	36.905
2	2.522	15.762	57.329	2.612	16.328	53.233
3	1.700	10.623	67.952	2.254	14.085	67.318
4	1.439	8.995	76.946	1.541	9.628	76.946
5	.881	5.504	82.451			
Logged	Initial Eigenvalues			Rotation sums of squared loadings		
Component	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	7.773	48.581	48.581	6.486	40.539	40.539
2	2.662	16.639	65.220	2.878	17.985	58.525
3	1.512	9.448	74.668	2.088	13.052	71.577
4	1.264	7.899	82.566	1.758	10.989	82.566
5	.660	4.128	86.694			

Source: Data from HE-BCIS (2009/10)

Notes: Kaiser-Meyer-Olkin Measure of Sampling Adequacy indicating sampling adequacy (Kaiser, 1970; Field, 2009). Principle Components were kept in accordance with recommended eigenvalues of at least 1 as recommended by Osborne and Costello (2009), a scree plot was used to confirm this visually.

Table B2. Variable loadings values for original (top) and logged (bottom) forms of variable values

		Original				Logged			
Var	Loadings	Factor 1	Factor 2	Factor 3	Factor 4	Factor 1	Factor 2	Factor 3	Factor 4
V2	Number of Contract Research with Non SME	**0.904**	0.001	-0.012	-0.077	**0.916**	0.066	0.012	-0.040
V8	Number of HEI Owned Spin Offs Survived 3yrs	**0.864**	0.102	0.328	-0.084	**0.867**	0.177	0.300	-0.010
V12	Number of Active HEI Owned Spin Offs	**0.833**	0.082	0.437	-0.017	**0.843**	0.148	0.333	0.083
V15	Estimated Employment of HEI Owned Spin Offs	**0.833**	0.124	-0.016	0.017	**0.838**	0.167	0.104	-0.006
V4	Number of Disclosures	**0.819**	0.099	0.238	0.057	**0.863**	0.151	0.198	0.141
V3	Number of Contract Research with Non Commercial	**0.794**	-0.026	-0.066	0.023	**0.763**	0.141	-0.136	0.042
V6	Number of Patents Granted	**0.755**	0.116	-0.015	0.057	**0.793**	0.058	0.153	-0.084
V5	New Patent Apps	**0.752**	0.066	0.424	0.056	**0.841**	0.074	0.301	0.050
V1	Number of Contract Research with SME	**0.634**	0.187	0.019	0.001	**0.774**	0.133	0.108	0.027
V10	Number of Staff Spin Offs Survived 3yrs	0.102	**0.953**	0.153	0.018	0.166	**0.925**	0.230	0.120
V14	Number of Active Staff Owned Spin Offs	0.064	**0.932**	0.116	0.024	0.130	**0.940**	0.176	0.127
V16	Estimated Employment of Staff Spin Offs	0.174	**0.829**	0.062	-0.014	0.221	**0.920**	0.092	0.050
V13	Number of Active Not HEI Owned Spin Offs	0.052	0.102	**0.922**	0.134	0.196	0.209	**0.909**	0.120
V9	Number of Formal Not HEI Owned Spin Offs Survived 3yrs	0.206	0.207	**0.902**	-0.029	0.290	0.256	**0.877**	0.019
V11	Number of Graduate Spin Offs Survived 3yrs	0.116	-0.003	-0.002	**0.878**	0.066	0.156	0.070	**0.902**
V7	Number of Graduate Spin Offs	-0.095	0.023	0.094	**0.852**	-0.026	0.068	0.046	**0.925**
	Cronbach Alpha	0.788	0.944	0.814	0.712	0.946	0.928	0.929	0.829

Note: Components were removed from the principle component analysis if they did not have a rotated factor loading of above 0.5 and crossloadings of greater than 0.2 difference were removed (Field, 2009)

Table C: Top 10 rankings of universities across each factor (original and logged data)

Original Data			
UKEA	**Staff Spin-outs**	**Non-HEI Spin-outs**	**Graduate Start-ups**
1. University of Oxford	1. University of Southampton	1. University of Edinburgh	1. University of Central Lancashire
2. Imperial College of Science, Technology and Medicine	2. University of Teesside	2. Ravensbourne (#2)	2. Royal College of Art
3. University College London(#3)	3. University of Cambridge	3. University of the Arts, London	3. University of the Arts, London
4. University of Manchester	4. University of Strathclyde	4. University of Cambridge	4. University for Creative Arts
5. University of Cambridge	5. Cardiff University	5. Swansea Metropolitan University	5. Kingston University
6. University of Birmingham	6. University of the West of England, Bristol	6. University of Strathclyde	6. University of Oxford
7. University of Edinburgh	7. Swansea University	7. University of Sheffield	7. Loughborough University
8. University of Leeds	8. University of East London	8. Cardiff University	8. University of Bedfordshire
9. University of Newcastle-upon-Tyne	9. University of Glamorgan	9. University of Bristol	9. University of Portsmouth
10. University of Nottingham	10. University of Sussex	10. University of Newcastle-upon-Tyne	10. Coventry University
Logged Data			
UKEA	**Staff Spin-outs**	**Non-HEI Spin-outs**	**Graduate Start-ups**
1. University of Oxford	1. University of Southampton	1. University of Edinburgh	1. University of Central Lancashire
2. University College London(#3)	2. University of Teesside	2. University of Cambridge	2. Royal College of Art
3. Imperial College of Science, Technology and Medicine	3. University of Cambridge	3. Swansea Metropolitan University	3. University of the Arts, London
4. University of Cambridge	4. University of Strathclyde	4. University of Strathclyde	4. University for the Creative Arts
5. University of Manchester	5. University of the West of England, Bristol	5. University of Sheffield	5. University of Bedfordshire
6. University of Southampton	6. University of East London	6. Cardiff University	6. University of Huddersfield
7. University of Leeds	7. Swansea University	7. University of Bristol	7. Nottingham Trent University
8. University of Nottingham	8. University of Sussex	8. University of Aberdeen	8. Swansea Metropolitan University
9. University of Bristol	9. Cardiff University	9. University of Newcastle-upon-Tyne	9. University of Portsmouth
10. University of Birmingham	10. University of Lancaster	10. University of the Arts, London	10. University of Newcastle-upon-Tyne

Figure 1. Constellation graphs for TSA sub-indexes, "University Knowledge Exploitation Activity (UKEA)" (a and b), "Staff Spin-out Activity" (c and d), "Non-HEI Owned Spin-out Activity" (e and f) and "Graduate Start-up Activity" (g and h), using original data (a, c, e and g) and logged data (b, d, f and h).

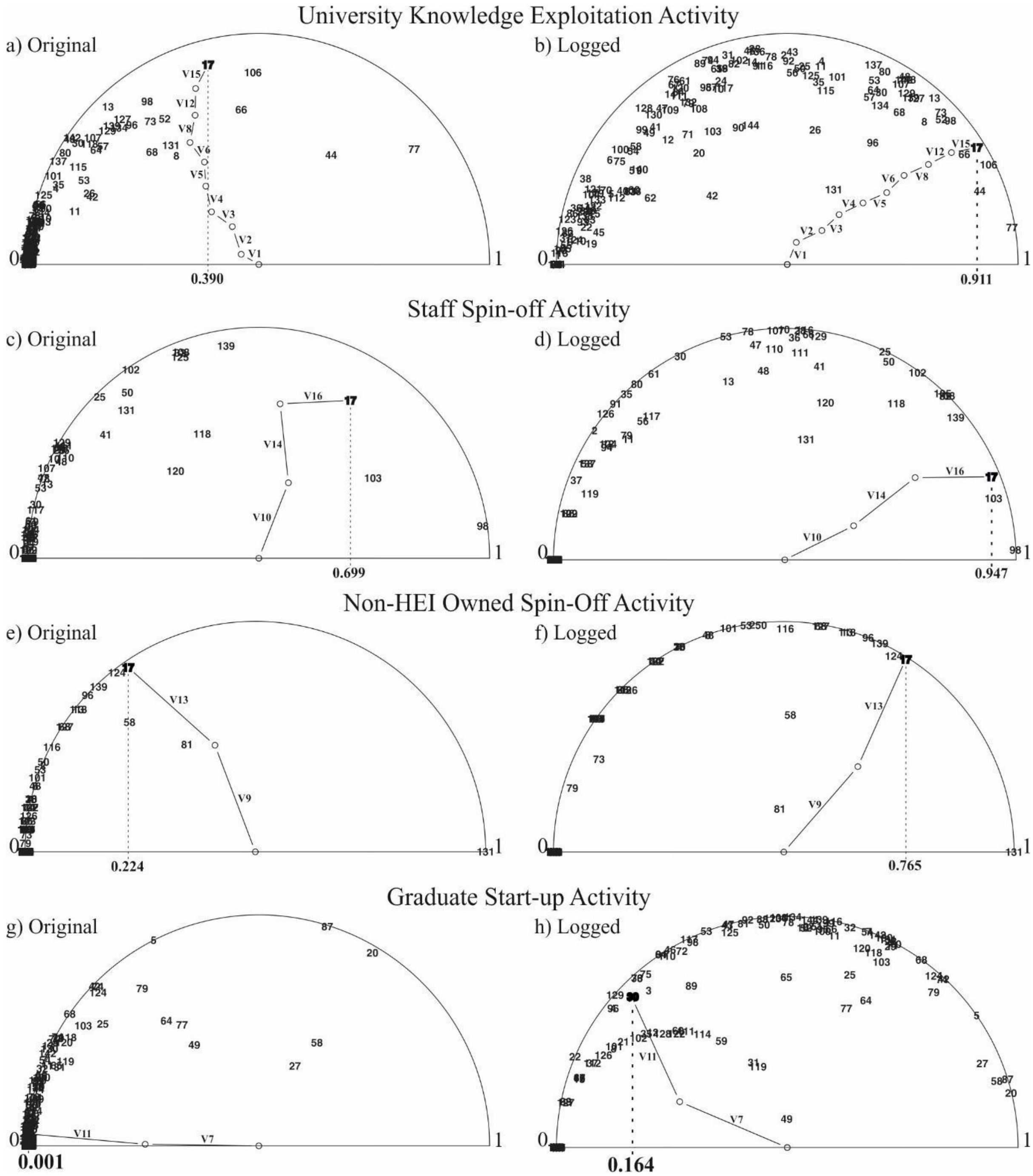

Figure 2. Constellation graph for final TSA index using original and logged data.

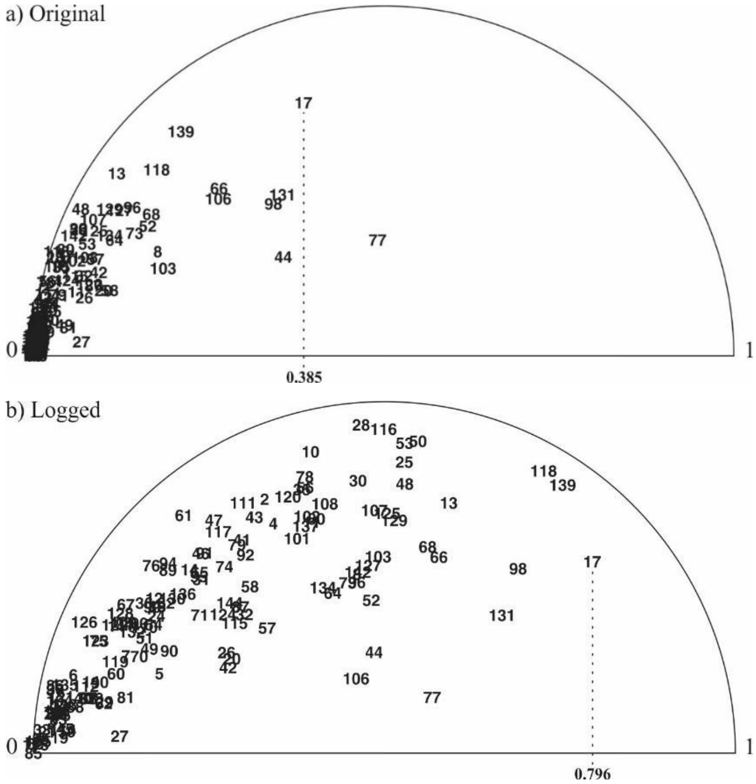

Figure 3. Scatterplot of universities based on paired index values (using original and logged data)

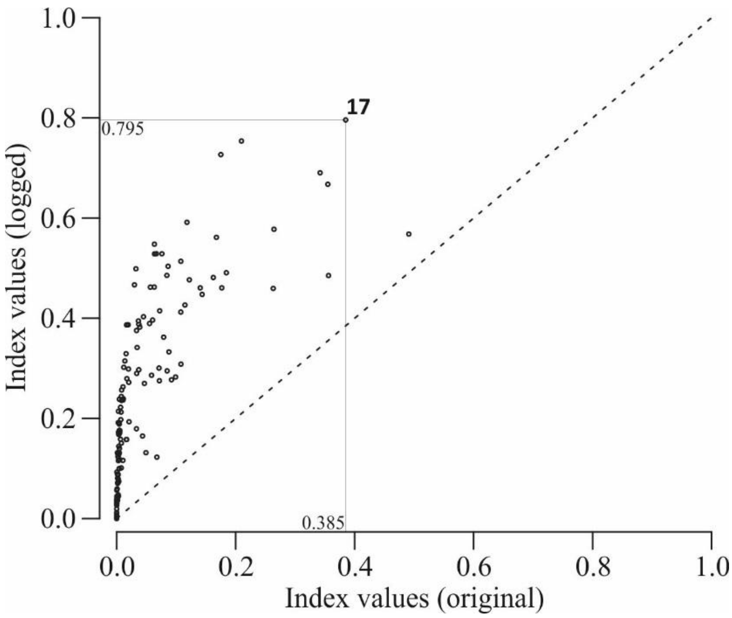

Figure 4. Rank order of Universities towards TSA based on original data

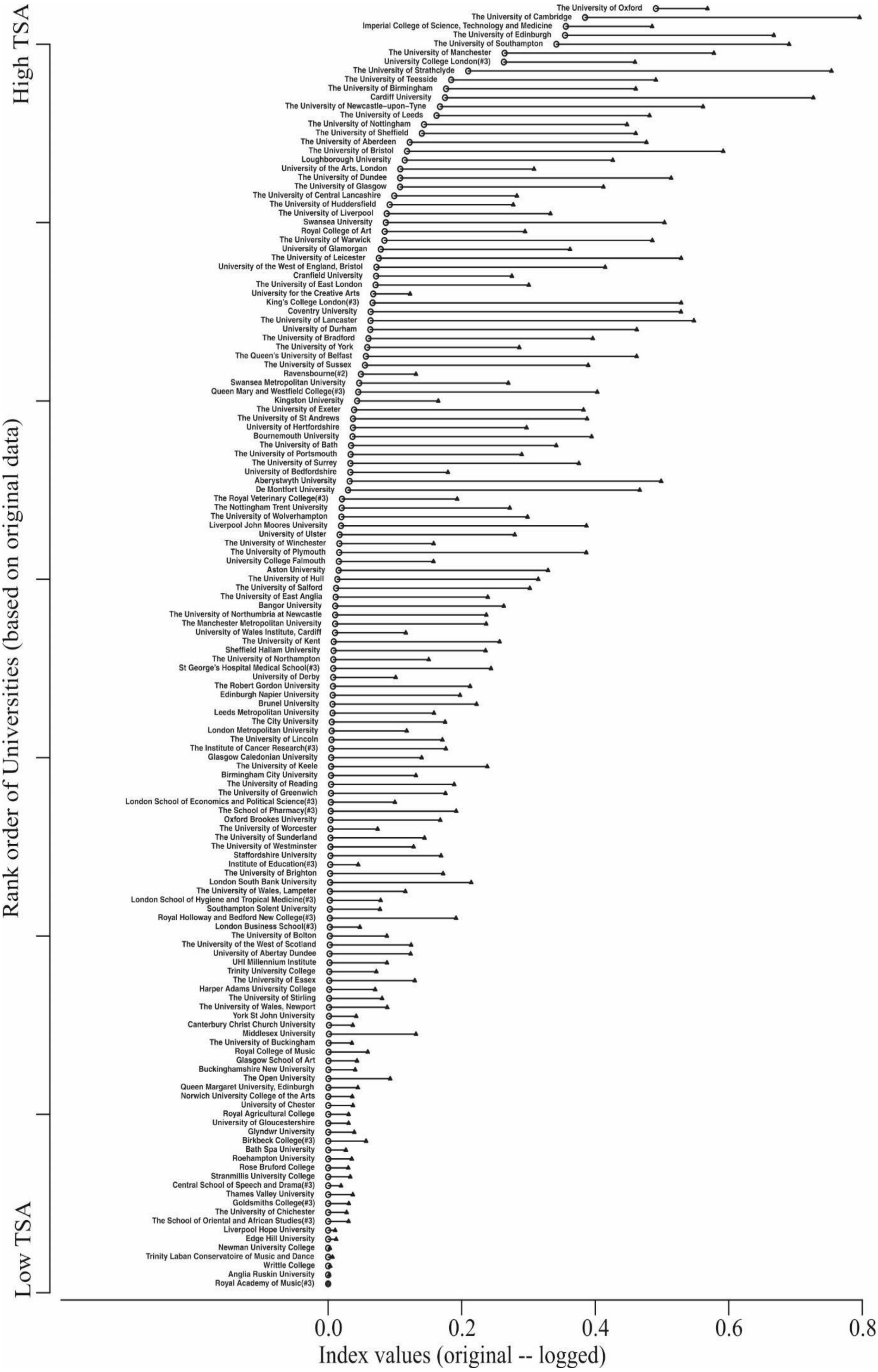

Figure 5. Rank order of Universities towards TSA based on Log$_n$ data

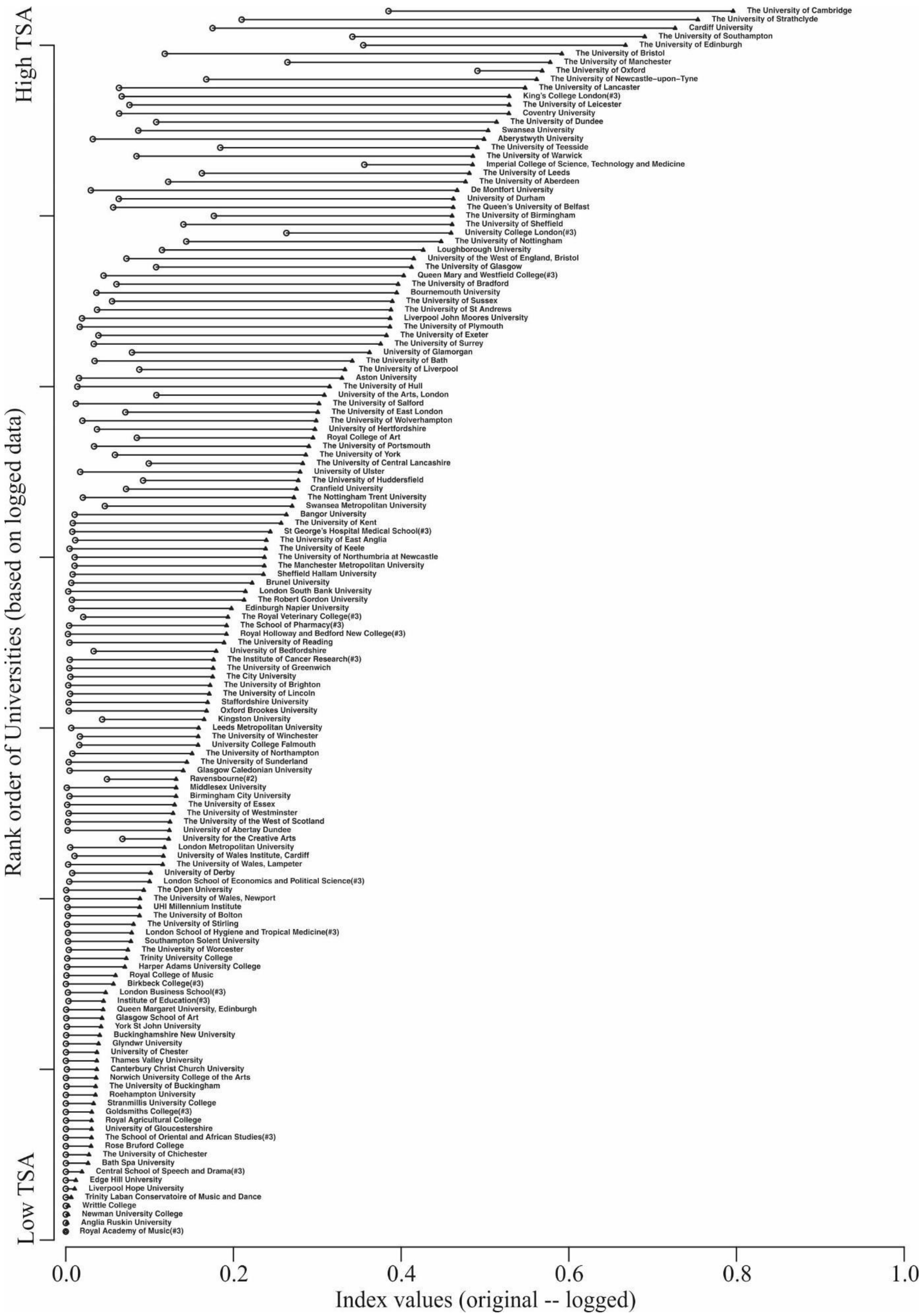

Figure 6. Constellation graph based elucidation of TSA sub-indexes and final index for the universities, Aston University and University of Cambridge, using original and logged data.

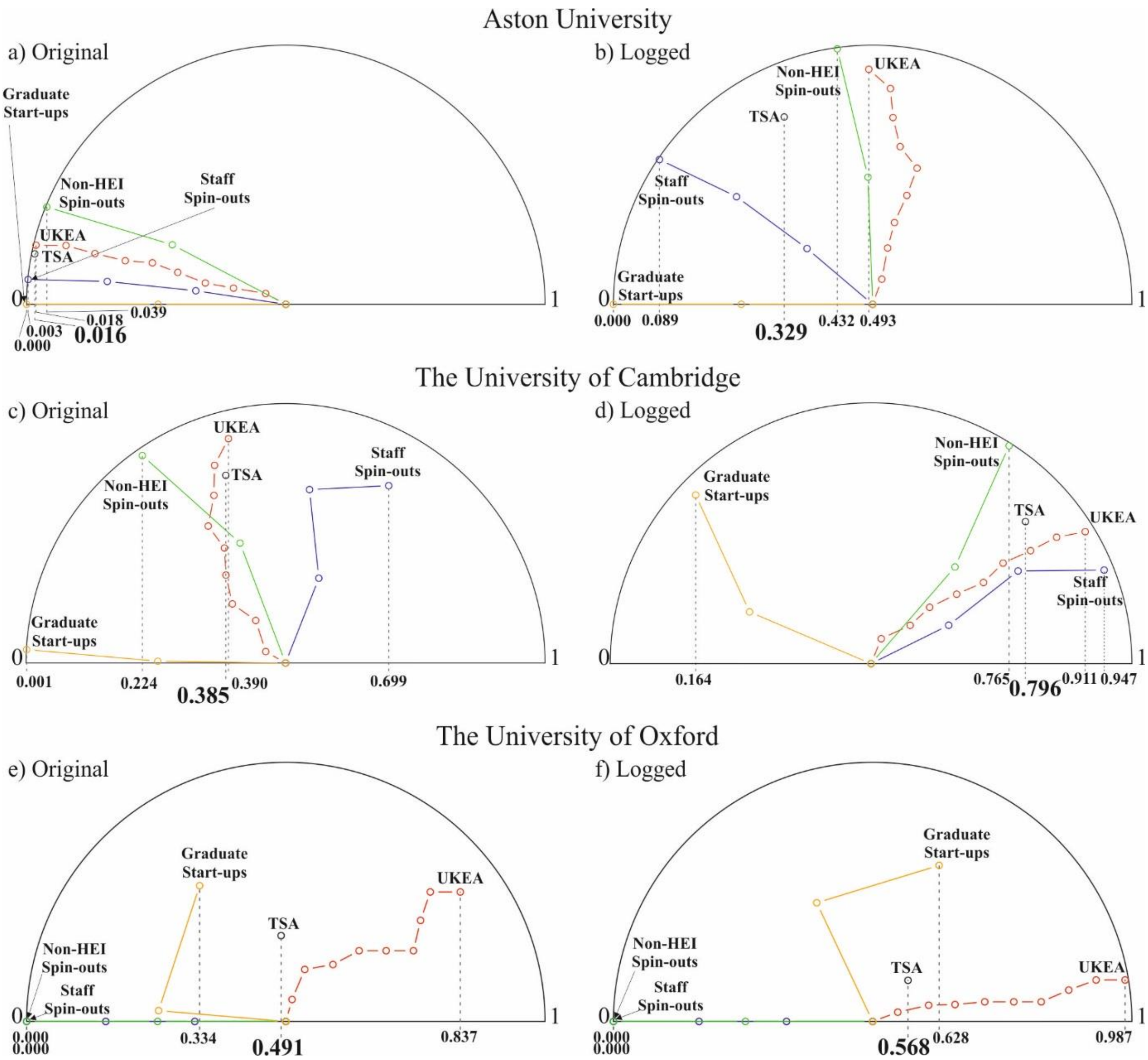

Figure 7. Constellation graph based elucidation of TSA sub-indexes and final index for the universities, Aston University and University of Cambridge, using original and logged data.