Putting university-industry interaction into perspective: a view from inside South African universities

Glenda Kruss[1]
Education and Skills Development
Human Sciences Research Council
Private Bag X9182
Cape Town 8000
SOUTH AFRICA

gkruss@hsrc.ac.za
+2721 4668086 (phone)
+27214612696 (fax)

Mariette Visser
Education and Skills Development
Human Sciences Research Council

[1] Corresponding author

Abstract

Firms and economic policy makers need an enhanced understanding of universities, in terms of what academics value and how they interact, if they are to enhance collaboration around the generation and transfer of knowledge and technology between universities and industry. The literature increasingly focuses on identifying incentives and barriers within universities that facilitate or constrain interaction with firms, but is largely limited to contexts in Europe and the USA. The paper contributes by situating university-industry linkages within the total pattern of academic interaction with external actors in diverse types of university, across an immature national system of innovation in a late developing economy context, South Africa. The empirical analysis maps the heterogeneity of academic engagement, focusing on firms, through principal component analysis of an original dataset derived from a survey of individual academics. It concludes that the incentives that drive South African academics and that block university-industry interaction are strongly related to universities' nature as reputationally controlled work organisations, and to the ways in which they balance and prioritise their roles in national development.

Putting university-industry linkages into perspective: a view from inside South African universities

1. Introduction

Firms and economic policy makers need an enhanced understanding of universities, in terms of what they value and how they interact, if they are to enhance collaboration around the generation and transfer of knowledge and technology between universities and industry. The literature increasingly focuses on identifying incentives and barriers related to academics and universities that facilitate or constrain interaction with firms in Europe and the USA. However, conditions vary across countries with different economic development trajectories, and there is a need for more studies in a wider range of contexts. Hence, this paper examines interactive practices of universities in South Africa. In immature national systems of innovation in late developing countries such as South Africa, universities and PRIs face the dual challenge of linking to global science, and of addressing local economic and social problems (Suzigan and Albuquerque 2011, Albuquerque et al 2015). These problems relate to local resource conditions, but equally, to the legacy of colonisation, racial and ethnic segregation, and resultant high levels of poverty, inequality and diversity. As economies and systems grow, the demands, and hence the multiple roles universities are expected to play, became more complex. Distinct types of university may combine and balance these multiple roles in diverse ways. Hence, academics and scientists may be driven to interact with farmers, informal sector producers, marginalised communities and local agencies, and not only formal sector firms (Johnson and Hirt 2010, Kruss et al 2012). They may prioritise research that aims to solve problems that will improve the quality of life of citizens, for example, partnering with government or development agencies to use nanotechnology to design new low-cost means of water purification. They may be required to address citizen's health problems across a heterogenous range of diseases, from those typical of highly developed countries to diseases of poverty. They may of course, prioritise basic research that will enable them to build scientific reputations on the global stage, above research in collaboration with firms at national level. Or they may lack the capability to interact with firms, or any other external partners, at all.

Situating university-industry linkages within the total pattern of interaction with external actors in diverse types of university across a national system of innovation can thus provide critical insights in late developing economy contexts – the aim of the paper. The empirical analysis identifies and maps patterns of interaction, using an original dataset derived from a survey of individual academics in four types of university. The value of such research is that it can provide insight into the incentives that are more likely to drive, or the barriers that can block, university-firm interaction and collaboration, in immature systems of innovation.

The paper begins by considering the emerging literature on incentives and barriers to interaction, and outlines the concepts adopted to analyse patterns of interaction from a university perspective. Section 3 describes contextual features of the higher education system in South Africa. It then describes the survey methodology, and the principal component method used to analyse the data. Section 5 describes patterns and trends in the interaction with all partners and with firms specifically; section 6 discusses the value of analyzing the frequency and forms of interaction in diverse types of university across a national system; and section 7 draws out policy implications.

2. Literature review

2.1. A growing empirical focus on academic incentives and barriers, and understanding university perspectives

A vast literature on university-industry interaction has emerged, most of which has a narrow, highly focused scope on a single issue or specific form of university-industry interaction, investigated from the empirical perspective of firms. For example, a common theme is proximity as a determinant of university-industry linkages (Carboni 2013; Lindelof and Lofsten 2004; Fuentes and Dutrenit 2014; Hewitt-Dundas 2013). Research conducted from the university perspective has tended to focus on determinants of entrepreneurial forms of interaction, linked to commercialisation of university knowledge and revenue generating activities, such as the optimal conditions for promoting academic spin-off firms (Niosi 2006; Pries and Guild 2007; Mustar et al 2006); how research centres promote commercially relevant knowledge production (Ponomariov 2013); or the effective use of technology transfer offices (Muscio 2010). There is considerable effort debating the relationship between entrepreneurial and academic roles, rewards and performance (Van Looy et al 2004; Tijssen 2004; Ranga et al 2003; Gulbrandsen and Smeby 2005).

However, the research literature increasingly recognises that policy makers and firms need to understand the conditions inside universities and the incentives that drive academics to collaborate. Mowery and Sampat (2005) emphasise that it is difficult to conceptualise universities in the same way as economic institutions, because of their distinct forms of governance and because of the very real tension among the different roles universities are expected to play within a knowledge-based economy. A set of studies focus attention on the barriers to interaction that arise from the differences and similarities between the values, motivations and orientations of universities and firms (Bruneel et al 2010; Musico and Pozzali 2013). More studies are emerging focussed on individual academic incentives and diverse university systems (Schartinger et al 2001; Gunasekara 2006; Wright 2014; Shah and Pahnke 2014; Bozeman et al 2012; Aschhoff and Grimpe 2014). Some research considered the role, organisation and attitudes of different types of university and different types of unit (faculty, department or research centre) in driving interaction with firms (Kenney and Goe 2004; Secondo and Ugo 2014; Martinelli et al 2007). DÉste and Patel (2007) in contrast, concluded that the nature of individual researchers, rather than organisational units or universities, influence the forms and frequency of interaction (see also D'Este, P. and Perkmann 2011). A recent trend is thus to explore individual propensities to interact. Goel et al (2015) examined the entrepreneurship propensity of individual academics, highlighting gender differences connected with seniority and leadership. Rizzo (2015) showed that young Italian scientists were more likely to establish academic spin-offs as a mechanism for advancement, in the context of an academic system with few opportunities and many bottlenecks.

Significantly for our purposes, there is growing recognition that entrepreneurial forms of action are not necessarily those most prized by universities, and that a broader understanding of 'academic engagement' in response to economic and social challenges, is required. Ramos-Vielba and Fernandez-Esquinas (2011) for example, demonstrated the wide variety of channels of knowledge transfer in Andalusian universities, proposing that policy makers should move beyond a narrow focus on patents and spin-offs. Abreu and Grinevich (2013) broadened the scope of 'academic entrepreneurship' to include any activity that occurs beyond traditional academic roles of teaching and research, and that leads to financial reward for the academic or institution.

Cessaroni and Piccaluga (2015) extended this further, questioning whether and how broader models of social engagement are replacing narrow knowledge transfer models focused on commercialisation in Italian universities.

In this regard, Perkmann et al (2013) conducted a useful systematic review of the literature, which questioned whether and how 'academic engagement' is distinct from commercialisation, in terms of its drivers and benefits. 'Academic engagement' is defined as any form of 'knowledge-related collaboration by academic researchers with non-academic organisations'; but commercialisation activities refer specifically to academic entrepreneurship and the generation of intellectual property through patenting and licensing (Perkmann et al 2013). Similar to D'Este and Patel (2007), they focused on the critical role of individual academics, arguing that universities are "'professional bureaucracies' … that rely on the independent initiative of autonomous, highly skilled professionals to reach their organisational goals" (Perkman et al: 426). Their review found that although both forms tend to be driven by individual imperatives, organisation-level support is more significant for commercialisation activities, while academic engagement is more typically driven by individuals and their units/teams, particularly in engineering and applied sciences.

The paper contributes to this emerging literature, by engaging with three elements of the research agenda Perkman et al propose. The first relates to the rationale for the paper: the systematic review highlighted the significance of research to inform firms' understanding of what motivates academics to engage, particularly the importance of academic benefits. The second relates to the empirical focus of the paper: the review emphasised the need to extend empirical coverage beyond the US and Europe, to investigate countries at different stages of development, with different innovation and higher education systems, using survey tools at the micro-level. The third element relates to the main contribution of the paper: the claim that much of the literature underestimates the diversity of universities and higher education institutional systems in different country contexts, leading to the proposal that it is important to investigate "diverse patterns of university-society interactions in various settings'' (Perkman et al 2013: 450). That is, one question that has not been well considered is whether and how the frequency and forms of interaction differ for individual academics in universities of distinct types across a national higher education system. This is a particularly pertinent question in the context of immature systems of innovation, where universities are expected to balance complex multiple roles that may be the preserve of other actors or organisations in more mature systems. Therefore, the paper will analyse the heterogeneity of academic engagement in different types of university in South Africa, to inform debate on the incentives and barriers to university-firm interaction from the perspective of universities.

2.2 Country level research across national systems of innovation

Until recently, there were not many systematic studies of the scale, nature and conditions for university-industry interaction across national systems of innovation in middle and low income country contexts. A small body of research was conducted in 12 countries in Africa, Latin America and Asia (Albuquerque et al 2015), exploring how and why relationships between universities and firms differ across countries and regions at different stages of development. The South African research on which the paper draws was designed within the ambit of this global comparative research. It extended the seminal work of Cohen, Nelson and Walsh (2002) in the US, which surveyed patterns of interaction, focusing on the types of relationships, channels of interaction, benefits and

constraints, from the perspective of firms, by adding an additional element – to map patterns of interaction from the perspective of universities and public research institutes.

In the South African context, since the advent of a democratic government in 1994, national science and technology policy incentivised interaction with firms through a variety of instruments, such as funding programmes for collaborative research, the establishment of technology transfer offices in all universities, a legal framework governing intellectual property rights from publicly funded research, a technology stations programme, and funding for regional innovation hubs, technoparks and clusters in priority fields and sectors. At the same time, national higher education policy encouraged universities to promote community engagement and social responsiveness, evident in new forms of engagement through teaching, research and outreach with marginalised communities, particularly those who are women, black, in rural areas or informal settlements (Kruss 2012; CHE 2010a). These contextual conditions informed the addition of new items to the survey instrument: to determine the presence of interaction in general; to reflect teaching and outreach roles in addition to research and innovation; and with the full range of partners alongside firms: government, informal sector firms, civil society or community actors, and including marginalised communities (see Kruss et al 2012; Kruss and Petersen 2009).

2.3. Drivers, forms and benefits of interaction

Many studies have investigated the benefits of entrepreneurialism and academic engagement for universities (Prigge 2005; Harman 2001; Kruss 2006). The framework for research in immature systems of innovation distinguished intersecting drivers of interaction for firms and universities that shape specific forms of interaction, each associated with benefits and risks for firm and university actors (Kruss 2005; Arza 2010; Arza and Dutrenit 2010). Key analytical concepts are elaborated in this section.

University drivers of interaction with firms are interpreted in terms of intellectual and/or financial imperatives, to take the distinctive nature of universities into account. Similar to the idea of professional bureaucracies proposed by Perkman et al (2013), we adopted Whitley's (2000; 2003) definition of universities as 'reputationally controlled work organisations'. As organisations, they structure the production of knowledge around the competitive pursuit of individual scientific reputations, as judged and measured by publication of codified knowledge, most typically in peer-reviewed journals. Individual academics are driven by their 'intellectual imperatives' to pursue forms of interaction that will enhance scientific reputations, but this may be in combination, balance or tension with 'financial imperatives' to raise third-stream income or income for research.

Firm strategies are either passive or proactive, driven more strongly by firm's financial or intellectual imperatives. The interaction between the imperatives of firms and universities shapes distinct types of relationship with different benefits for universities, firms and the national system of innovation. Forms of interaction were classified into four broad types (Arza 2010). Interaction motivated by the financial strategies of universities and passive strategies of firms is more likely to take 'service' forms, with knowledge flows mainly from the university to the firm, such as consultancy, contracts or testing. Such interaction is primarily to the benefit of the firm, with a risk to the knowledge project of the university when restrictions are placed on

proprietary knowledge. In contrast, interactions motivated by the intellectual strategies of the university and proactive strategies of firms are more likely to take 'bi-directional' forms, where knowledge flows are two-way and there is a high potential for joint learning, such as joint R&D projects or networks, to mutual benefit. 'Traditional' forms of interaction are driven by the intellectual imperatives of the university and the passive strategies of firms, with indirect knowledge flows to firms, but defined strongly by academic functions, such as hiring graduates, conferences and publications, or financial flows from firms to support academic functions (bursaries, endowments). These are to the direct benefit of reputational concerns, but may not impact directly on firm technological capability building. Finally, 'commercial' forms of interaction are driven by the financial/ entrepreneurial strategies of universities and the proactive strategies of firms, taking the form of spin-off companies or incubators that require direct personal interaction at critical stages. These tend to be of financial benefit to the university, and may pose risks to the core roles of teaching and research.

2.4. Universities as reputationally controlled work organisations in competitive higher education systems

Public university systems in different countries can be distinguished along two main dimensions: the intensity of competition around scientific reputations in the local, national and international arenas; and the level of intellectual pluralism and flexibility encouraged in terms of changing research goals across a university or the system (Whitley 2000, 2003). These impact on the degree to which research is coordinated between different kinds of organisations (those with stronger and weaker reputations), and the openness to new research goals, approaches and programmes to address new kinds of problems – such as those arising from industry. In a highly differentiated and segmented higher education system with strong reputational competition between research universities and applied research or technology transfer institutions such as South Africa, hierarchies of institutions typically limit and restrict what is possible in setting new research agendas, novelty is restricted, and flows of knowledge are limited. As Whitley (2003) claims, in such cases, it is extremely difficult for universities on the margins to improve their reputational standing, as they cannot attract leading scientists nor win research resources competitively.

Academics in universities with stronger or weaker reputations are thus likely to experience the intellectual and financial imperatives driving interaction in different ways. The strength of the individual pursuit of reputations, and the nature of differentiation and segmentation within a national higher education system, are significant for understanding the frequency and forms of interaction in general, and with firms specifically, across a higher education system.

3. Methodology

3.1. Study design

Based on the literature review and the framework underpinning the survey, specific questions are raised to investigate patterns of interaction in the paper:

1. What is the intensity of reputational competition in the immature system of innovation in South Africa?
2. What is the frequency and forms of academic engagement in different types of university, in terms of the nature of partners, types of relationship and outcomes ?

7

3. What is the frequency and forms of interaction with firms specifically?
4. How do these patterns reflect the balance between financial and intellectual imperatives driving academics?
5. What are the policy insights for understanding incentives and barriers to interaction with firms?

The research design was a mixed-methods comparative case study approach. A survey of a large, generalisable sample of academics based at five universities was conducted in 2010. This was complemented by qualitative data, used to interpret data trends. Through interviews with institutional university leaders and managers, and analysis of strategic documents, university history, missions, policy and institutional cultures were investigated.

The official higher education typology was the basis for selection of cases – research universities (ResU), comprehensive universities (CompU) and universities of technology (UoT). A fourth type was added to include a set of rurally located, under-resourced universities attempting to develop a common strategy to reposition themselves (RuralU). Two research universities were included to reflect their relative influence in the system, as well as historical differences that shaped their roles.

The aim of the survey instrument was to measure the ways in which academics 'extend their scholarship to the benefit of external partners', in terms of the nature of partners (29 items), the types of relationships (18 items) and channels of interaction (20 items), the outputs (11 items) and outcomes (19 items), and perceived constraints (13 items) (Albuquerque et al 2015). The items within each dimension were constructed in the form of a Likert scale. Respondents were asked to indicate the frequency of their practice for each item, by providing a number between 1 (not at all) and 4 (on a wide scale). If an academic indicated that they had not engaged with external partners at all, a set of items probed their reasons.

3.2. The survey of academics

Contact details of a total population of 3 477 academics were acquired from the universities, and a total of 2 159 academics responded to the survey, yielding a sample with an overall valid response rate of 62% (Table 1).

Table 1: Response rate per university

Institution	Population	Responses	Response rate
RuralU	290	174	60%
CompU	563	343	61%
ResU1	1 186	738	62%
ResU2	716	442	62%
UoT	722	462	64%
Total	3 477	2 159	62%

The population and sample distributions displayed similar gender, racial and academic rank trends within each university, with distinct differences between types. ResU1/2 and CompU were more than three quarters white, while just less than half (47%) of the samples in UoT and almost a third (32%) of those in RuralU was white. All had a gender distribution of 60% male and 40% female.

3.3. Data analysis

The aim was to map patterns of academic practices across a university and the system as a whole. Data analysis proceeded first by calculating a Weighted Average Index (WAI) to rank each item in a dimension in terms of both the scale and the frequency with which it was reported, for each university and the total population. Principal Component Analysis (PCA) of four dimensions – partners, type of relationship, outputs and outcomes – was then conducted in order to reduce complexity, and reveal patterns of interaction. The PCA was conducted using SPSS software. The PCA extraction method made use of Varimax rotation method with Kaiser Normalization. Values for the latent variables inferred by the components produced by the PCA were populated with means of each set of variables within a component. For the population of all universities this procedure produced six types of partners; four types of relationships; four channels of information; two types of outputs; three types of outcomes and benefits; three types of obstacles and challenges; and two types of reasons for not engaging at all with external partners. Table 2 summarizes statistics on the variables derived from PCA. It is evident from the third column that the internal consistency and reliability (Cronbach's Alpha) of the components are acceptable.

Table 2. Summary statistics on variables derived from PCA

Components derived from PCA External partners	Total variance explained (PCA)	Number of items and (Cronbach's Alpha)	N	Mean	Std. Deviation	Variance
Academic	11.197	4 items (0.761)	1737	2.458	0.77989	0.608
Community	5.279	2 items (0.601)	1739	2.2274	0.9531	0.908
Government	3.893	3 items (0.661)	1740	1.8707	0.77272	0.597
Firm	21.302	4 items (0.751)	1737	1.7856	0.72922	0.532
Welfare	6.765	5 items (0.761)	1739	1.7159	0.65102	0.424
Civil society	4.785	3 items (0.587)	1739	1.2803	0.47041	0.221
Types of relationships						
Alternative teaching	6.406	4 items (0.688)	1738	2.5685	0.77544	0.601
Engaged teaching and outreach	10.44	6 items (0.745)	1739	2.2844	0.69518	0.483
Engaged research	28.271	5 items (0.757)	1739	2.2188	0.75346	0.568
Technology transfer	5.62	4 items (0.737)	1739	1.7833	0.72805	0.53
Outputs						
Traditional academic	32.481	6 items (0.778)	1734	2.6124	0.6975	0.487
Economic and social	15.554	5 items (0.705)	1734	1.5646	0.56879	0.324
Outcomes and benefits						
Academic benefits	8.71	6 items (0.803)	1731	2.9171	0.67285	0.453
Community and social development	36.984	8 items (0.862)	1731	2.1273	0.7044	0.496
Productivity and employment generation	8.14	4 items (0.780)	1730	1.7786	0.75778	0.574
Reasons for not engaging						
Academic identity	11.77	2 items (0.643)	418	2.1136	1.06374	1.132
Institutional conditions to support engagement	42.96	10 items (0.894)	418	1.7711	0.75959	0.577

4. Types of university in a strongly segmented and hierarchical higher education system

The intensity of reputational competition in the South African higher education system is analysed in order to situate the roles of each university, and the main intellectual and financial imperatives likely to drive interaction.

Public universities were established in diverse periods to meet specific economic and political purposes, and these origins shaped their differential and unequal nature as 'reputationally controlled work organisations'. A strongly politicized society negatively influenced the degree of flexibility and pluralism possible, with highly polarized intellectual traditions promoted in different types of university. The system can thus be characterised as strongly differentiated, segmented and hierarchical.

The research universities, based in the major metropolitan areas and developed regions, were most well-established, tracing their origins back to the turn of the nineteenth century. There was intense reputational competition between these universities at the national level, and they were strongly segmented from the other universities, which aspired to their level of achievement and the reputation for scientific excellence achieved globally, in niche fields (Cloete et al 2006; Pouris 2007; CHE 2015). The English speaking universities (*ResU2*) with a strong commitment to the principles of academic autonomy, tended to develop stronger flexibility and pluralism in research agendas than the Afrikaans speaking universities (*ResU1*), which were more isolated and strongly tied to an authoritarian, ethnic and cultural nationalist tradition associated with the apartheid state. Over many decades, ResU2 had built a global research reputation in key disciplinary fields that was integral to its vision, strategy and functioning, with many long serving, highly qualified and well published academics. This was balanced with a liberal institutional ethos, commitment to a social justice agenda and a strong defense of academic freedom. For a time after 1994, ResU1 adopted a deliberate entrepreneurial strategy, reflected through the promotion of innovation, income-generating research and industry partnerships, supported by a range of entrepreneurial structures (Kruss 2005). At the time of research, new leadership was shifting to a strategy of academic excellence and global reputation building. Both universities were well resourced, with private sources of income exceeding government subsidy, and student fees growing to almost match it.

Historically, the role of *universities of technology* was to teach applied technology fields, a 'binary divide' that shaped their trajectory into the present. Since their formation through a government-driven process of higher education restructuring from 2004 (DoE 2002), UoTs faced multiple challenges of redefining their identity and roles, and establishinng scientific reputations in a hierarchical system dominated by research universities (Winberg 2005; Thatiah and Schauffer 2007; CHE 2010). Research culture was weak, and capacity-building of academic staff to grow the research base was a major strategic focus (Dyason et al 2010). The intensity of reputational competition was relatively low, although some, like UoT, were rapidly developing national reputations in selected technology fields. Further challenges arose from a strong reliance on government subsidy and tuition fees, drawing from a typically impoverished student base.

The *comprehensive universities* were established to provide a stronger teaching orientation alongside locally relvevant research and technology development. CompU was based in the metropolitan area of a region characterized by high levels of poverty and unemployment. The challenges of a complex institutional merger (a historically white university, a UoT and one campus of a historically black distance university); and conceptualizing a new identity and reputation, operating across multiple campuses, have been immense.

However, the merged universities brought long established traditions and practices of industry and community engagement, and the balance of private funding increased over a short period, suggesting a growth in reputation.

Located in the most impoverished areas of the same region, *RuralU* was typical of ethnically defined universities established as part of the apartheid political strategy, facing extensive reputational challenges as primarily teaching universities, poorly funded, poorly managed and under-resourced over decades, with weak research cultures. These universities displayed very low degrees of reputational competition, oriented to local audiences and local goals. However, with a long identity of political resistance, their reputations were not solely determined by academic disciplinary peers, but also by social and political commitment to transformation and responsiveness (Nkomo and Swartz 2006). RuralU relied primarily on government funds, and struggled with high levels of student debt.

In a segmented hierarchical national system, RuralU is near the bottom, with severe constraints on its ability to build reputation, which shapes how individual academics are motivated to interact with external partners. Financial imperatives relate to accessing funds for basic operations, while intellectual imperatives relate to developing research capabilities, or addressing local problems. ResU2 is at the top of the hierarchy in terms of its reputational status and financial stability, so that intellectual imperatives could drive interaction more strongly, and financial imperatives could be experienced as the need to supplement and add value to core activities. ResU1, comprehensive university and UoT follow in terms of reputational standing, in that order. ResU1 had a history of financial imperatives driven by entrepreneurial motivations to supplement university income, and intellectual imperatives to enhance reputation to match or exceed the top national research universities. Intellectual imperatives at CompÚ and UoT were likely to be linked to establishing scientific reputations in niche fields, while financial imperatives could be related to either basic operations or value-addition.

5. Patterns of interaction in the five universities

The balance of roles, the financial and intellectual imperatives driving academics to interact with firms, and the forms of interaction and benefits they pursue, are thus likely to differ between universities. This section analyses the frequency and forms of interaction, in terms of the nature of partners, the types of relationship and the outcomes and benefits to determine whether and how they differ.

5.1. Scale and frequency of interaction

Descriptive analysis of the frequency of interaction and the number of partners as reported in Table 3 suggests that the high 81% aggregate engagement reflects a generalized awareness of the need to be responsive to social and economic problems, rather than strong or frequent interactive activity. A range from 43% of academics at UoT to 59% at CompU did not engage at all, or did so on an isolated scale only, indicating a low scale of interaction in general. Between a fifth and a third of academics engaged on a moderate to wide scale, but with a single partner, suggesting dyadic forms of interaction typical of service and traditional forms of interaction. A smaller group, ranging between 16% and 25% of academics, engaged actively in networks, that is, on a moderate to wide scale with more than two partners. There is a marked difference in the relative size of these

groups in each university, and this is statistically significant. ResU2 had the lowest reports of no engagement, but equally, lower proportions of frequent and networked interaction. In contrast, a quarter of academics at UoT were clear that they did not interact, while almost 60% were interacting frequently, and almost 40% of these with multiple partners. Interaction on an isolated scale only was most likely at all three types of university, in comparison with the UoT; and the two research universities were more likely to interact frequently with only a single partner.

Table 3: Comparing the scale and frequency of interaction across universities

	ResU2	ResU1	CompU	UoT	RuralU	TOTAL / AVERAGE
Number of engaged academics	**412**	**563**	**272**	**344**	**150**	
On an isolated scale only (2)	38%	34%	38%	17%	40%	33%
Moderate scale (3 and 4) with a single partner (*frequent*)	33%	28%	23%	21%	24%	26%
Moderate scale (3 and 4) with more than two partners (*networked*)	23%	14%	18%	37%	22%	23%
No Engagement reported	7%	24%	21%	26%	14%	19%
Number of academics in sample	**442**	**738**	**343**	**462**	**174**	

Source: survey dataset; Kruss et al 2012

On average across the four types, the level of active academic engagement was relatively low, but there were core groups of frequently and actively engaged academics in each type of university.

5.2. Barriers relate to academic identity

The main reason 19% of academics did not interact at all was related to *academic identity (*engagement is not central to my academic role; or not appropriate to my academic field), but also, *lack of institutional support*: lack of clear structures, policy, recognition as scholarship, administration systems, different priorities of universities and partners, financial resources or conceptual clarity. Figure 1 reflects the relative importance of these two components at each university. ResU2 had the largest difference between the two sets of reasons, suggesting that academics do not engage because it is not appropriate to their academic identity, while institutional support is less important. In contrast, at UoT, aspiring to establish scientific reputation, and with the largest group of academics who do not engage (26%), academic identity was less significant as a barrier, and almost as important as institutional support. Academics in universities with stronger reputations evidently viewed academic identity as a significant barrier to interaction.
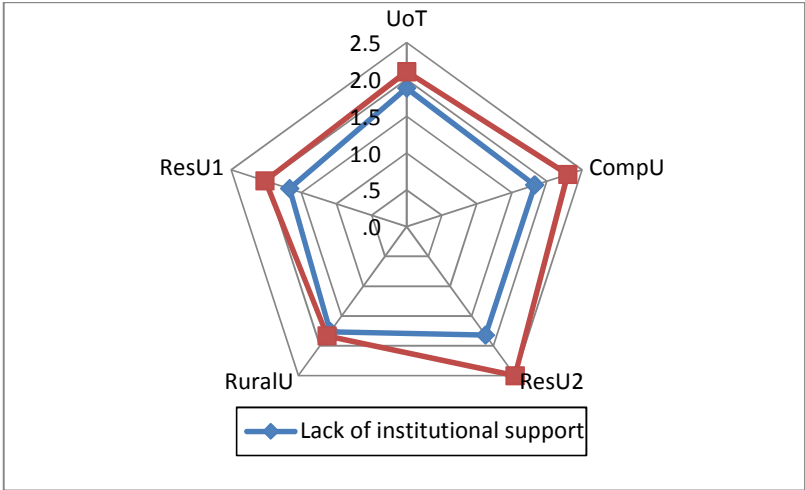
Figure 1: Reason academics do not engage

5.3. Academic partners are most common

Interaction with firms needs to be understood relative to the total pattern of academic engagement. Figure 2 compares the frequency of interaction on any scale with six types of partner identified through PCA, per university.
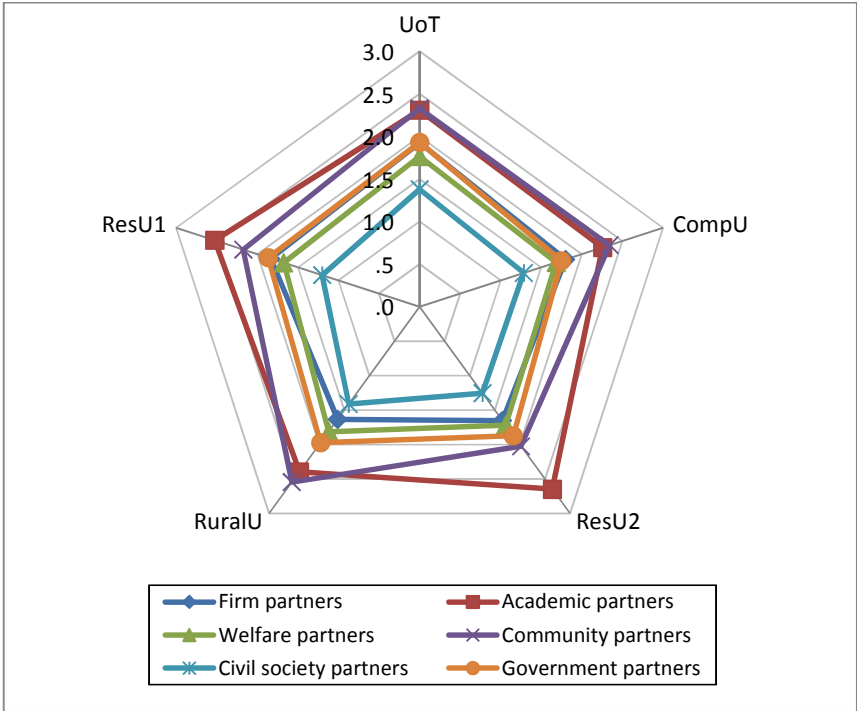
Figure 2. Comparison of the means of types of partner by university

Academic partners were more frequently engaged (international universities, funding agencies, science councils and SA universities), especially at the research universities, followed by community partners (individuals and

households, and a specific local community). Academic partners were as significant as community partners at the UoT, RuralU and CompU, hinting at their orientation to local problems. Government (provincial, local and national departments), welfare (NGOs, welfare agencies, community organisations, development agencies and social movements), firm (large SA, multi-national companies, small, medium and micro enterprises, and sectoral associations) and civil society (trade unions, political organisations, and civic associations) partners were then ranked closely to each in different ways in each type of university. Chi-square tests on interaction revealed that the differences were statistically significant: for firm partners, χ^2(12, $N = 1739$) = 42.51, p = .000); academic partners, χ^2(12, $N = 1739$) = 72.10, p = .000); community partners, χ^2(12, $N = 1743$) = 54.19, p = .000); and civil society partners, χ^2(12, $N = 1742$) = 43.15, p = .000). Associations with welfare partners, χ^2(12, $N = 1742$) = 18.01, p = .12) and government partners, χ^2(12, $N = 1744$) = 18.89, p = .091) were not statistically significant.

**5.4. Universities differ in their interaction with firm partners**

Thus, on average, firm partners were only the fourth or fifth most frequent, for all types of university. Such aggregation however, masks significant activity and differences. UoT had the highest frequency of firm partners, followed by ResU1 and CompU. Engaged academics at ResU2 and RuralU did not frequently interact with firm partners. Table 4 drills down to investigate the types of firms with which a group of academics do interact on a moderate to wide scale (3 and 4), relative to the total sample of academics, and to the set of engaged academics in each university (the latter is reflected in Figure 3 for ease of comparison).

Interaction was most frequent with large national firms (LNF), particularly at UoT and ResU1, where a larger proportion of the engaged academics interacted with firms. (A Chi-square test on interaction with LNFs in the different universities showed a statistically significant relationship, χ^2(12, $N = 1737$) = 41.98, p = .000). Where academics at ResU2 interacted frequently with firms, it was more likely to be LNFs. They were less likely to interact with all types of firms than ResU1, which was attempting to build a global research reputation and had adopted an entrepreneurial university strategy. Of note, ResU1, CompU (which incorporated a UoT with a strong technical reputation) and even UoT were more likely to interact with multinational companies (MNCs) than ResU2, likely relying on global reputations built in niche SET fields. (A Chi-square test showed a statistically significant relationship, χ^2(12, $N = 1737$) = 28.67, p = .004). UoT and CompU were more likely to interact with small, medium and micro-enterprises (SMMEs), supported and incentivised by a national programme to build regional technology platforms. (A Chi-square test likewise showed a statistically significant relationship, χ^2(12, $N = 1738$) = 86.45, p = .000). Academics at RuralU were least likely to interact with firms, but more likely with SMMEs than other types of firm, which suggests that the isolated location and weak reputation were barriers to interaction with LNFs and MNCs, and reflects their strong local orientation.

Table 4. Interaction on a moderate to wide scale with firms by university

Moderate scale (3 and 4)	ResU2	ResU1	CompU	UoT	RuralU	TOTAL / AVERAGE
LNFs % of all academics	25	28	26	31	18	27
LNFs % of engaged academics	26	37	33	41	21	33

Moderate scale (3 and 4)	ResU2	ResU1	CompU	UoT	RuralU	TOTAL / AVERAGE
SMMEs % of all academics	19	20	26	32	21	24
SMMEs % of engaged academics	20	26	33	44	24	29
MNCs % of all academics	16	17	17	14	12	16
MNCs % of engaged academics	17	23	21	19	14	20
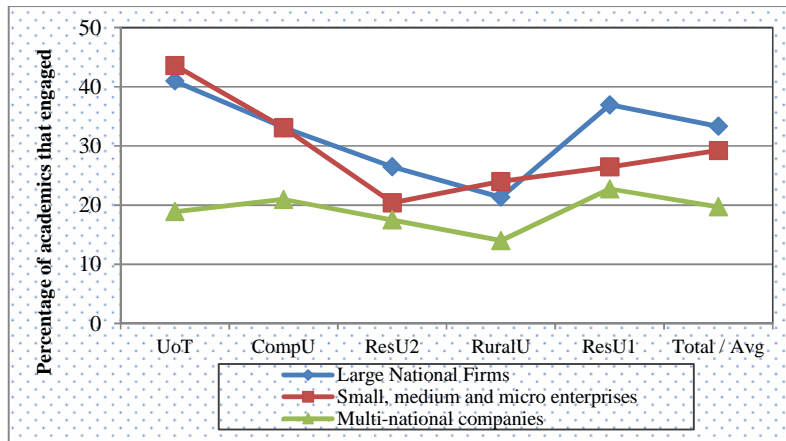
Figure 3. Percentage of engaged academics interacting frequently with firms, by university

The frequency of individual academics' interaction with firms was thus aligned with a university's strategic orientation and reputational standing in the hierarchical system.

**5.5. Teaching-related types of relationships predominate**

Are these interactions likely to be traditional, service, entrepreneurial or networked types of relationship? Education of socially responsive students[2], an indirect but most frequently reported type of relationship, loaded onto a factor that was named e*ngaged teaching and outreach* to encompass the range of teaching, professional development, research and service activities included: service learning, student voluntary outreach, community-based research (closely connected with student learning), clinical services, and work integrated learning. This was in distinction to *alternative teaching*, which included continuing education, customized training (two typical types of relationship with firms), collaborative curriculum design and alternative modes of delivery. These can be classified as traditional and service forms of interaction. *Engaged research* included both applied and strategic research, in dyadic and networked forms: collaborative R&D, consultancy, contracts, participatory research, and policy research. Finally, *technology transfer* consisted of design of new technologies, technology transfer, design of new interventions and joint commercialization.

These factors were not totally aligned with the four ideal forms of university-firm interaction outlined above. Collaborative R&D and consultancy are classified as bi-directional and service forms of interaction respectively (Arza 2010), but here, both loaded to *engaged research*. The analysis thus identifies underlying associations

---

[2] This item was included in the survey instrument, based on evidence from a pilot study.

when *all* kinds of external partners, and not only firms, are taken into account. It suggests that teaching-related rather than research-related types of relationship predominate.

However, as with the pattern of partners, the observed differences between the universities are all statistically significant (Figure 4: engaged research, χ^2(12, N = 1739) = 28.30, p = .005); engaged teaching and outreach, χ^2(12, N = 1739) = 100.63, p = .000); alternative teaching, χ^2(12, N = 1738) = 99.91, p = .000); and technology transfer, χ^2(12, N = 1739) = 45.80, p = .000). A*lternative teaching* was the most frequent type of relationship at all universities, particularly at UoT and CompU, those most frequently interacting with firms. *Engaged teaching and outreach* was the second most frequent, except at ResU2 where engaged research and alternative teaching were most frequent. The difference between the research universities, in terms of reputational competition as driver of interaction, was evident in that e*ngaged research* was more frequent at ResU2 than at ResU1. Technology transfer was the least frequent type of relationship at all types of university, but less so at UoT, and more so at ResU2.
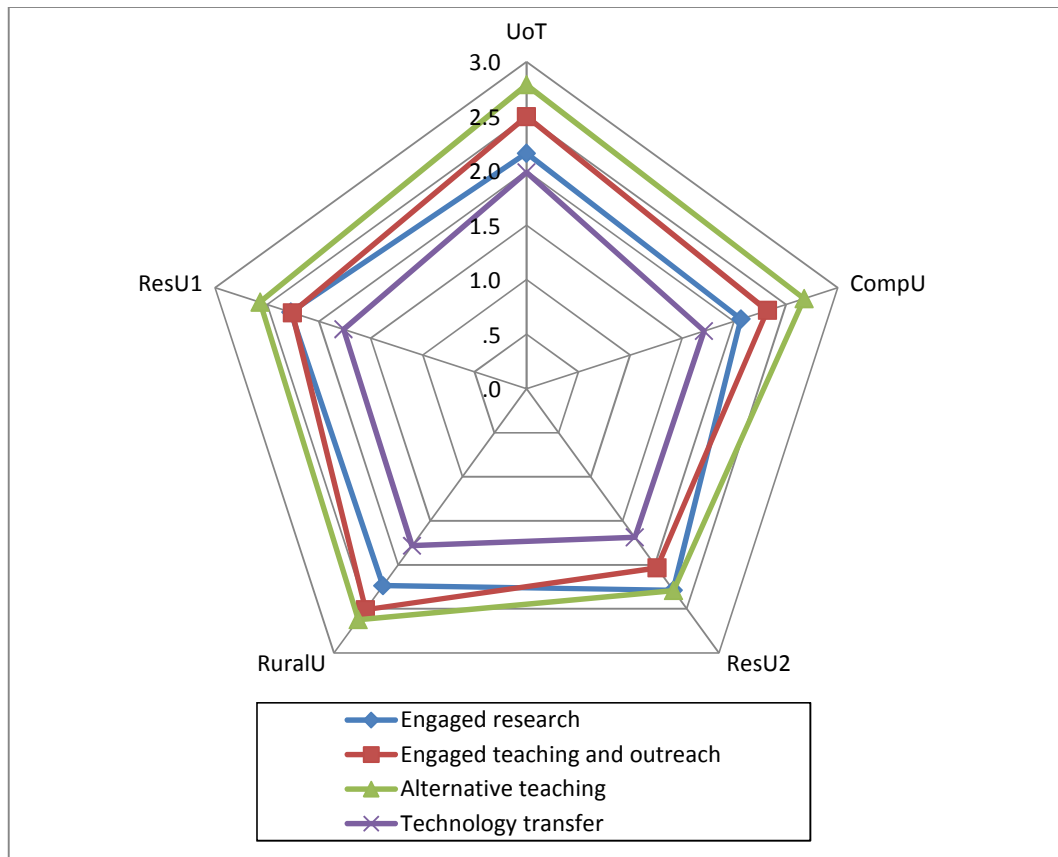
Figure 4: Frequency of types of relationships by university

5.6. Types of relationship with firms

Academic engagement is thus more prevalent than entrepreneurial type of relationship, across the system. To explore existing entrepreneurial-related activity in greater detail, we calculated the percentage of academics that

reported each type of relationship on a moderate to wide scale (3 and 4), in their frequent interaction with firms (3 and 4) (Figures 5, 6 and 7). The results revealed some unexpected trends at some universities.
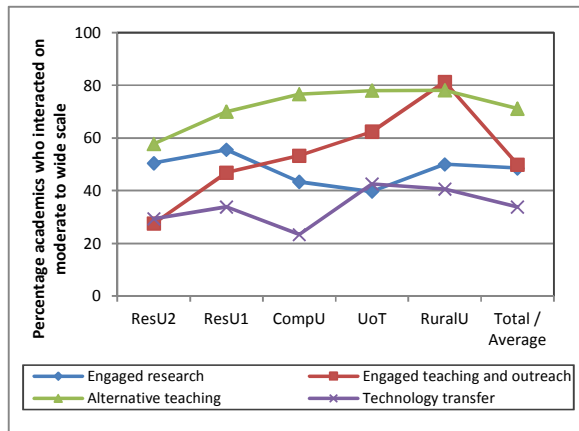

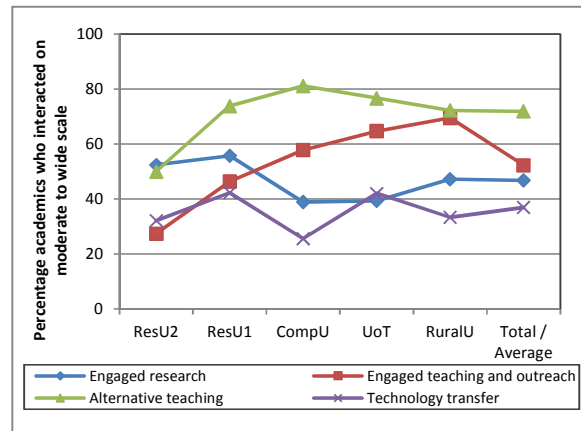**Figure 5. Frequent type of relationship of frequent interaction with LNFs**

Figure 6. Frequent type of relationship of frequent interaction with SMMEs
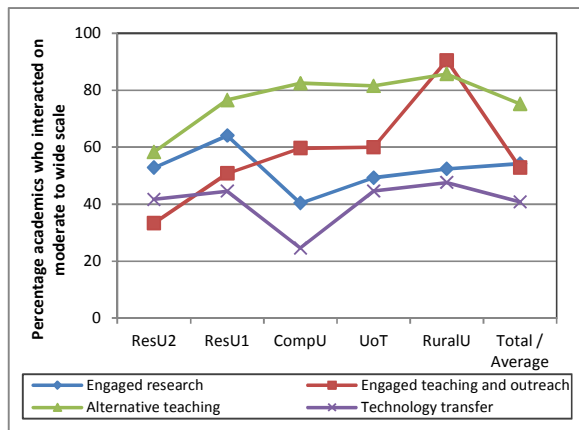

Figure 7. Frequent type of relationship of frequent interaction with MNCs

For this most entrepreneurially engaged group of academics, *technology transfer* types of relationship were least likely at CompU. This is a surprising trend, given the relative importance of firm partners at this university, and the institutional emphasis on technology transfer and regional economic development. Technology transfer types of relationship were most frequent for the group of entrepreneurially engaged academics at UoT, in line with their core roles, and aspiration to build SET reputations. There is another exception and surprising trend – the small group at RuralU was more likely to interact through technology transfer types of relationship with MNCs (48%) than the academics at any of the other universities. This suggests emergent activity that potentially can be developed further. The entrepreneurially engaged group at ResU2 was also more likely to interact through technology transfer with MNCs than with LNFs or SMMEs, which highlights significant 'spots of interaction' based on these academics' global reputation. At ResU1, this group is more likely to interact with SMMEs and MNCs than LNFss. These trends highlight a potential gap in interaction with large firms to promote capability building and competitiveness nationally.

17

Analysis of the *engaged research* type of relationship confirms that ResU1 academics interacted more strongly with firms than ResU2, particularly with MNCs, despite the fact that academics at ResU2 in general were more likely to interact through engaged research. Engaged research was equally as frequent for UoT as technology transfer, for all types of firms. Such trends likewise identify areas of university-industry linkages that offer potential spaces for intervention, to deepen and grow in future.

Further qualitative in-depth investigation is required to explain the gaps, blockages or emergent trends highlighted, but the analysis serves to identify spaces for intervention.

5.7. Academic outputs and outcomes are the main benefit

A final set of analyses was conducted to explore how the main benefits of interaction reflect the imperatives driving academics. A distinction was drawn between outputs – results of interaction that are measurable - and outcomes – the impact of interaction that is less easily measurable in the short term.

Traditional academic outputs (with an overall mean of 2.6) was the most important, with the highest frequency across all types of university: academic publications, dissertations, academic collaboration, reports, policy documents, popular publications, scientific discoveries and graduates with relevant skills and values. The second factor, *economic and social* outputs, included new or improved products and processes, community infrastructure and facilities, spin-off companies and cultural artefacts. Analysis of variance revealed that there were significant differences, with the two research universities reporting traditional academic outputs to a larger extent than the other three; and the UoT and RuralU indicating higher frequencies of economic and social outputs than the rest.

The main type of outcomes reinforced this pattern. The first factor, *community and social development* benefits included: community empowerment, community-based campaigns, public awareness and advocacy, improved quality of life for individuals and communities, incorporation of indigenous knowledge, regional development, intervention plans and guidelines and policy interventions. The second factor, *academic benefits,* consisted of: theoretical and methodological development in an academic field, academic and institutional reputation, relevant research focus and new research projects, participatory curriculum development, new academic programmes and materials, training and skills development and improved teaching and learning. The third factor, *productivity and employment generation* included entrepreneurial benefits: firm productivity and competitiveness, firm employment generation, novel uses of technology and community employment generation.

Academic outcomes were reported most frequently at all universities, with high means, but of note, UoT (mean= 3.03), RuralU (2.92), and ResU1 (2.91) reported the highest frequencies, while CompU (2.88) and ResU2 (2.86) reported the lowest frequencies, suggesting that in general, the benefits of interaction were less highly valued. RuralU reported the highest frequency for community and social development related benefits, while academics at UoT reported the highest productivity and employment generation benefits, aligned with their mandates and position in the national system.

In all types of university, the set of academics that interacted frequently with firms also most frequently reported academic benefits from their interaction with all types of firm (Table 5). However, Res U2 and ResU1 (although less starkly) valued academic outcomes more strongly, in contrast to the trends at RuralU, CompU and UoT .

Table 5. Frequent outcomes of frequent interaction with firms (percentage)

	ResU2	ResU1	CompU	UoT	RuralU	Average
LNFs						
Academic benefits	80	86	84	89	94	86
Community and social development	20	36	36	57	69	40
Productivity and employment generation	24	28	43	59	53	39
SMMEs						
Academic benefits	83	86	83	87	83	85
Community and social development	24	39	34	56	50	41
Productivity and employment generation	25	34	41	57	39	41
MNCs						
Academic benefits	83	91	81	89	90	87
Community and social development	19	38	35	60	62	39
Productivity and employment generation	21	38	46	63	67	42

In the South African context, a high value is thus placed on academic benefits that can build scientific reputations (Whitley 2003) or enable these professional bureaucracies to attain their organisational goals (Perkman et al 2013). The pattern of benefits clearly reflects that intellectual imperatives drive academics most strongly, and that academic benefits are an important motivation for interaction with all types of firms, for all types of university – echoing Perkman et al (2013)'s conclusion, that there is a positive correlation between academic engagement and scientific productivity. It seems that the stronger the reputation of a university, the less its academics are motivated by productivity and employment generation benefits. Community and social development imperatives may also drive interaction with firm partners, and in some universities, to a greater extent than entrepreneurial imperatives.

6. Discussion: the value of analyzing the frequency and forms of interaction in diverse types of university across a national system

Such analysis can inform firms' and policy makers understanding of the complexity of academics' motivations to engage, in a nuanced manner across a higher education system. The conclusion returns to consider these policy implications in greater depth, while this section demonstrates how the study contributes to the literature.

6.1. Situating firm interaction within the total pattern of interactive activity

First, the research extends empirical coverage beyond the developed nations, to the South Africa context (Wright 2014; Perkman et al 2013, Gunasekara 2006). The analysis reflects the patterns of interaction in an emerging economy with an immature system of innovation, characterised by a hierarchical, segmented higher education system that restricts knowledge flows and mobility. There was a strong awareness on the part of most academics of the importance of interaction for national development; but when aggregating across the sample, the scale of active and networked interaction was relatively low, particularly considering that academic partners,

19

teaching oriented types of relationship and academic benefits were most frequently reported. Firm partners, research and innovation oriented types of relationship and productivity benefits were not reported on a wide scale. Given the South African shift to a developmental state policy framework, community partners, engaged teaching and community and social development benefits were also important (Kruss 2012). The pursuit of global and national reputations, and national democratic policy imperatives means that intellectual imperatives tend to drive academics most strongly, that traditional forms of interaction tend to prevail, and that academic engagement oriented to community and social development is more significant than entrepreneurial interaction.

The promotion of university-industry interaction in a late developing context like South Africa should take as its starting point, and be located within an appreciation of, such a holistic and comprehensive analysis of the total pattern of academics' interactive activity, across the national system of innovation.

6.2. Frequency and forms of interaction with firms differ between distinct types of university

Second, the main contribution is to demonstrate that the frequency and forms of interaction in general and with firms specifically, differ for academics in universities of distinct types across a national higher education system. We conclude that the incentives that drive South African academics and that block university-industry interaction are strongly related to their differentiated nature as reputationally controlled work organisations, grappling to balance and prioritise multiple roles in national development and global science and technology.

Through disaggregation and investigation of heterogeneity and diversity, analysis of micro-level data can reveal important evidence of emergent activity and 'spots of interaction' (Rapini et al 2006) with national and global firms. These spots of interaction represent partial connections between science and technology systems in immature systems of innovation, which can be nurtured to contribute to technological capability building and national development (Albuquerque et al 2015). As D'Este and Patel (2007) point out, if policy makers understand the wider range of forms of academic engagement in addition to the main entrepreneurial forms, initiatives can be created to build universities and academics capabilities to link to knowledge users in firms more effectively and on a wider scale.

Conclusion: Heterogenous and complex incentives and barriers to interaction with firms

However, the highly differentiated, segmented and hierarchical higher education system in South Africa is a major barrier to the promotion of *all* forms of interaction. In such a system, policy interventions are required to break down segmentation and hierarchies, and enhance knowledge flows and mobility.

One possible mechanism is to identify the types of university where interaction with firms is already occurring, but perhaps on a small scale; where there should be interaction but it is missing; or how interaction can likely be grown. The conclusion thus considers the policy implications from each of the cases, to illustrate the range of interventions required in contexts where there are complex heterogenous incentives driving individual academics, and systemic barriers to interaction.

Academics at UoT, which prioritised entrepreneurial and technology development roles, and had scientific reputation in niche areas only, were most likely to engage with large national firms and SMMEs (slightly less with MNCs), through technology transfer types of relationship and to report productivity benefits. This

university type represents a potential 'spot of interaction' to focus interventions to support a larger scale of entrepreneurial activity, that can draw on the US and European literature (for example, Niosi, 2006; Muscio 2010; Mustar et al 2006).

Academics at ResU2, with the strongest global and national reputation, were less motivated to interact with firms, less likely to actively pursue technology transfer types of relationship, (except with MNCs), and least likely to report productivity benefits. In contrast, academics at ResU1 had prioritised financial imperatives and the entrepreneurial role, and were most likely to interact with firms through engaged research types of relationship, and more likely to report academic benefits from such interaction. Thus, to promote industry interaction at research universities will require a strategy that can convince academics of the potential value and academic benefits, alongside more conventional financial incentives. As Perkman et al (2013:442) point out, this too is a widespread problem in US and European contexts: "Particularly when collaborating with the best academic researchers, firms need to take into account that these academics will under most circumstances only work with them if there is also some academic benefit to be derived" (see also Muscio and Pozzali 2013; Bruneel et al 2010; Bozeman et al 2013).

CompU faced the challenge of establishing academic reputation as a new institutional type, with an emphasis on professional and occupational education and training, as well as technological research oriented to address local problems. Interaction with all types of firms primarily took teaching-oriented forms, with sizable productivity and employment benefits. These indirect forms of interaction with firms are important in the national system of innovation, but the low frequency of engaged research with firms represents a gap. Here, a different strategy is needed to build capabilities and scientific reputations, to extend, deepen and nurture 'spots of interaction'. Such a problem does not have coverage in the literature, and requires further research to inform practice in late developing economies.

The pattern at RuralU pointed to greater complexity and introduced a further dimension, in that academics were most likely to pursue engaged teaching types of relationship with firms of all types, and technology transfer relationships with MNCs, with community and social development benefits most frequent. These are indicators of potentially significant 'spots of interaction' in a university with weak reputational status, oriented to development of the marginalised and vulnerable communities in its immediate environment. In this kind of university, strategies to build capabilities and scientific reputations are also needed, but here, new alternative kinds of intervention are required - to link informal sector actors into formal value chains and networks of interaction with MNCs and large firms, to create new ways of addressing development priorities. This requires consideration of the emerging literature on innovation for inclusive development (Cozzens and Sutz 2013; Santiago 2014).

In conclusion, if linkages with firms are to be strengthened across a system of innovation to promote national development in contexts like South Africa, it is critical to take into account the view from inside the higher education system, facing local problems and the global knowledge frontier. Strategies for intervention need to be informed by the heterogeneity of intellectual and financial imperatives shaping patterns of academic engagement in diverse types of university.

Reference list

Abreu, M. and Grinevich, V. (2013). The nature of academic entrepreneurship in the UK: widening the focus on entrepreneurial activities. *Research Policy*, 42, 408-422.

Albuquerque, E., Suzigan, W., Kruss, G. & Lee, K. 2015. *Changing dominant patterns of interactions: lessons from an investigation on universities and firms in Africa, Asia and Latin America*. : London: Edward Elgar.

Arza, V. 2010. Channels, benefits and risks of public-private interactions for knowledge transfer: conceptual framework inspired by Latin America. *Science and Public Policy*, 37(7), 473-484.

Aschhoff, B. and Grimpe, C. 2014. Contemporaneous peer effects, career age and the industry involvement of academics in biotechnology. *Research Policy*, 43, 367-381.

Audretsch, D. and Lehmann, E. (2005). Do university policies make a difference? *Research Policy*, 34 (3), 343-347.

Bozeman, B., Fay, D., and Slade, C. (2013). Research collaboration in universities and academic entrepreneurship: the-state-of-the-art.*The Journal of Technology Transfer,* 38(1), 1-67.

Bruneel, J., D'Este, P. and Salter, A. (2010). Investigating the factors that diminish the barriers to university–industry collaboration. *Research Policy*, 39, (7), 858–868.

Carboni, O. (2013). Spatial and industry proximity in collaborative research: evidence from Italian manufacturing firms. *Journal of Technology Transfer*, 38(6), 896-910.

Cesaroni, F. and Piccaluga, A. (2015). The activities of university knowledge transfer offices: towards the third mission in Italy. *The Journal of Technology Transfer*, doi:10/1007/s10961-015-9401-3

Cloete, N., Fehnel, R., Gibbon, T., Maassen, P., Moja, T. and Perold, H. (2006). *Transformation in higher education: Global pressures and local realities*. Dordrecht: Springer.

Cohen, W.M., Nelson, R.R. & Walsh, J.P. 2002. Links and impacts: the influence of public research on industrial R&D. *Management Science*, 48(1) p1-23.

Council on Higher Education (CHE). 2010a. Community Engagement in South African Higher Education. *Kagisano* No. 6. January

Council on Higher Education (CHE). 2010b. *Universities of Technology - Deepening the Debate*. Kagisano 7. Pretoria: CHE.

Council on Higher Education (CHE). 2015. *VitalStats: Public Higher Education, 2013*. Pretoria: CHE.

Cozzens, S. & Sutz, J. (2014). Innovation in informal settings: reflections and proposals for a research agenda. *Innovation and Development*, 4(1) 5-31.

DÉste, P. and Patel, P. (2007) University–industry linkages in the UK: What are the factors underlying the variety of interactions with industry? *Research Policy*, 36 (9), 1295–1313.

Déste, P. and Perkmann, M. (2011). Why do academics engage with industry? The entrepreneurial university and individual motivations. *The Journal of Technology Transfer,* 36(3), 316-339.

Dutrenit, G. and Arza, V. (2010). Channels and benefits of interactions between public research organisations and industry: comparing four Latin American countries, *Science and Public Policy*, 37(7), 541-553.

Dyason, K., Lategan, L. and Mpako-Ntusi, T. (2010). Case studies in research capacity building. In CHE. *Universities of technology: deepening the debate*. Kagisano 7. Pretoria: CHE.

Fuentes, C. and Dutrenit, G. (2014). Geographic proximity and university–industry interaction: the case of Mexico. *The Journal of Technology Transfer*, doi: 10.1007/s10961-014-9364-9.

Goel, R.K. Göktepe-Hultén, D. and Ram, R. (2015). Academics' entrepreneurship propensies and gender differences. *The Journal of Technology Transfer*, 40 (1), 161-177.

Gulbrandsen, M. and Smeby, J. (2005). Industry funding and university professors' research performance. *Research Policy*, 34 (6), 932-950.

Gurnasekara, C. (2006). Reframing the role of universities in the development of regional innovation systems. *The Journal of Technology Transfer*, 31: 101-113.

Harman, G. (2001). University-industry research partnerships in Australia: extent, benefits and risks. *Higher Education Research and Development*. 20 (3), 245-264.

Hewitt-Dundas, N. (2013). The role of proximity in university-business cooperation for innovation. *The Journal of Technology Transfer,* 38 (2), 93-115.

Johnson, A. and Hirt, B. (2010). Reshaping academic capitalism to meet development priorities: the case of public universities in Kenya. *Higher Education*, doi: 10.1007/s10734-010-9342-6.

Kenney, M. and Goe, R. (2004). The role of social embeddedness in professorial entrepreneurship: a comparison of electrical engineering and computer science and UC Berkley and Stanford. *Research Policy*, 33, 691-707.

Kruss, G., Visser, M. Aphane, M. and Haupt, G. (2012). *Academic interaction with social partners. Investigating the contribution of universities to economic and social development*. Cape Town: HSRC Press.

Kruss, G & Petersen, I. 2009. University-firm interaction in the region. In P. Kotecha (Ed.), *Towards a common future: higher education in the SADC region. Research findings from four SARUA studies*. Johannesburg: SARUA.

Kruss, G. (2012). Reconceptualising engagement. A conceptual framework for analysing university interaction with social partners. *South African Review of Sociology*, 43(2), 5-26.

Kruss, G., Adeoti, J. and Nabudere, D. (2012). Universities and Knowledge-based Development in sub-Saharan Africa: Comparing University–Firm Interaction in Nigeria, Uganda and South Africa. *The Journal of Development Studies*, 48(4), 516-530.

Kruss, G. (2006). Working partnerships: the challenge of creating mutual benefit for academics and industry. *Perspectives in Education*, 24(3), 1-13.

Kruss, G. (2005). Harnessing innovation potential? Institutional approaches to industry-higher education partnerships in South Africa. *Industry and Higher Education*,19(2),131-142.

Lindelof, P. and Lofsten, H. (2004). Proximity as a Resource Base for Competitive Advantage: University-Industry Links for Technology Transfer. *The Journal of Technology Transfer,* 29(3), 311-326.

Department of Education, South Africa (DoE). 2002. Transformation and restructuring: A new institutional landscape for higher education. *Government Gazette* No. 23549. Pretoria: Government Printers.

Martinelli, A., Meyer, M. and von Tunzelmann, N. (2007). Becoming an entrepreneurial university? A case study of knowledge exchange relationships and faculty attitudes in a medium-sized, research-oriented university. *Journal of Technology Transfer,* doi: 10.1007/s10961-007-9031-5

Mowery, D. and Sampat, B. (2005). Universities in national innovation systems. In Fagerberg, J., Mowery, D.C. and Nelson, R.R. (Eds). 2005. *The Oxford Handbook of Innovation.* Oxford: Oxford University Press.

Muscio, A. (2010). What drives the university use of technology transfer offices? Evidence from Italy. *The Journal of Technology Transfer*, 35 (2), 181-202.

Muscio, A. and Pozzali, A. (2013). The effects of cognitive distance in university-industry collaborations: some evidence from Italian universities. *The Journal of Technology Transfer*, 38 (4), 486-508.

Mustar, P., Renault, M., Colombo, M., Piva, E., Fontes, M., Lockett, A., Wright, M., Clarysse, B. and Moray, N. (2006). Conceptualising the heterogeneity of research-based spin-offs: a multi-dimensional taxonomy. *Research Policy*, 35, 289-308.

Niosi, J. (2006). Success factors in Canadian academic spin-offs. *The Journal of Technology Transfer*, 31(4), 451-457.

Nkomo, M. and Swartz, D. (2006). *Within the realm of possibility: from disadvantage to development at the University of Fort Hare and the University of the North.* Cape Town: HSRC Press.

Perkmann, M., Tartari, V., McKelvey. M., Autio, E., Brostrom, A., D'Este, P., Fini, R., Geuna, A., Grimaldi, R., Hughes, A., Krabel, S., Kitson, M., Llerena, P., Lissoni, F., Salter, A., and Sobrero, M. (2013). Academic engagement and commercialisation: a review of the literature on university-industry relations. *Research Policy*, 42 (2), 423.442.

Ponomariov, B. (2013). Government-sponsored university-industry collaboration and the production of nanotechnology patents in US universities. *The Journal of Technology Transfer*. 38 (6), 749-767.

Pouris, A. (2007). The international performance of the South African academic institutions: a citation assessment. *Higher Education*, *54*(4), 501-509.

Pries, F. and Guild, P. (2007). Commercial exploitation of new technologies arising from university research: start-ups and markets for technology. *R&D Management*, 37(4), 319-328.

Prigge, G. (2005). University-industry partnerships: what do they mean to universities? A review of the literature. *Industry and Higher Education*, June, 221-229.

Ramos-Vielba, I. and Fernandez-Esquinas, M. (2011). Beneath the tip of the iceberg: exploring the multiple forms of university-industry linkages. *Higher Education*, doi: 10/1007/s10734-011-9491-2

Tanga, L, Debackere, K. and von Tunzelmann, N. (2003). Entrepreneurial universities and the dynamics of academic knowledge production: a case study of basic vs applied research in Belgium. *Scientometrics,* 58(2), 301-320.

Rizzo, U. (2015). Why do scientists create academic spin-offs? The influence of the context. *The Journal of Technology Transfer,* 40(2), 198-226.

Santiago, F. (2014). Innovation for inclusive development. *Innovation and Development*, 4(1),1-4.
Secondo, R. and Ugo, F. (2014). University Third mission in Italy: organization, faculty attitude and academic specialization. *The Journal of Technology Transfer*, 39 (3), 472-486.

Schartinger , D., Schibany, A. and Gassler, H. (2001). Interactive relations between universities and firms: empirical evidence from Austria. *The Journal of Technology Transfer*, 26(3), 255-268.

Shah, S. and Pahnke, E. (2014). Parting the ivory curtain: understanding how universities support a diverse set of startups. *The Journal of Technology Transfer*, 39(5), 780-792.

Suzigan, W. and Albuquerque, E. (2011). The underestimated role of universities for the Brazilian system of innovation. *Brazilian Journal of Political Economy*, 31 (1), 3-30.

Thatiah, K. and Schauffer, D. (2007). How now 'cloned' cow? Challenging conceptualisations of South African universities of technology.South African Journal of Higher Education, 21(1),181-191.

Tjissen, R. (2004). Is the commercialisation of scientific research affecting the production of public knowledge? Global trends in the output of corporate research articles. *Research Policy*, 33, 709-733.

Van Looy, B., Ranga, M., Callaert, J., Debackere, K. and Zimmerman, E. (2004). Combining entrepreneurial and scientific performance in academia: towards a compound and a residual Matthew-effect? *Research Policy*, 33(3), 425-441.

Whitley, R. (2000). *The Intellectual and Social Organization of the Sciences*.Oxford: Oxford University press.

Whitley, R. (2003). Competition and pluralism in the public sciences: the impact of institutional frameworks on the organization of academic science. *Research Policy*, 32: 1015 – 1029.

Winberg, C. (2005). Continuities and discontinuities in the journey from technikon to universities of technology. *South African Journal of Higher Education,* 19(2), 189-200.

Wright, M. (2014). Academic entrepreneurship, technology transfer and society: where next? *The Journal of Technology Transfer,* 39 (3), 322-334.