This paper was presented at The XXIII ISPIM Conference – Action for Innovation: Innovating from Experience – in Barcelona, Spain on 17-20 June 2012. The publication is available to ISPIM members at www.ispim.org.

Academics' identities and actions for innovation

Zhi Li*

Griffith University, 170 Kessels Rd, Nathan Brisbane, 4111, Queensland Australia.
E-mail: z.li@griffith.edu.au

Marie Wilson

Griffith University, 170 Kessels Rd, Nathan Brisbane, 4111, Queensland Australia.
E-mail: m.wilson@griffith.edu.au

* Corresponding author

Abstract:
The role of universities and academics played in the innovation has been increasingly emphasized in the management literature and practice. However, the innovation policy emphasising on output-based outcome has somehow misrepresented the nature of academics' knowledge creation and dissemination, as well as universities' impacts on economy. While existing studies have developed thorough knowledge of university-firm level formal collaborations, research has just started to touch on less formal innovation activities. Following the plea for adopting a diverse approach, our research examined innovation and commercial activities in academia, and validated this survey instrument by structural equation model (SEM). Results confirmed that academics engaged in a wide range of innovative activities as a reflection of professional identities and commitment at the individual level. Understanding the link between psychological indicators and behavioural parameters provide new insights of successful actions for innovation.

Keywords: Professional Identity, Academics, University-Industry Collaborations, Structural Equation Modelling (SEM), Ecological Validity

1. Introduction

University-industry collaborations and research commercialization have become a widely-interested topic in the field of R&D management, as well as key policy initiatives (Grimaldi *et al.*, 2011). Existing policy initiatives focuses primarily on developing the innovation system by establishing organizational linkages: government agencies, private enterprises, as well as research commercialization within universities. The majority of published research examined university-related innovation in U.S., with some proportion from E.U. including U.K (D' Este & Perkmann, 2011; Clarysee, *et al.*, 2011; Rothaermel *et al.*, 2007). Despite the fast technology-based innovation growth in Australasian regions, actions for innovation have not been systematically examined by theoretical and empirical research.

Despite debates on the missions of higher education, the expectation for universities to become more "enterprise" is raising (Margison and Considine, 2000). Under such an initiative, universities increasingly invests in commercial and schemes by developing collaboration with industry R&D and transferring technology through patents, licensing, and establishing entrepreneurial start-ups. Consistently with the policy incentive, research of university-industry linkages has primarily focused on innovation outputs, intellectual properties, if not patent only. Nevertheless, the emphasis on patents and output-based innovation has considerably misrepresented the nature of universities' impacts on economy, as well as knowledge creation and dissemination by academics (Agrawal and Henderson, 2002). Patents alone do not describe the nature of innovation or the complex nature and relationship of academics and industries collaborations (Anderson, 2001; Rappert *et al*., 1999). Nevertheless, academics working in the tertiary sector, particularly those working in research-based universities, are eminently associated with national and regional economy by established formal mechanisms and facilities for university technology transfer.

It is worth to highlight that, even when universities change and adapt to the "enterprise" expectations, the academics within them often do not (Ambos *et al*., 2008). Echoing the debate about the university's missions, academics' role identities that emphasize autonomy, personal expertise, and commitment to the profession may be inconsistent with entrepreneurial or managerial role-identities (Freidson, 2001, Stensaker and Norgård, 2001). Conversely, we know from other studies of professionals, that engagement with the organization leads to increased productivity and performance (Van Looy *et al*., 2006), and commitment to achieve organizational requirements (Organ *et al*., 2006). While some recent studies have examined the barriers to commercialization in terms of skills and support (Harman and Stone, 2006; Spilling and Godø, 2008; Magnusson *et al*., 2009), research on academics' engagement with commercial and entrepreneurial activities at the individual level, psychological factors (to a large extent as attitudinal and motivational) and behaviour metrics, is hitherto developed or discussed.

As far as academics' actions for innovation are concerned, not only is the gap of existing in the unit of analysis, but also is identified as the disciplinary imbalance from existing published research. Recent research has suggested, comparing to high-innovative academic disciplines such as engineering and biomedical sciences, social sciences as the missing link in the innovation system (Hughes, 2012). As a result, we know little about innovation initiatives and commercialization activities that are undertaken in informal mechanisms (Grimpe and Fier, 2010; Link *et al*., 2007). The dearth of research of both horizontal and vertical dimensions is on account of the lack of a diverse approach to the complex nature of the university-industry linkages (Hughes, 2006). This is the departure point of our research project.

In this research, we attempt to introduce such a diverse approach examining academic actions for innovation associated with the complexity of professional identities in academia. Our research focuses on the individual level academics professionals at a public-funded "enterprise" university and incorporates the concept of identity with academic involvement in research commercialization and innovation activities. This paper is structured as follow. We outline the trend and theme of existing work on university-industry linkage. Drawing the gap identified from the literature, we raise our research question on the diverse approach to academic actions for innovation as a reflection of professional role identities. The results present survey data from a sample of academics in New Zealand, statistical analyses enabled us

to examine the diverse approach by a range of technology transfer and research commercialization activities, specifically validating it as an instrument by structure equation modelling. By discussing the implication of our results, we draw conclusions and raise research agenda.

2. Literature Review

2.1 The role of identity in academic actions for innovation

By the level or unit of analysis, existing research on university-involved innovation is categorized into three levels: the system (legislation and policy initiaves), university internal mechanisms and individual scientists/entrepreneurs (Grimaldi *et al.*, 2011). More recently, researchers and practitioners have realized that effective innovation requires more than good idea and intensions. If we take another close look at academics' engagement in innovative actions, professional identity, along with all factors such as leadership, foresight, and inspiration, play an important role leveraging research commercialization and technology transfer (D'Este and Perkmann, 2011). Understanding the diverse nature of actions for innovation reflects the complex issue of professional identities facing academics who engaged in technology transfer and research commercialization (Colyvs and Powell, 2007; Owen-Smith, 2003). For these reason, our research focuses on academic action for innovation at the individual level.

There is practical difficulty and infeasibility in attempting to isolate the academic profession from social changes that are confronting and challenging almost all professional realms. Confronting with changes in the traditional context, academic professionals become vulnerable to control of their knowledge and intellectual property (Nixon, 1996, p. 5). In particular, there are tensions between the publication and dissemination ideals of the profession and the secrecy and non-disclosure requirements of intellectual property (Gulbrandsen and Smeby 2005; Van Looy *et al.*, 2004). The intangibility of knowledge and disputed control of knowledge capital underpin ongoing debate on who actually owns academic work and to what uses it should be directed (McSherry, 2001).

Within the arena of this debate, academics who pursue applied research with commercial values attract increasing attention from both university and industry (Jacob and Hellström, 2000). The ability to generate, access and control applied knowledge gives the entrepreneurial academic an active role in knowledge commercialisation. An academic can become an entrepreneur (Fincher, 1999) or be involved with the entrepreneurial transfer of innovations (Etzkowitz & Leydesdorff, 2000). The capacities of research, research integration, and technology transfer increase the career trajectories available to academics (Owen-Smith & Powell, 2003). This new set of choices may be more consistent with the concept of career autonomy than with the concepts of autonomy that characterise the ideal professional type (Harley *et al.*, 2004).

With sociological knowledge of professions, we can anticipate that professional identity plays an important part and interact in complex ways with organizational and institutional parameters. These interactions also have impacts on relationships between academics, with their universities and their collaborators. These will influence academics' motivation and engagement with technology transfer and research commercialization. While most of existing

studies put focus on the organizational level outputs, with a few recent ones examine the barriers to commercialization in terms of skills and support, we know little about the association of psychological indicators and behavioural outcomes in academic entrepreneurship. Establishing such a link will provide a pathway to better understand actions for innovation through academic research. Encoring with an appeal for a diverse approach to university technology transfer (Hughes, 2006), we argue that applying a diversity approach to examine academic innovation activities provides a theoretical lens reflecting the complexity of professional role identities in academia.

2.2 University-industry collaborations: formal and informal mechanisms

Developing relationships between the university and the industry is an on-going process. New companies are largely established for the purpose of patent implementation and development of new technological products and services. Therefore, start-ups need continuing technological supports from university to solve some potential problems related with new inventions, and the university also provide assurance to maintaining qualities of new products, as well as new knowledge to upgrade new inventions. Patenting and licensing are a widely-applied means to protect new ideas and consolidate knowledge created by academics. Start-ups in conjunction with patents/licensing have become a major mechanism maintain and strengthen formal relations with academics.

When the plea for innovation becomes universal, universities are inevitably emerging into the national and local system of knowledge exchange, and academics are increasingly engaging with commercial activities and establish linkages with industrial partners. Researchers within the broader field of innovation management have developed knowledge of university-industry collaborations and research commercialization at institutional and organizational levels (Grimaldi, *et al.*, 2011, Rothaermel *et al.*, 2007). Under this dominant trend, the physical science and engineering disciplines have become the dominant focus of the innovation system, whereas social sciences including the role of business and finance disciplines are comparatively overlooked in the overall design and implementation of innovation policy (Hughes, 2012), and collaborations in informal channels seem to become a missing circle on the chain connecting university and partners (D'Este and Perkmann, 2011; Link *et al.*, 2007).

The disciplinary imbalance and the lack of research on both formal and informal mechanisms have both impacted on developing comprehensive knowledge and the diverse nature of actions for innovation in the university (Hughes, 2006). Therefore, we need to understand the importance of informal mechanisms that academics collaborate with industry for innovation purposes. Some more recent studies highlighted, in many cases, informal mechanisms are found to play an even more significant role through motivating individual academics' engagement in building academic-industry linkages (Franklin *et al.*, 2001). "Without such motivation among faculty and 'would be' entrepreneurs, successful university commercialization in terms of spin-offs or licences/patents might be almost impossible" (Rasmussen *et al.*, 2006, p.11). Informal mechanisms enable firms to connect with universities' research with relatively few costs (Charles and Howells, 1992; Westhead and Storey, 1995). Lee (2000) suggested that "the most significant benefit realized by firms is an increased access to new university research and discoveries, and the most significant benefits by faculty members is complementing their own academic research by securing funds for graduate students and lab equipment, and by seeking insights into their own research" (p.111).

Nevertheless, perhaps due to the 'informal' nature, whether academics *informally* engage with a (much) wider range of activities for innovation purposes remains unknown. We believe that the general definition of entrepreneurship is too wide, while as generally being interpreted as "commercial", it is narrower than and considerably different from academics innovative actions in the university. We propose that informal activities reflect the diverse nature of academics' actions for innovation, as well as the complexity of professional identity. To resolve this puzzle, we asked in addition to formal mechanisms, what innovative activities are undertaken by academics; and to what extent a diverse approach can measure formal and informal activities?

3. Method

The research is designed and developed on a cross-sectional survey. With considerations of both theoretical framework and methodological procedures, we aim to employ survey to establish and develop a structural data matrix comprising responses at the individual level. In addition, self-reported questionnaires reach a large population of respondents to report their actual behaviour to strengthen the ecological validity, therefore exempt from impacts on the experimental control. To retain the consistency of policy and operation at the institutional level, we selected sample from one public-funded research-intensive university and participants are draw from academics on a stratified sampling procedure by controlling demographic factors.

Participants were asked if they have completed any project or collaborated with industrial partners under the management of UTTO, as well as reporting approximate numbers of completed projects activities under each category over a five-year timeframe. Participants were also asked to report academic ranks, educational backgrounds, as well as gender. Demographic information is also investigated as to develop demographic understanding of academics' engaging with innovative actions through formal and informal mechanisms.

Table 1 The diverse approach: the scale of academics actions for innovation

	Type of Projects/Activities	***No.(approx.)***
(a)	Consulting	
(b)	Contract research	
(c)	New Company/Commercial Spin-off	
(d)	Delivering continuing professional education	
(e)	Commercial Presentations/Seminars/Workshops	
(f)	Industry liaison programmes, industrial affiliate programme	
(g)	Intellectual property (patents, licences, etc.)	
(h)	Other activities not covered in previous questions (e.g., translation services, non-university consulting, continuing clinical practice, professional supervision, etc.).	

We designed questions to capture the diversity of actions for innovation undertaken by academics, which include both formal mechanisms organized by university technology transfer office (UTTO) and informal interactions. Previous studies on knowledge commercialization in

higher education and technology transfer from university to business also contribute to develop a measuring instrument dictated the diverse approach (Baldwin, 1986; Feldman, 1990; Geisler and Rubenstein, 1989; Van Dierdonck *et al*., 1990). Based on annual revenue contributions, consultation, intellectual properties, and star-up companies, are major referent activities that are managed by UTTO at the participating university. Our pilot interview participants revealed that, academics are asked by industrial partners and organizations to conduct contract research, delivering commercial presentation, seminars and workshops, as well as establishing and managing industrial liaison and affiliate programme. Pilot interview also showed that there are activities, such as translation services, continuing clinical practice, supervision for projects or internship, engage academics with industry and other domain by their professional abilities and skills in research-related performances. Those activities are not empirically documented or stratified into any categorized technology transfer mechanism, and they have on-going service-based nature which is different from other commercially-purposed activities. We group these actions together as a separate indicator. Based on a literature review and pilot interviews, a scale is developed and composed as shown in Table 1.

4. Results

Our research received 194 returned questionnaires, and the response rate yeilds 48. 5% (n=400). After entering data, four cases were deleted for incomplete data and demographic information. The data matrix was based on190 cases, falling in a suggested good range of sample size (Comrey, 1992), as well as satisfying the recommendation of needing a minimum of 10 cases per variable in the analysis (Bentler and Chou, 1987). Table-2 below demonstrates a summary of respondents according to their demographic information by controlling responses to the initial question university's management of collaborations with industrial sectors.

Table 2 Participants' Demographic Information

Demographics		***Working through tech-transfer office***		***Total***
		No	Yes	
Academic Rank	Senior Tutors/Tutors	10	3	13
	Junior	31	44	75
	Senior	33	51	84
Educational Background[1]	No Attaining PhD[2]	13	10	23
	Since 1990	51	42	93
	Prior to 1990	20	46	66
Gender	Female	38	30	68
	Male	54	68	122
Total		92	98	190

[1] Year in which participants gained PhD or an equivalent Degree
[2] Including candidates who were currently working on PhD or equivalent degrees

Case-wise analyses are conducted by comparing between responses towards "working through university technology transfer office (UTTO)" and reports of collaborative projects. As summarized in Table 2, more than half of surveyed academics (n=98, 51.6%) have worked with UTTO. Academics in senior positions (Professors and Associate Professors) were slightly over-representative in our sample (n=84, 44.2%), but their engagement (n=51, 52.0%) with UTTO-managed commercial activities is not significantly than those junior to them (n=45; 48%). Almost half of our survey academics (n=93, 48.9%) achieved PhD or equivalent degrees since 1990, but more than half of them have not worked with UTTO (n=51; 54.3%). In contrast, the number of academics who attained doctoral or equivalent degrees prior to 1990 (n=46) and have worked with UTTO is more than twice as much as those who did not work with UTTO (n=20), which is accounts for and consistent with academics in senior positions and their collaboration with UTTO. About 10% of UTTO-managed activities were taken upon faculties who did not achieve PhD or equivalent degrees, which reflect that a number of university-involved collaboration funds doctoral candidates to complete their research and degrees. 35.8% of survey academics are female (n=68), and one third of which (n=30, 30.6%) worked on innovation and commercialization through UTTO, and it is consistent with the gender proportion in current organization, as well as the general demographic distribution in academia.

Table 3 Descriptive Analysis of Academics Actions for Innovation

	N	***Mean***	***Std. Deviation***	***% Missing***
Consulting	115	2.71	2.025	39.5
Contract Research	103	2.28	2.036	45.8
Commercial Presentations/Seminars/Workshops	75	3.05	2.211	60.5
Delivering Continuing Professional Education	74	3.08	2.563	61.1
Activities not covered in previous categories	43	2.42	2.206	77.4
Intellectual Property (patents, licences, etc)	31	1.68	1.759	83.7
Industrial Liaison Programme, Affiliate Programme	25	1.60	1.581	86.8
New Companies and Commercial Spin-offs	17	2.00	2.291	91.1

As far as the diversity of academics' actions for innovation is concerned, Table-3 provides results of descriptive analysis for eight innovative actions included in our scale. Participants have engaged in industrial collaborations in all eight types, which demonstrated the face validity of this newly-devised scale. "Consulting" (n=115) and "Contract Research" (m=103) outweigh other types of innovative and commercial activities, including Intellectual Property (n=31) and New Companies and spin-offs (n=17). As results shown before, university-industry collaborations are executed by university and self-management mechanisms. Table 4 below demonstrates a summary comparing numbers and percentages UTTO-managed commercialization and non-UTTO managed actions for innovation.

Table 4 summarizes that 338 projects have completed under UTTO's management, taking up 70% of overall commercially-oriented projects and activities. Formal mechanisms, "Intellectual Property" and "New Companies and Spin-offs" (highlighted bold in Table 4) consistently take up about 10% in all three categories (non-UTTO-managed, UTTO-managed, and the total number) of academics actions for innovation. In comparison, consulting (23.8%),

contract research (21.3%), and other informal mechanisms completed by academics are significantly more. Education and training oriented informal mechanisms, including "Commercial Presentations/ Seminars/Workshops" (n=75, 15.5%) and "Delivering Continuing Professional Education" (n=74, 15.3%) are three times more than formal mechanisms.

Table 4 Actions for innovation with and without UTTO management (numbers and percentages)

Activities and Actions for innovation	***Non-UTTO***		***With UTTO***		***Total***	
Consulting	35	24.14%	80	23.67%	115	23.81%
Contract Research	22	15.17%	81	23.96%	103	21.33%
Commercial Presentations/ Seminars/Workshops	22	15.17%	53	15.68%	75	15.53%
Delivering Continuing Professional Education	28	19.31%	46	13.61%	74	15.32%
Activities not covered in previous categories	15	10.34%	28	8.28%	43	8.90%
Intellectual Property (patents, licences, etc)	8	**5.52%**	23	**6.80%**	31	**6.42%**
Industrial Liaison Programme, Affiliate Programme	9	6.21%	16	4.73%	25	5.18%
New Companies and Commercial Spin-offs	6	**4.14%**	11	**3.25%**	17	**3.52%**
	145	30.0%	338	70.0%	483	100.00%

In order to develop analysis by the structural equation modelling (SEM) procedure, we conducted the correlation analysis. Table 5 presents this correlation matrix. Consulting and Contract Research are positive correlated with all other innovative actions. Except for non-categorized activities, "Intellectual Property" (IP) is also significant correlated with other forms of innovative actions, among which IP's correlation with New Companies/Start-ups is positive 1.00 ($p<0.01$). This correlation analysis demonstrates the need to test our diverse approach by factor analyses.

Table 5 Correlations: academic actions for innovation

	Consulting	*CR*	*NCSs*	*DCPE*	*PPSW*	*ILAP*	*IP*
Contract Research (CR)	.795(**)						
New Companies Spin-offs (NCSs)	.791(**)	.570(*)					
Delivering Continuing Professional Education (DCPE)	.626(**)	.614(**)	0.534				
Public Presentations /Seminars/Workshops (PPSW)	.653(**)	.683(**)	0.557	.809(**)			
Industrial Liaison/ Affiliate Programme (ILAP)	.619(**)	.769(**)	.(a)	0.454	0.404		
Intellectual Property (IP)	.695(**)	.694(**)	1.000(**)	.520(*)	.519(*)	.671(*)	
Activities not covered in previous categories	.511(**)	.407(*)	.(a)	0.158	0.405	-0.225	0.578

**. Correlation is significant at the 0.01 level (2-tailed)
*. Correlation is significant at the 0.05 level (2-tailed)
a. Cannot be computed because at least one of the variables is constant

Based on previous data analysis, the data matrix was analysed by Exploratory Factor Analysis (EFA) and Confirmatory Factor Analysis (CFA). EFA was executed first to test if measuring items constrain as an expected same factor (scale). Table 6 shows the exploratory

factor analysis of eight types of university-industry collaborations. Eight types of collaborations all have positive factor loading on one component[1]. However, industrial liaison program and un-categorized activities have a fairly low factor loading in this component, and un-categorized collaborations are loaded higher on component two. Both of them are deleted from the compilation of measuring instrument of university-industry collaborations.

Table 6 Exploratory Factor Analysis

	Component	
	1	2
Consulting	.850	-.011
Contract Research	.722	-.057
New Companies and Commercial Spin-offs	.457	-.637
Delivering Continuing Professional Education	.739	.378
Commercial Presentations/Seminars/Workshops	.760	.237
Industrial Liaison Programme, Affiliate Programme	.392	.324
Intellectual Property (patents, licences, etc)	.527	-.619
Activities not covered in previous categories	.168	.478

Extraction Method: Principal Component Analysis.
a 2 components extracted.

Based on the result of EFA, we selected the six types of activities consistently loaded on component one to test its reliability and validity as a model of university-industry collaborations. The six items yields Cronbach's Alpha ($\alpha = 0.780$) for the reliability statistics, with mean of inter-item covariances is 1.140 and variance at 0.881. The reliability test and covariance evaluation satisfy requirements of modeling under structural equation procedure.

Figure 1 configures the finalized version of a measuring instrument of a diverse approach by the AMOS graphic (Byrne, 2001). “Academic innovative actions” are modelled as latent variable, and six types of activities are observed as observed indicators. “New Companies and Commercial Spin-offs” are constrained as 1, and the other collaboration types are under free estimation. The initial modification indices indicated that two pairs of errors (erCA3 and erCA6; erCA4 and erCA5) are strongly correlated, which is consistent with the correlation test. These two correlated error covariances are consistent with inter-item correlation shown on table 5 in which “New Companies and Commercial Spin-offs” and “Intellectual Property” highly correlates as 1.00; and “Delivering Continuing Professional Education” and “Commercial Presentations/ Seminars/ Workshops” positively correlates as 0.809. The model was modified by adding two covariances between two pairs of errors. This modification improves the model fit.

According to Byrne (2001), CMIN/DF in the range of 3 to 1 is indicative of an acceptable fit between the hypothetical model and the sample data." (Carmines and McIver, 1981, p. 80) GFI is less than or equal to 1indicates a close fit. AGFI is bounded above by 1, which indicates a

[1] New Companies and Intellectual Property also have negative loading on component two, and the absolute value of these negative loading are higher than those on component one.

perfect fit (Joreskog and Sorbom, 1982). The CFI is identical to the McDonald and Marsh (1990) relative noncentrality index (RNI), and CFI values close to 1 indicate a very good fit.

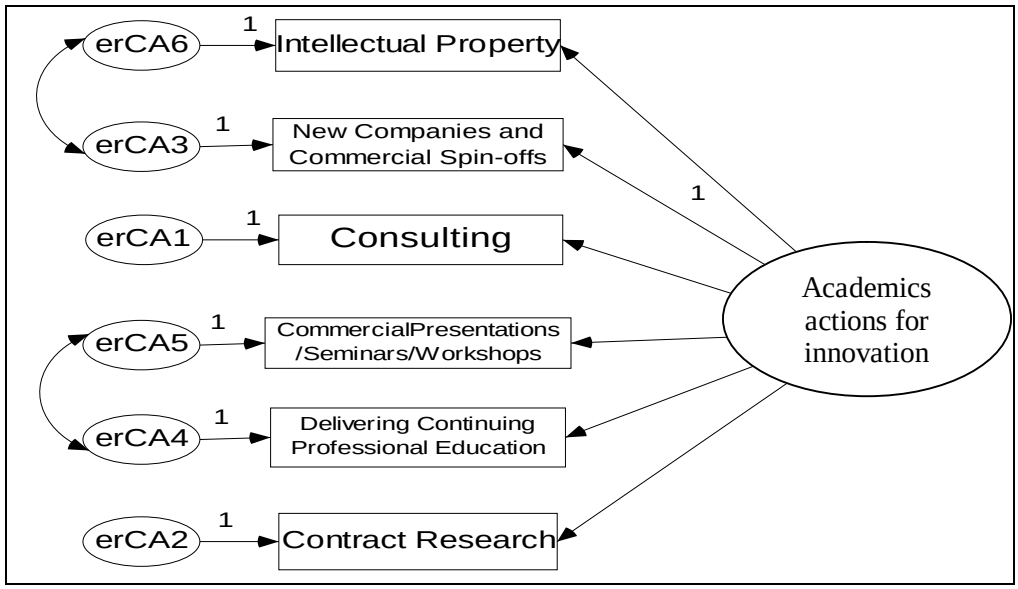

Figure 1 SEM configuration of academic innovative actions by a diverse approach

The finalized model is noted as Chi-square = 15.27; Degrees of freedom = 7; Probability level = .033. Key model fit statistics are summarized as CMIN/DF= 2.18; GFI= 0.98; AGFI=0.92; CFI=0.98; RMSEA=0.08. Goodness-fit-indices summary indicated that this model achieved a good fit level on CMIN/DF; GFI; AGFI; CFI. Table 7 shows estimate of each indicative type of university-industry collaborations in this model. Estimates of all indicators are significantly over 1 and satisfy convergent validity test of this measuring instrument, strengthening the content validity of the survey (Shadish, *et al*., 2002). The diverse approach of academic actions for innovation validated in this research also demonstrated strong ecological validity as crucial factors to generalize findings to larger populations in the academic setting (Mitchell and Jolley, 2001; Schmuckler, 2001) (Steiger, 1990).

Table 7 Estimate of a diverse approach

			Estimate	***S.E.***	***C.R.***	***P***
Consulting	←	Academics actions for innovation	6.448	1.427	4.517	***
Contract Research	←		4.109	.917	4.480	***
Public Presentations /Seminars/Workshops	←		4.024	.924	4.355	***
Delivering Continuing Professional Education	←		3.793	.910	4.167	***
Intellectual Property	←		1.176	.256	4.590	***
New Companies and Commercial Spin-offs	←		1.000			

"P=***" indicates p-value less than 0.01

5. Discussion

While the issue of the diverse nature of university-industry collaborations is raised in some research (Hall *et al*., 2001; Hughes, 2006; D'Este and Patel 2007; Perkmann and Walsh, 2007), there was limited empirical evidence to demonstrate the diversity concerning academic commercial and entrepreneurial activities at the individual level (Grimaldi *et al.*, 2011). This partially results from the lack of an approach to examine both formal and informal mechanisms systematically. By developing and validating this diverse approach, this paper is going to discuss issues related to the diverse approach of academic actions for innovation in relation to the complexity of professional identities in academia.

Literature reviewed earlier in this paper has identified that existing research on university-industry collaborations focus on output-based mechanisms at the organizational level (Hughes, 2003; 2006), whereas innovative and entrepreneurial activities take place in multiple forms across inter-organizational and individual levels. Unlike previous research, we applied a diverse approach to examine academics' actions for innovation through formal and informal mechanism. By validating this diverse approach, our research has demonstrated that academics engagement in a wide range of innovative, entrepreneurial and commercial activities for multiple purposes. In addition to intellectual properties, and start-up companies, consulting and contract research have involved more academics population at the entrepreneurial university (Phan and Siegel 2006; Rothaermel *et al.*, 2007). In comparing to IPs and start-up companies, academics participate in more commercial activities with education and training purposes and goals. While not as significant in the number and the proportion as other mechanisms, academics also involved with continuing clinical practice, projects or internship supervision that are both on-going and service based. While there is no empirical evidence to show the causal link, consulting and contract research are related with all other forms of innovative actions categorized as formal and informal mechanisms, which further demonstrated the diversity of academics actions for innovation.

Consistent with previous studies, the diversity nature illustrated by our research provide empirical evidence that the predominant focus on formal mechanisms at the organizational level have mislead or caused misinterpretation of the nature of knowledge creation and dissemination in academia (Agrawal and Henderson, 2002). Academics engage with informal innovative activities and mechanisms more (often) than through formal university-industry collaboration. This approach is adopted in research on stimulating technological entrepreneurship in universities, forming partnership with industries, and tangible outputs. For this purpose, university technology transfer office (UTTO) was deemed to play an important part in establishing, structure, system, and facilities to maintain the relationship and partnership with the industries and firms. In our research, while UTTO is managing half of human capital and over two third of overall innovative projects and activities, its attractiveness to junior faculty members and its involvement with informal innovative actions is weakening (Grimaldi *et al.*, 2011). Comparing to senior faculties, young academics are exposed to commercial values and operation in their professional socialization process, and develop commercialized professionalism to adapt to the expectations from the entrepreneurial university (Li, 2010; Hakala, 2009). This suggests that UTTO's role and function, methods to assess UTTO's effectiveness, in particular facilitating informal interactions to formal collaborations, are in needs of further research.

The most common analytical approach adopted is to examine technology transfer facilities, internal and external mechanism and programs, such as incubators or technology transfer offices, scientific park. We have seen some recent studies discussed another type of impact of these programs by inducing scientists and engineers to become entrepreneurs who otherwise would never involve in commercialization (Bains, 2005). The impacts of successful academic entrepreneurs are not only on scientists' career paths, but also on public policy which encourage the growth of new firms and start-ups as to facilitate technology transfer in knowledge-based economy. The transformation at both institutional and individual levels is summarized by the term, academic capitalism. The term academic capitalism was firstly introduced and defined as "any institutional and professional market or marketlike [sic] efforts to secure external moneys" (Slaugher and Leslie, 1997, p.8). Later, the term was also specified as "the involvement of colleges and faculty in market-like behaviors" (Rhoades and Slaugher, 2004, p. 37).

Whether the goal or motivation for academic capitalism is for secure external moneys (D' Este and Perkmann, 2011), the core is that colleges and faculty develop commercially-oriented behaviour patterns. University spin-off/start-up companies provided such a support mechanism and perhaps financial incentive for research outputs to be commercially utilized and commoditized. While academics who are successful in commercialising their knowledge gained more favour from the universities, as well as from their collaborative counterparts, at the individual level, academic capitalism does not necessarily transform entrepreneurial academics to academic entrepreneurs (Meyer, 2003). Academics' actions for innovation expanding towards "engaged scholarship" (van de Ven, 2007) in integration, teaching, and application (Boyer, 1997) enriched their professional socialization processes. The diversity of academic actions for innovation demarcated in our research reflects he complexity of professional identity and adds one more slide to researchers, lecturers, and "star-scientists". In future research, we might be able to identify specific commercial and entrepreneurial behaviors, and examine their relationship with and impacts on academic identity.

6. Conclusion and implication

To examine the diverse nature of university-industry collaboration, this research developed a scale including a wide range of behavioral indicators as academics' actions for innovation. Based on key findings of this research, we conclude that:

- Academics' actions for innovation are undertaken through a wide range of commercial and entrepreneurial activities;
- Academics' actions for innovation can be measured by indicators as formal and informal university-industry collaborations;
- The diversity of academics' actions for innovation reflects the complexity of their professional identity in a commercialising context.

While we carefully design and develop our research, some limitations are needed to address. Firstly, the research is a cross-section survey and employed the quantitative SEM technique to examine and validate the diverse approach to innovation activities. Our research does not reflect whether, and how, innovation activities emerge from academic research and impact on professional identities over time; neither can illustrate the causal link from informal to formal interactions. Secondly, we acknowledged the importance of academic discipline and its potential effects to academics' innovation actions, but we are unable to discuss disciplinary

differences or discipline-based results. A variable controlling academic disciplines included in the pilot survey was requested to be removed from the questionnaires by the Ethics Committee. While we are confident that participants in this research are multi-disciplinary as the sample selection and survey distribution processes were carefully monitored by faculty/schools, we are unable to report *discipline-based* analyses and results, since no other variables were used to substitute or reflect this specific demographic data. Institutional orientations for research, teaching and public service vary considerably between universities (Ramsden, 1999; Marginson, 2007a, 2007b). Last but not the last, to retain the institutional and organizational consistence in policy and operation, our research distributed the survey instrument in a single research-based public university to reduce the 'noise'. We acknowledge the role of context plays an important part in constructing professional identity and encouraging academics actions for innovation, and suggest future research should include institutional variable, moderate contextual effect, as well as develop cross-disciplinary and multi-level analysis.

The scale and results reported in this paper are parts of our research project on "professional identities and relationships in the "enterprise" academy". This project aims to develop further understanding on how academics integrate distinct professional orientations in forming their complex professional identifies, and how academic relationship with universities shape their involvement with activities that not traditionally pursued by academics. Addressing and assessing these inter-related factors and their impact on their involvement in the research commercialization initiatives, we wish to argue that engaging commercially-oriented activates reinstates belief in public service among academics, re-connecting them with both general public and specific audiences, as well as developing hybrid forms of professionalism to reconcile conflicts raised by multiple role identities. Academics' actions for innovation are not only for technological advancement, but also for multiple goals and purposes. The development of academic-industry links, particularly through informal mechanisms, might provide solutions to social and cultural issues.

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