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University-Industry Collaboration and Regional Innovation Systems in East Asia: An Overview

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ABSTRACT

Regional innovation systems are increasingly being seen as important institutional infrastructures supporting innovation within the production structure of regions in East Asia. Within these infrastructures university-industry collaboration is an essential linkage enabling the growth of knowledge-based economies. There are many factors which cause linkages to be weak or strong with the consequent effects on the efficiency of the regional innovation system to deliver the vibrant growth expected by fast-growing economies in East Asia. This conceptual paper seeks to address the nature of these university-industry relationships in regional innovation systems. The paper initially explores the basis of this nature according to organisational aspects of university-industry collaboration, motivations for university-industry relationships, the formation process, and university-industry inter-organisational relationships. This informs the research method which is a systematic literature review identifying and interpreting research in the fields of university-industry collaboration and regional innovation systems. Findings confirm the linkages involved including formal and informal collaboration. Through an iterative process a conceptual model is evolved outlining the nature of university-industry collaboration and regional innovation systems in East Asia. There are clear limitations to the findings of a conceptual paper but these provide avenues for future research and the policy implications for governments in East Asia.

Keywords: *University, industry, collaboration, regional, innovation, systems*

INTRODUCTION

University-industry collaboration has had an extensive history (Bower, 1993) and there has been a considerable increase in these types of partnerships in recent years in areas like East Asia (Duggan, 1997; Powers, 2003; Caloghirou et al, 2001; Baldwin and Link, 1998; Mansfield, 1998). Such an increase is believed to be due to a combination of pressures on both universities and industry (Meyer-Krahmer and Schmock, 1998; Santoro, 2000). For universities pressures include rising costs, funding and the growth of new knowledge – these have resulted in resource pressures on universities who have sought relationships with industry to maintain subject area market leadership (Hagen, 2002; Nimtz et al, 1995). For industry pressures include global competition, short product life cycles and technological change (which have transformed their competitive environment) (Ali, 1994; Bettis and Hitt, 1995). Due to societal pressure on universities they are seen as "engines for economic growth" in East Asia rather than their past social remit (Blumenthal, 2003; Cohen et al, 1998). Pressures such as these have led to university-industry collaborations for the enhancement of economic competitiveness and innovation in East Asia (Ankrah, 2007). Within this context Autio and Laamanen (1995) talk about "the ability to recognise technical problems, the ability to develop new concepts and tangible solutions to technical problems, the concepts and tangibles developed to solve technical problems, and the ability to exploit the concepts and tangibles in an effective way" (p. 647). Further to this, knowledge transfer is considered different to technology transfer since knowledge transfer is a wider set of activities than technology transfer (Gopalakrishnan and Santoro, 2004). Technology transfer is viewed as an exchange process by Burati and Penco (2001) where a collaborative venture transpires involving a technology donor and recipient working in

partnership to adapt and develop technologies (with the aim of dealing with the customisation of technology required to develop specific applications, applying new technology to create value for the recipient taking into account both internal and external factors, and the needs of potential users).

Academic work of particular relevance to university-industry collaboration and regional innovation systems in East Asia includes that of Uyarra (2005) who investigated theoretical issues and empirical evidence of regional innovation strategies with regard to knowledge, diversity and regional innovation policies. Uyarra (2005) noted that "regional governance structures emerge from a dual process of top-down institutional change, and bottom-up regional political and economic mobilisation" (p.2). Lagendijk (2003) observed that regional devolution was transforming regions into political regions. A further regional approach has responded to economic and strategic consideration (Lagendijk, 2003) involving a second wave of regionalism (new regionalism) (Uyarra, 2005). Underpinning this view of regionalist is global economic restructuring reinforcing the region in terms of economic governance and regional strategic view particularly concerned with globalisation (Uyarra, 2005).

Conceptual development concerning regional innovation led to the new regionalist literature (Lovering, 1999) and to models of territorial innovation (Moulaert and Sekia, 2003). These concepts include regional innovation systems, the triple helix, innovative milieu, technological districts and learning regions (Uyarra, 2005). Concerning these Lagendijk (2003) noted the need to manage and develop resources to achieve competitive advantage. Furthermore, Lovering (2001) considered the new regionalist emphasis with regard to globalisation and felt that this had been overstated for some regions. A further note of contention relates to the measurement of regional competitiveness (Metcalfe et al., 2003; Bristow, 2005). Here, Lagendijk and Cornford (2000) contend that regions sometimes adopt models from successful regions for external investment rather than for development needs. In relation to regional growth and location, Moulaert and Sekia (2003) noted the capability to develop human resources for growth. Moreover, Lovering (2001) noted the emergence of a regional service class and a regional development industry (Lagendijk and Cornford, 2000) involving academics, consultants, politicians and practitioners reinforcing regional development concepts. In order to transfer knowledge and concepts global networks are used (Amin, 2000, Gertler, 2001). Additionally, the impact of extra-regional networks on the generation and transmission of knowledge has been observed by Mackinnon et al. (2002). The importance of national government influencing regional government resources has been further noted by Lagendijk (2003). Bunnell and Coe (2001) suggest that rather than focussing on one regional scale attention should be given to interrelations across and between the scales and Randles and Dicken (2004) consider the question of scale as 'elastic'.

There has been a tendency to understate the importance of technological trajectories in determining regional infrastructure according to Freel (2003). Evidenced here bottom-up dynamics do not necessarily relate to regional boundaries (Uyarra, 2005). Consequently, there is the need for clustering of firms in a specific sector (Martin and Sunley, 2003) and there are economies of distance among the distant webs (MacLeod, 2001).

A trend has arisen to copy models that have been successful for a specific region (Hospers and Beugelsdijk, 2002). Science centres, technology parks and cluster policies are examples (Uyarra, 2005). There have been few studies of less fortunate regions (Lovering, 1999, p.391) with little study of failure (Howells, 2002) due to studies focussing on successful regions (Uyarra, 2005; Gibbs et al., 2001). Concerns have arisen on the use of concepts including regional innovation systems to study declining economies, peripheral regions and rural areas (Doloreaux, 2002; Asheim and Isaksen, 2002). It is therefore presumed rare to identify the requisite aspects for a regional system of innovation (Evangelista et a., 2002).

It has been reported by Lawton-Smith et al. (2003) that the regional agenda appears to be concerned with institution building with institutions taking priority over firms. It has been argued by Gibbs et al. (2001) that there is more focus on quantity of intra-regional institutions rather than inter-relations and quality. Radosevic (2002) argues when designing regional innovation strategies new organisations should emphasise programmes and functions. It is suggested by Oughton et al. (2002) that there is a need to apply "policy measures that engender institutional change and

promote partnerships, networking and learning" (p.108). Furthermore, Lovering (2001) argued that selective regional policies may result in the diversion of resources and support of specific interests.

According to Ankrah (2007) there is a large amount of research on university – industry partnerships especially with regard to technology and knowledge transfer. As a consequence considerable literature is in existence regarding mechanisms developed for interaction between industry and university and collaborative outcomes (Ankrah, 2007). There is also considerable literature available regarding the university/ business relationship. Furthermore, what has been published could be described as ad hoc in nature (Ankrah, 2007) and also on a regional basis (Smilor et al, 1990). The nature of the literature shows that co-operation between universities and industry was considered to be less important before 1990 than after (Howells and Nedeva, 2003; Nimtz et al, 1995; Poyago-Theotoky et al, 2002). Since university – industry relationships are evolving, contemporary papers build on the findings of the early literature (Blumenthal, 2003; Geisler, 1995; Howells et al, 1998, Newberg and Dunn, 2002).

With regard university-industry collaboration and regional innovation systems in East Asia it is evident that most are led by governments. A pioneer development of regional innovation systems in Japan was the Tsukuba Science City, and this was followed by Daedeok Innopolis and Hsinchu regional innovation systems in South Korea and Taiwan, built in 1973 and 1979 (Su and Chen, 2014). Recent years have seen developments in other regions with China developing regional innovation systems in the 1980s such as Zhongguancun Science Park, and other regions have evolved into global innovation and production networks including the Pearl River Delta, Yangtze River Delta and the Beijing-Tianjin-Tanggu region (Su and Chen, 2014). This paper therefore seeks to answer the research question "what is the nature of the university-industry relationship in regional innovation systems in East Asia?"

Organisational Aspects of University-Industry Collaboration

Various types of inter-organisational relationships undertaken in practice are reported in the literature and these include interlocking directorates, trade associations, alliances, consortia, networks and joint ventures and these vary according to partnership linkages (Barringer and Harrison, 2000). In fact, it has been observed that in the literature a number of terms are used to describe the different inter-organisational relationships (Chiesa and Manzini, 1998). Furthermore, it is concurred that co-operative arrangements take various forms to a varying degree of complexity and partner involvement (Geisler, 1997). Indeed, it is posited that the possibility for university - industry relationships are fairly wide (Shenhar, 1993). Moreover, forms of university - industry inter-organisational relationships in the case of technology transfer occur according to the technology flow and the length of the relationship (Chen, 1994).

Four classifications for university-industry inter-organisational relationships have been given and these are research support, co-operative research, knowledge transfer and technology transfer (Santoro, 2000). Research support includes endowments and trust funds, co-operative research - informal intentions, institutional facilities, group arrangements, institutional agreements, knowledge transfer - co-operative education, institutional programmes, personal interactions and technology transfer – commercialisation activities and product development through research centres at universities (Santoro, 2000).

It is considered that the creation of a typology that illustrates the possible links between universities and industry, and more specifically between universities and businesses, is not easy (Blackman and Seagal, 1991). Furthermore, the framework of Bonarccorsi and Piccaluga (1994) is reasonably wide and consists of the categories of the creation of focused structures, formal non targeted agreements, formal targeted agreements, personal informal relationships and personal formal relationships. It is noted by Boanarccorsi and Piccaluga (1994) that these six groups provide an increasing involvement level according to the degree of formalisation, length of agreement and organisational resource involvement from the university. In fact a university's resource involvement progresses from formal personal relationships through the categories to focused structures where there is a university wide involvement in industry collaboration structures (Bonarccorsi and Piccaluga, 1994).

Formalisation of agreement can exist for personal formal relationships and third parties whilst in remaining groupings formalised

relations are evident (Bonarccorsi and Picaluga, 1994). The issue of formalisation is considered to be significant since formalisation and monitoring of inter-organisational relationships can cause disagreement and loss of trust amongst partners through them attempting to retain independence for their organisations in a situation where interdependence is increasing (Ring and van de Ven, 1994).

Motivations for University-Industry Relationships

From the literature on inter-organisational relationships between 1960 and 1990 six critical contingencies have been posited by Oliver (1990) across linkages, settings and organisations and these are necessity, asymmetry, reciprocity, efficiency, stability and legitimacy (Oliver, 1990). According to Oliver (1990) two delimiting assumptions are behind the determinants which are that deliberate decisions are assumed to be made to form an inter-organisational relationship by organisations and an organisational perspective involving a top management approach is assumed (the determinants can also explain lower reasons) (Oliver, 1990). The six contingencies show strong correlation with alliance strategy motives (Eisenhardt and Schoonhoven, 1996). Motivations for universities and businesses engaged in inter-organisational relationships appear to closely align with the six critical contingencies/ determinants (Oliver, 1990) as motives for organisations to embrace inter-organisational relationships.

Many governments are encouraging collaboration between universities and industry, in a situation of rapid technological change and international competition, for wealth creation through improving innovative activity (Barnes et al, 2002; Schartinger et al, 2001). It appears that a significant issue for policy making by East Asian governments, especially with regard to research budgets, is the operation of the university - industry interface to enable the exploitation of research to be transferred to industry for economic growth (Hall, 2004; Lopez-Martinez et al, 1994). Universities therefore encourage university - industry relationships in accordance with government and institutional policy (Howells et al, 1998). Whereas industry offers expertise in product development, commercialisation, market knowledge (Sherwood et al, 2004) and employment openings for graduates (Lee and Win, 2004; Santoro and Betts, 2002) universities offer research infrastructure and expertise (Sherwood et al, 2004). Therefore, in order to take advantage of these mutual advantages, there is motivation for universities to develop relationships with industry (Ankrah, 2007).

Increasing pressure on public finance for universities, against a background of government grants for university-industry initiatives (Harman and Sherwell, 2002), has given an incentive for universities to look for other revenue to fund research and equipment. This has been through the exploitation of intellectual property rights, licensing of patents and the commercialisation of research to reduce university dependence on public funds (Logar et al, 2001). It has also been reported that relationships with industry appeal to universities since there is more bureaucracy involved with public funding than with industrial funding (Blumenthal, 2003; Santoro and Chakrabarti, 1999). It has also been reported that academic staff are motivated to enter into relationships with industry through personal financial gain (Siegel et al, 2003; Siegel et al, 2004).

It has been found that organisations are motivated to enter into inter-organisational relationships to attain dependability and predictability in order to respond to environmental uncertainty (Oliver, 1990). Related motivations have included the shift to the knowledge based economy and the change in university-industry relationships to partnerships from sponsorship involving ongoing interaction (Jacob et al, 2000). Considerable resource pressure has affected universities due to the growth in new knowledge which has resulted in universities entering into alliances with industry to stay at the forefront of academic areas in terms of subjects and research (Ankrah, 2007). In particular university academics consider such links to provide opportunities to enable them to train and place students, develop skills, and develop and test theories (Cyert and Goodman, 1997). It has also been posited that universities undertake collaborative arrangements with industry, including businesses, to enable students and academics to solve practical problems through project work, undertake instructional case studies, gain insights from industrial research and to gain exposure to industrial environments (Meyer-Krahmer and Schmoch, 1998; Santoro and Chakrabarti, 2001). These activities contribute to the improvement of teaching

quality and curriculum development (Santoro and Gopalakrishnan, 2001; Meyer-Krahmer and Schmoch, 1998). Moreover, it has been suggested that a significant incentive for Higher Education Institutions (HEIs) to partner with industry, including businesses, is for journal publications (Harman and Sherwell, 2002).

Due to the need for universities to enhance their image they will form relationships with industry (Lopez-Martinez et al, 1994; Mora-Valentin, 2000) and there are societal, political and public pressures for them to show their economic relevance to society and to exhibit entrepreneurship and social accountability (Cohen et al, 1998). Through the need for knowledge and technology transfer, and diffusion, they will be motivated to enter into collaboration with industry in order to drive economic development (Blumenthal, 2003; Hagen, 2002; Siegel et al, 2003; 2004). In relation to this it has been found that a fundamental motive of scientists in universities is for recognition in the industrial scientific community (Hagstrom, 1965) and this can be achieved by research grants, presentations at international conferences and joint publications (academic eminence can be achieved through industry supporting university research) (Siegel, et al, 2003; 2004).

Due to the fast changing technological and competitive environment governments have taken action to support research interaction between universities and businesses since it is considered that universities can support economic regeneration and act as engines of economic growth through dissemination of expertise and knowledge by higher education industry linked partnerships (Bettis and Hitt, 1995; Mora-Valentin, 2000). National and regional research programmes have been created by governments and a good example of these are the knowledge transfer partnerships (Caloghirou et al, 2001) and industry can benefit from these programmes through collaboration with universities (Howells et al, 1998).

Motivation for industry to enter into inter-organisational relationships with universities is for financial gain from the commercialisation of academic based technologies and many businesses will require exclusive rights to technologies (Siegel et al, 2003). Industry is therefore interested in controlling the direction of academic research as well as control of the technologies generated (Newberg and Dunn, 2002; Rappert et al, 1999; Siegel et al, 2003). Other motivations for firms to subscribe to university - industry inter-organisational relationships are to have access to students and for hiring and most collaborative research programmes will seek to target the most able students (Bloedon and Stokes, 1994). According to the OECD (1990) university staff and senior researchers will undertake consultancy work for the time they are allowed to undertake activities outside academia.

There will be several motivations for industry to have inter-organisational relationships with universities from a standpoint of efficiency (Ankrah, 2007). It has been reported that university - industry research increases patenting activity, research and development (R&D) and firm sales (Cohen et al, 1998). Businesses will partner with HEIs for knowledge creation and exploitation, cost savings, innovative activity and research outputs (George et al, 2002). This will result in firms having competitive advantage and improved financial performance (Grant, 1996). The enhancement of R&D and technology growth through grants, tax credits and a legal environment underpinning R&D is another motivation for government (Barnes et al, 2002; Bramorski and Madan, 1993). Continuing professional development (CPD), multi-disciplinary leading technologies, advanced expertise and research facilities as part of human capital development will also be industrial motives since there will be enhanced competitive advantage and the shortening of life cycles (Bonaccorsi and Piccaluga, 1994).

The move to the knowledge based economy has been considered to be an influencing factor for industry to enter into relationships with universities (Santoro and Betts, 2002). It has also been concluded that academic research has augmented the ability of businesses to resolve complicated problems (Pavitt, 1998). According to Howells et al (1988) and Klofsten and Jones-Evans (1996) university – industry partnerships are a good way of influencing technology-based firms, especially businesses to achieve growth. Lopez-Martinez et al (1994), in their study on university - industry relationships, have illustrated that the lack of in-house ability by industry to undertake technological research has been an important business executive motivation. It has also been found that for firms with an R&D capacity collaboration is still appreciated since it enhances limited human and financial resources and reduces risk (Hicks, 1993). Research networks with other

universities and firms and the potential for more complicated collaborative arrangements such as consortia with multiple businesses and universities are a motivation for businesses to enter into inter-organisational relationships with universities (George et al, 2002; Cyert and Goodman, 1997).

It has also been found that businesses can improve their standing by associating themselves with leading universities (Siegel et al, 2003) and links with prominent research universities are believed to increase a firm's position with regard to important stakeholders (Mian, 1997).

Formation Process

Out of the models on the process of inter-organisational relationship formation (Tuten and Urban, 2001) a model which is believed to be relevant for university – industry inter-organisational relationships formation is the Mitsuhashi (2002) business to business alliance formation model which describes a five stage alliance formation process.

The initial stage in the formation of a university – industry inter-organisational relationship is the determination of the purpose of the partnership and this will be followed by finding an actual partner (Mead et al, 1999) and a number of criteria have been proposed for the selection of partners (Champness, 2000; Dodgson, 1991). It is, however, believed that efforts should be made to undertake prospective partner evaluation, no matter what partner selection criteria are adopted, since there are benefits including ensuring that the collaboration is appropriate (Barnes et al, 2002).

It has been found that if partners have previous experiences of co-operation then the outcomes of inter-organisational relationships are better (Dill, 1990; Geisler, 1995). Existing relationships between partners are crucial since, where experience with an existing partner exists, trust will be developed and universities and industry will adjust to the demands, evolution and expectations of previous alliances (Gulati and Gargiolu, 1999). Previous collaboration experience (Schartinger et al, 2001) will be important from earlier research, technological and personal interactions and this will reduce organisational and personal obstacles and enhance contact between universities and businesses.

During the formation stage it is critical to define administrative and managerial responsibilities for the inter-organisational relationship, involving financial accountability, and a suitable partnership objective is for the partners to select a project manager (equal collaborative participation by partners will be important) (Peterson, 1995). A project plan needs to be agreed by partners with the specification of milestones (Buttrick, 2000). Differences between partners should be dealt with to avoid collaboration conflict, specification of interim, and end delivery provided, and measures of success identified (Peterson, 1995).

Depending on the complex and formal nature of the inter-organisational relationship it will be essential to have it legally bound by a contract to underline the commitment of the partners (Kanter, 1994; Burnham, 1997). For the inter-organisational relationship of universities and businesses the intellectual property agreement will be the same as the legal document and will specify partner agreements and relationships during, and after, the project collaboration approved by partners (Ankrah, 2007).

University - Industry Inter-Organisational Relationships

The university and industry inter-organisational relationship will enter the operational stage (Sherwood et al, 2004) following its formation and this involves a constant evolutionary and learning process (several factors will influence this relationship) (Doz, 1996; Ritter and Gemünden, 2003). A number of activities will take place between the organisations during the operational phase and these will have the objective of attaining the goals of the inter-organisational relationship (Ritter and Gemünden, 2003). In the literature a number of factors are found to induce or restrict inter-organisational relationships between universities and industry (Azaroff, 1982; Dean, 1981; Fowler, 1984). These include capacity and resources, legal issues, institutional policies and contractual mechanisms, management and organisational issues, issues relating to the technology, political issues, social issues and other issues (Ankrah, 2007). The complex interaction of these factors, with the resultant positive and negative impacts, will determine the success of a collaborative project (Barnes et al, 2002). In particular, managerial and organisational issues are critical factors inducing or restricting relationships between universities and industry (Siegel et al, 2003). It is also considered that substantial managerial effort is needed for university and industry inter-

organisational relationships to succeed taking into account the cultural nature of the partners concerned (Dodgson, 1991).

RESEARCH METHODOLOGY

The research has been carried out to address the research question - "what is the nature of the university-industry relationship in regional innovation systems in East Asia?" The study has used a systematic literature review approach to identify and interpret research in the fields of university-industry collaboration and regional innovation systems in East Asia. According to Fink (1998) "A literature review is a systematic method of identifying, evaluating and interpreting the work of researchers, scholars and practitioners in a chosen field" (Fink, 1998). In terms of the investigation of information, ideas, data and evidence the approach of Hart (1998) was followed. "The selection of available documents (both published and unpublished) on the topic, which contain information, ideas, data and evidence written from a particular standpoint to fulfil certain aims or express certain views on the nature of the topic and how it is investigated, and the effective evaluation of these documents in relation to the research being proposed" (Hart, 1998; 13). In particular the review involved three processes including systematic review (major writings), historical review (chronological order) and thematic review (conceptual) (Thomas, 2011). The main types of sources for the literature were primary – direct descriptions of research studies or other events including academic journal articles that report research studies, and books explaining the author's philosophy or theoretical models, and secondary – documents written by an author who did not exactly observe or participate in the events described or who was not the originator of the concepts outlined including textbooks and reviews of research (Marrelli, 2005; Borg and Gall, 1979).

This research is a critique of the literature concerning university-industry collaboration in East Asia and considers the significance of these theories in relation to the development of regional innovation systems. In order to compile the literature library sources used were the OPAC library catalogue, FINDit gateway to electronic journals and books, guides, inter-library loans and library collections. The literature process involved knowing and comprehending the literature, followed by applying, analysis, synthesis and evaluation (Levy and Ellis, 2006). Also, scholarly literature databases were used including ABI/INFORM, Elsevier, Emerald, Google Scholar, ProQuest and Science Direct. In order to find the appropriate literature a number of searches were used including keywords search (specific word or phrase), backward search (backward references search, backward authors search, previously used keywords), and forward search (forward references search and forward authors search).

The research investigation and analysis was undertaken in three stages: (1) review of university-industry collaboration in East Asia, (2) review of regional innovation systems in East Asia, and (3) the nature of university-industry collaboration and regional innovation systems in East Asia in terms of linkages, partnerships, efficiency and "good/best practice". The research is of both academic and practical significance, contributing to the body of understanding on the processes involved in the university-industry inter-relationship in East Asia. Research findings in the next section report the findings of these three research stages.

RESEARCH FINDINGS

The research findings below are reported according to the stages of the research methodology: (1) review of university-industry collaboration in East Asia, (2) review of regional innovation systems in East Asia, and (3) the nature of university-industry collaboration and regional innovation systems in East Asia.

(1) University-industry collaboration in East Asia

University-industry collaboration literature focuses on the linkages that are in existence, and these include patenting, applied research, quality of universities, knowledge transfer, licensing, spin offs, science parks, research contracts and consultancy, incubators, collaborative research, student placements and venture capital. With patents these are seen as indicators of R&D activity and are a metric of choice (Scotchmer, 2004), and are measured by considering patents granted from the United States Patent and Trademark Office (USPTO). Although applied research is important some countries emphasise training rather than applied research and although in Japan there is considerable collaboration between academics in research universities and firms these university-industry

linkages are not as numerous as in the United States and in other countries such as Korea are even less prevalent (Mok, 2010). The quality of universities is exhibited in their ranking and this is evidenced by the rakings of the Times Higher Education Supplement (THES, 2008), for example.

Also, doctoral qualifications of staff provide a good indicator of the quality of universities and in Indonesia, for example only 5% have doctoral qualifications (Hill, 2010), and many universities in Indonesia and the Philippines have less qualified faculty and limited ability to offer graduate programmes in science, technology, engineering and mathematics (STEM) (Tan, 2010). With the difficult conditions in some universities there is considerable pressure from the business sector for the best qualified graduates (Chapman, 2009). Citations attributed to Chinese publications in scientific journals have been in about 13th position in the past (Simon and Cao, 2009, pp. 99-100) and at this time some 500 biologists were classified "productive" (Simon and Cao, 2009, p. 318). Typical university-industry linkages through technology transfer are provided by Potter (2008).

An important way of contributing to developing industry is through the support of graduate entrepreneurship (no 11, table 2) and through more entrepreneurs this complements the promotion of research (Audretsch, 2008). A number of routes are suggested (Potter, 2008) and this has been shown by the National University of Singapore on its entrepreneurship courses and through university incubators. For successful entrepreneurial ideas to evolve into viable start-ups there is a need for provision to help firms exit into the business world (Potter, 2008), networked incubation facilities with businesses (Hansen et al, 2000), and universities to provide continuous ideas and support (Patton, Warren and Bream, 2009). Typical approaches to the training of entrepreneurs (Potter, 2008) are shown in Table 1.

Table 1. *Typical approaches to the training of Entrepreneurs*

Number	Type of Approach
1	Business Plans
2	Business Games
3	Case Studies
4	Classroom Lectures
5	Communication Training
6	Consulting for SMEs
7	Courses for Entrepreneurship Teachers
8	Distance Education Programmes
9	Entrepreneurs as Guest Speakers
10	External Partnerships
11	Feasibility Studies
12	Placements with Small Firms
13	Specialist Entrepreneurship Degrees
14	Student Business Start-ups
15	Student Entrepreneur Clubs and Networks
16	Support for Graduate Student Start-ups after the Course
17	Across University Entrepreneurship Education

Source: *Potter (2008, pp. 323-324)*

With regard to formal university-industry linkages in some East Asian countries this is restricted due to limited expenditure on R&D by businesses and the quality of some universities (Hill, 2010). Contrary to this the Taiwan China Government has evolved a programme to promote the excellence of universities by establishing university-industry linkages as one of the criteria through which university academic staff and students are evaluated in order to enhance the promotion of collaboration between industry and universities (Mok, 2010). Further to this, an example of the stimulation of university-industry linkages in Japan is the TAMA Association with the aim to improve competitiveness of small and medium-sized enterprises (SMEs) in the Tama region north west of Tokyo (Kodama, 2008). At a national level the Chinese Government since 2001 has tried to encourage close collaborative activity between industry and universities through making commercialisation, research and teaching the core missions of research universities, and through this patenting activity

has grown quickly with patents from universities nearly 30% of all Chinese patents granted (Wu, 2010). Various local and national policies have been undertaken by China to support university-industry linkages and these included high technology development areas nearby important universities, development of university based science parks (40 nationally), patent laws strengthened, and legal and financial assistance for student and academic staff start-ups (Chen and Kenney, 2007; Liu and Jiang 2001; Walcott, 2003; Wei and Leung, 2005; Xue, 2004). Figure 1 below illustrates university-industry interaction in East Asia involving linkages evolved from the Triple Helix of university, industry and government relationships (Etzkowitz and Leydesdorff, 2000).

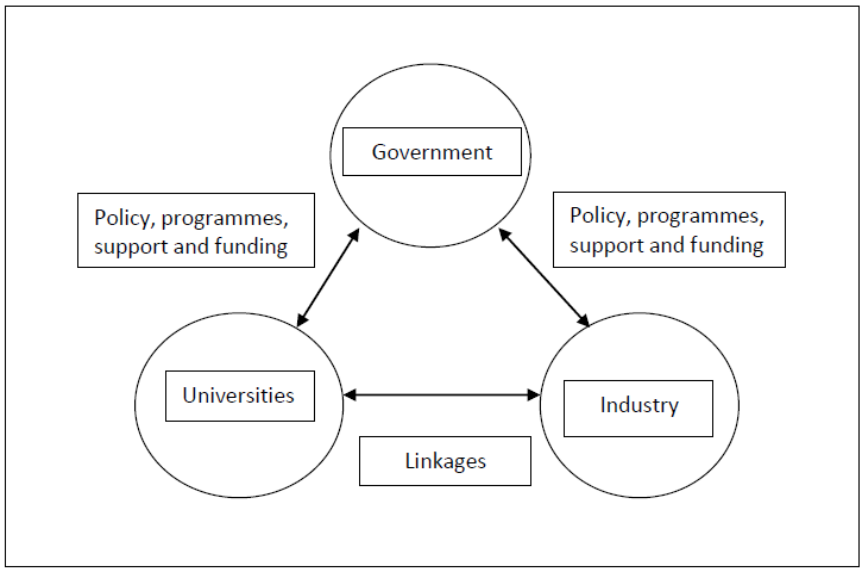

Figure 1: University-industry interaction in East Asia involving linkages

In China there are university affiliated enterprises which in other countries would be privately owned but are owned by universities (Chen and Kenney, 2007). These are the second mechanism, which are part of reforms implemented by China for university-industry linkages in recent years, with the first being technology transfer involving technical services, R&D (joint and contract), consulting and licensing (Ma, 2004; Zhang, 2003). Science and technology (S&T) oriented university affiliated firms are responsible for over 100 million RMB per year, and this is the case with those linked with Tsinghua and Beijing universities (Wu, 2010). With private firms in China around half of firms surveyed were involved with formal university collaboration during 2007, whereas informal collaboration involving the development of training programmes, laboratory space and the sharing of equipment, was more common similar to Japan (Wu, 2010). Furthermore, in Thailand university staff have been separated from civil servants to enable salary flexibility for better relationships with firms by the Education Reform Act (1999), and the Government identified seven areas for research capability improvement (agricultural biotechnology; environmental hazardous waste management; environmental science, technology and management; energy and environment; chemistry; post-harvest technology; petroleum and petroleum technology) in the Higher Education Development Project (Doner, Intarakumnerd and Ritchie, 2010).

In general in East Asia it has been found that firms may be incapable of identifying and using knowledge from universities (Kodama and Suzuki, 2007), and here intermediaries have been significant in enabling university-industry linkages. An example of this was the sugar industry in Thailand who were interested in cellulosic ethanol due to energy conservation, and since no Thai universities had the expertise, the firms collaborated with universities in Japan by intermediation of a trading company in Japan (Doner, Intarakumnerd and Ritchie, 2010). Although university-industry linkages are often observed with regard to high tech industries (biotechnology, electronics, software and telecommunications) there are also important linkages with low tech industries including the agricultural industry such as the shrimp industry in Thailand (Brimble and Doner, 2007; Kruss and Lorentzen, 2007).

With regard to university-industry linkages it has been found that the acquisition of

entrepreneurial skills by students and linking them to learning networks can enhance start-ups and idea transmission (Potter, 2008). Also, by focusing on quality research and teaching to create scientific excellence and world class research in departments directly influences local industry (Altbach, 2004). An example of this is the development of world class universities in China through the National 211 Project which was introduced in 1997 (Sigurdson, 2008). A further point to note here is that research universities in East Asia require collaboration with international partners for external knowledge flows in dynamic research areas (Adams, James and Clemmons, 2009). Table 2 below shows examples of literature sources investigated in this study and the mechanisms reported with regard to university-industry linkages.

Table 2: Examples of literature sources and typical mechanisms reported for University-industry linkages in East Asia

Literature sources	Mechanisms
Potter (2008) Hansen et al (2002)	Collaborative research, Cluster initiatives, External training, Incubators, Licensing, Mobility programmes for research staff, Research contracts and consultancy, Science parks, Spin-offs, Student placement in enterprises, Support for graduate entrepreneurship, Technology brokers, Technology centres, Technology networks, Technology transfer offices, Venture capital funds, Learning networks, Start-ups, Idea transmission.
Wu (2010) Scotchmer (2004)	Commercialisation, Research and Teaching, Patenting, Informal collaboration - development of training programmes, laboratory space and the sharing of equipment.

By taking the typical mechanisms reported for university-industry linkages in Table 2 these can be applied to Figure 1 for university-industry interaction in Figure 2.

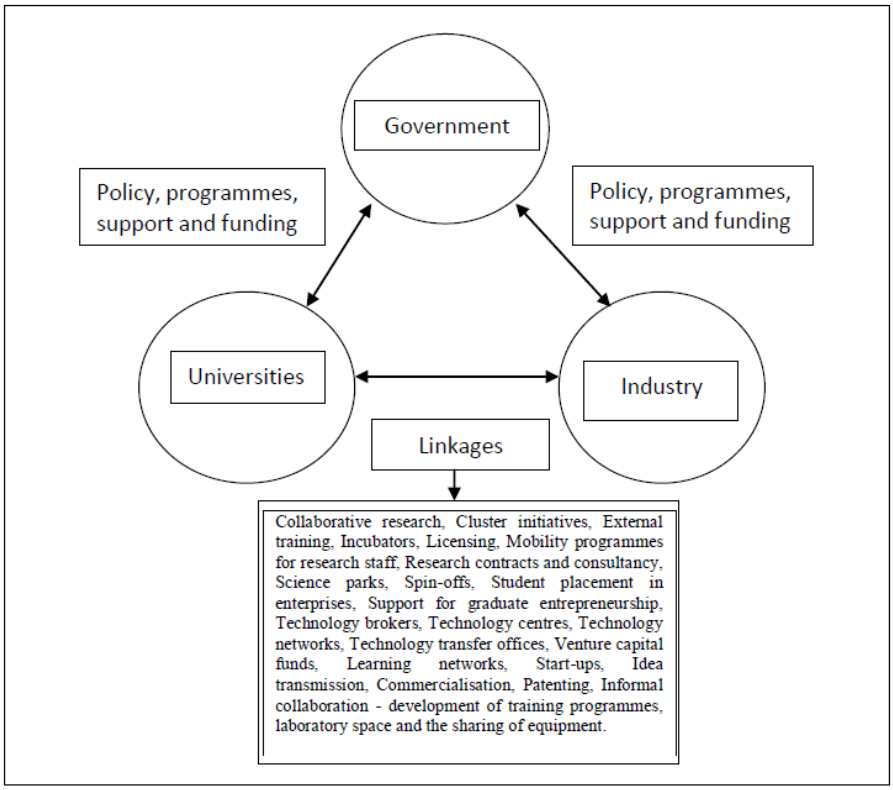

Figure 2: Typical Mechanisms involved in University-industry linkages in East Asia

(2) Regional innovation systems in East Asia

With other regions in the World increasingly demanding a larger amount of exports from East Asia there is the need to customise designs,

processes and products and adapt technologies which require university support in regional innovation systems (Kapur and Crowley, 2008). There is also the need for research that is commercially relevant from universities and regional research hubs (Hill, 2010). Universities can act as nodes in regional innovation systems connecting to other major World centres and through this create and diffuse new ideas (Etzkowitz and Leydesdorff, 2000). There is also the need for linkages between universities and industry for research efforts, commercialisation and exploitation of R&D for the connection of research excellence and regional economic strengths (LaRocque, 2007). This can be enhanced by professional development programmes and activities supported on a sub regional and regional basis, an example of which is SEAMEO-RIHED (2005). Further to this in South Korea there is the New University for Regional Development (NURI) which is a key project supported by the Government to develop strengths and specialities (UNESCO, 2003).

The role of universities in regional innovation systems in East Asia can be seen through examples such as Singapore where since 1990 it has developed higher education (HE) as a service that is globally tradable with education contributing to economic growth in regional hubs and in Hong Kong the UGC has supported the merging of universities and restructuring to evolve Hong Kong as a centre for scholarship and excellence at a regional level (Chan and Lo, 2007; Lee, 2005). In Hong Kong the potential of university-industry partnerships have been explored through technology transfer offices and spin off companies (Sharif and Baark, 2008). Further to this the Hong Kong Government set up research centres, some hosted by universities, in 2006, to provide a business related environment to enhance intellectual property and applied research, and based on close proximity to manufacturing in Pearl River Delta (PRD) to develop a service hub for regional technology (Baark and So, 2006). In other East Asian countries there are interesting developments such as in South Korea where universities are involved in the development of regional innovation systems providing knowledge to local industries, an example being the New University for Regional Innovation Project which was launched by the Ministry of Education, Science and Technology (MEST) in 2004 to ready graduates for work in industries locally (MEST, 2007). South Korean universities have also been involved in developing science parks (Kim, 2007).

(3) Nature of university-industry collaboration and regional innovation systems in East Asia.

In recent years East Asian governments have undertaken numerous initiatives to enhance the development of university-industry collaboration in regional innovation systems. An example of this is the Government of South Korea who started a number of programmes to enhance university-industry collaboration and regional innovation systems, and these have included the 21st Century Frontier R&D Project, Engineering Research Centre Programme, and the Leading Technology Development Programme (Sohn et al, 2009). Such programmes aim to balance and align innovation systems between non capital and capital regions and an example is the Regional Industry Support Programme which supported the development of regional innovation systems in thirteen non capital regions (Sohn et al, 2009). Although there have been successive programmes started for the South Korean regional innovation system these have tended not to be fully regional in nature since a top down approach for regional innovation policies has been adopted by the South Korean Government (Kim, 2007).

In Japan due to university-industry research collaboration close linkages have been formed between regional innovation systems and universities (Kitagawa, 2008). This has been based on the Science and Technology (S&T) Basic Law (1995) with 3 S&T Basic Plans (BPs) for regional innovation systems development: 1st S&T BP (1996-2000) – budget increase for S&T and the enhancement of university-industry linkages, 2nd S&T BP (2001-2005) – highlighting the significance of S&T policies at the regional level, 3rd BP (2006-2010) – setting up regional innovation systems through regional academic, industry and government linkages (Kitagawa, 2008). Following these policy developments regional innovation schemes were started including the Industrial Cluster Initiative (2001) to revitalise regions through public research institute, university and industry networks (Kitagawa and Woolgar, 2008). The Technology Advanced Metropolitan Area (TAMA) in the Tokyo Metropolitan Area was a successful university-industry linkage for the Industrial Cluster Initiative for SME patent applications and product developments

(Kodama, 2008). A similar scheme was the Knowledge Cluster Initiative (2002) with an erudite approach impulsing a technological innovation regional system through government industry university cooperation establishing centres of excellence networks in regions (Kitagawa and Woolgar, 2008). Such schemes illustrate regional level university-industry collaboration at a decentralised rather than centralised level. Figure 3 illustrates the nature of university-industry collaboration and regional innovation systems in East Asia.

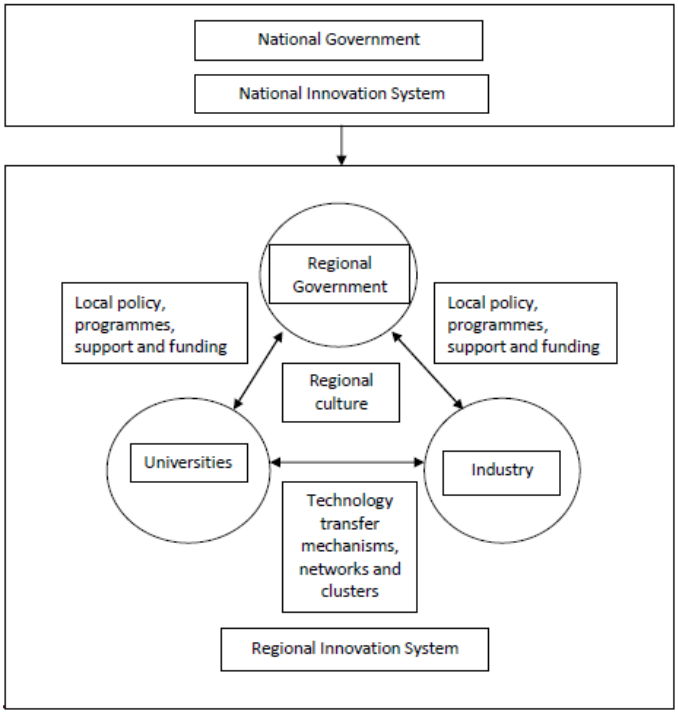

Figure 3: Nature of University-industry collaboration and regional innovation systems in East Asia

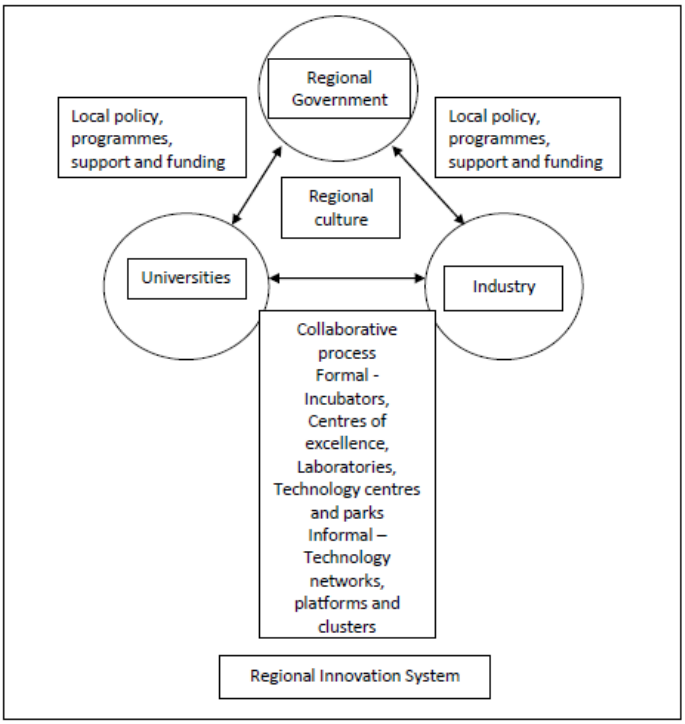

Figure 4: Model of university-industry collaboration and regional innovation systems in East Asia and the collaborative process

CONCLUSIONS

With regard to the research question "what is the nature of the university-industry relationship in regional innovation systems in East Asia?" this has been answered and illustrated in the findings of this research (Figure 5) and can be

further responded to in terms of the typologies that have been developed to express the diversity of relationships that may be employed in the collaborative process. Freeman (1991) distinguished between the following: joint ventures and research corporations; joint R&D agreements; technology exchange agreements; direct investment motivated by technology factors; licensing and second-sourcing agreements; sub-contracting, production-sharing and supplier networks; government-sponsored joint research programmes; computerised data-banks for technical and scientific interchange; and informal or personal networks. An evolved model of the nature of university-industry collaboration and regional innovation systems in East Asia is shown in Figure 4 which takes into consideration the collaborative process involving formal and informal relationships.

Although there have been many studies indicating the importance of formal relationships for the transfer of technology, a number of recent investigations have also highlighted the key role played by informal relationships as a means for sourcing ideas and information during the development process (Kreiner and Schulz, 1993; Shaw, 1993). However, in relation to informal exchange, this research has typically been anecdotal in nature. This view is supported by Freeman (1991) who argues that `although rarely measured systematically…informal networks are extremely important, but very hard to classify and measure'. More in-depth and systematic studies of informal interaction in the innovation process do exist, but these have been largely exploratory and have not been examined in different regional or technological contexts.

It has been noted in the literature that closely related to the subsequent benefits realised are the motivations (Geisler, 1995; Lee, 2000). There is also evidence that there is a positive relationship between outcomes and motivations (Lee, 2000). Although the benefits of university and industry inter-organisational relationships will outweigh any costs it is necessary for both sides to be aware of any limitations so that action can be taken to alleviate any problems through procedures and policies (Harman and Sherwell, 2002). By doing this it will be possible to ensure that the relationship is successful and to make failure less likely (Ankrah, 2007). This will also ensure that the goals of both universities and industry in East Asia are met (Harman and Sherwell, 2002). There are clear limitations to the findings of this conceptual paper but these provide avenues for future research and there are important policy implications for governments in East Asia arising out of the study of university-industry collaboration in regional innovation systems.

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