QUINTUPLE HELIX MODEL AND URBAN DEVELOPMENT: A SURVEY OF STRATEGIC COOPERATION BETWEEN UNIVERSITY AND INDUSTRY

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ABSTRACT: A strong innovation ecosystem is important for the success of the urban development based on innovation and knowledge. The extent of strategic cooperation between universities and the industries affect economic, societal, and environmental balance. This article elaborates on the concept of generating innovation based on the Quintuple Helix Model and the knowledge city. The Quintuple Helix Model is based on the Triple Helix Model, to form innovation ecosystem through cooperation among universities, industries and the government. The Quadruple Helix Model is the addition of the fourth helix of the social and cultural context and while the fifth helix in the Quintuple Helix Model is the environment. The Triple Helix Model development is in line with the concept of developing a knowledge city consisting of the economic, social, and environmental aspects. The basis for this model and concept are innovation and knowledge. The main focus in driving development based on innovation and knowledge is to increase productivity and global competitiveness.
Keywords: Innovation, knowledge, knowledge city.

INTRODUCTION

Innovation and knowledge function are twin drivers in urban development. An effective innovation ecosystem is critical in ensuring successful innovative initiatives among institutions of higher learning (Striukavo and Rayna, 2015). Innovation ecosystem can be defined as an environment and economic development and diffusion model formed by an ecology of actors whose goals are to create, store and transfer knowledge, skills and artefacts which define new technologies, enable technology development and innovation (e.g. industry, academia and government) (Rabelo et al., 2015). Universities as '*engines of innovation*' (Drucker and Goldstein, 2007) create talent and foster relationships and connectivity between citizens within the knowledge pool (Martinez- Fernandez and Sharpe, 2008). Universities are no longer ivory tower but has become a catalyst to stimulate national growth (Benneworth and Hospers, 2007; Gilman and Serbanica, 2015). Their roles are no longer confined to human capital development but encompass building research capabilities, technology development, commercialisation and innovation (Hershberg et al., 2007). Universities need to interact with others in order to be remain relevant and contribute to the urban development, especially in Knowledge Based Urban Development (KBUD) (Yigitcanlar and Lönnqvist, 2013). Quintuple Helix (QH) Model is used for clustering level strategic cooperation University and Industry (U-I) in urban development in order to identify social-spatial inequalities. The cooperation has become one of the agenda within higher education policy making as university research plays an important role in industrial innovation (Cohen et al., 2002; Mansfield, 1991).

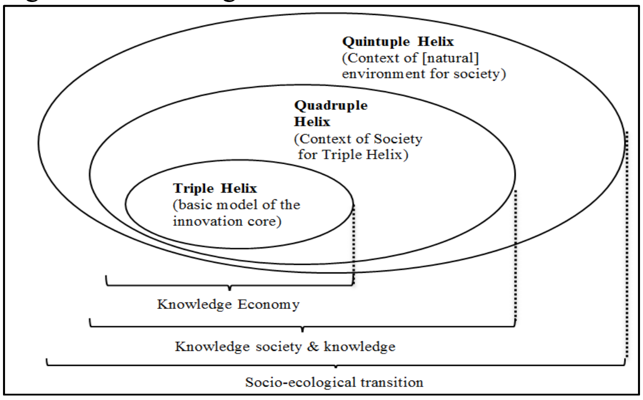
QH Model is in line with the concept of developing a knowledge city encompassing economic, social, and environmental aspects. The knowledge city concept represents the knowledge based urban development (Yigitcanlar and Lönnqvist, 2013). The first part of this article aims to elaborate on the concept of generating innovation based on the QH Model and knowledge city. The second purpose of this paper is to examine the levels of universities' and the industries' strategic cooperation which contribute to economic, social and environmental development in Malaysian context. Malaysia's urban development is currently at a transition stage moving from the second stage, efficiency-driven, to the third stage, innovation-driven. Malaysia is categorised as an upper middle income country by the value of GDP per capita (Global Competitiveness Report, 2013).

QUINTUPLE HELIX MODEL AND URBAN DEVELOPMENT

The important roles of knowledge are multi-dimensional and one of the factors that leads toward urban development (Yigitcanlar, 2005). Knowledge provides the impetus to inspire higher levels of innovation. There are two phases in the innovation process. First, innovation means invention, discovery, research and development (R&D). The incentive to innovate lies in the supply and demand equation of whether it will be applied in U-I strategic cooperation. Second, innovation is defined as diffusion, adjustment, adoption and imitation which will then turn into application and introduction in the market (Lambooy, 2006). There are currently six existing models of knowledge creation and innovation creation (Carayannis et al., 2012) focusing on urban development growth. (i) Mode 1 focuses on “the traditional role of university research in an elderly”, ‘linear model of innovation’ understanding”, and success in mode 1 ‘is defined as a quality or excellence that is approved by hierarchically established peers’ (Carayannis and Campbell, 2010). (ii) Mode 2 can be characterised by the following five principles: ‘knowledge produced in the context of application’, ‘transdisciplinary’, ‘heterogeneity and organizational diversity’, ‘social accountability and reflexivity’ and ‘quality control’.

Figure 1 illustrates the knowledge production and innovation. 1st helix, the TH explicitly acknowledges the importance of higher education for innovation. However, in one line of interpretation it could be argued that the TH places the emphasis on knowledge production and innovation in the economy so it is compatible with the knowledge economy. 2nd helix, the Quadruple Helix already encourages the perspective of the knowledge society, and of knowledge democracy for knowledge production and innovation (Carayannis and Campbell, 2010). In the perspectives of Quadruple Helix, the sustainable development of a knowledge economy requires co-evolution with the knowledge society. Then the last helix which is QH stresses the necessary socioecological transition of society and economy in the twenty-first century. The QH models are connected to mode 3, whereby a university can simultaneously follow or alternate between mode 1 and mode 2. The QH model is also considered as a way to overcome the major obstacles in cooperation between academia and industry (Carayannis and Rakhmatullin, 2014; Jonsson et al., 2015).

Figure 1: Knowledge Production and Innovation



Source: Carayannis et al. (2012), Etzkowitz and Leydesdorff (2000)

(iii) The ‘Triple Helix (TH) overlay provides a model at the level of social structure for the explanation of Mode 2 as a historically emerging structure for the production of scientific knowledge and its relation to Mode 1’, and it is a “model of ‘networks and hybrid organizations’ of ‘U-I-G relations’” (Etzkowitz and Leydesdorff , 2000). (iv) Mode 3 is more inclined to emphasise the co-existence and co-evolution of different knowledge and innovation modes. Mode 3 pointed to pluralism and diversity of knowledge and innovation modes as necessary conditions for the advancement of societies and economies. (Carayannis and Campbell, 2010).

(v) ‘The Quadruple Helix Model is based on the TH Model, adds as 4th helix the ‘public’, more specifically being defined as the ‘media-based and culture-based public’ and civil society. This “4th helix associates with ‘media’, ‘creative industries ‘culture’, ‘values’, ‘life styles’, ‘art’, and perhaps also the notion of the ‘creative class’ ” (Carayannis and Campbell, 2009). (vi) The QH Model is based on the TH Model and Quadruple Helix Model and adds as 5th helix the ‘natural environment’. The QH is a ‘five-helix model’, ‘where the environment or the natural environments represent the 5th helix’. The QH can be proposed as a framework for transdisciplinary (and interdisciplinary) analysis of sustainable development and social ecology’ (Carayannis and Campbell, 2010).

Table 1: The Benefits of Knowledge City and Quintuple Helix Model in Different Contexts

Context	**Benefits Knowledge City**	**Quintuple Helix Model**
Economic and organisational	- Creation of more rewarding and well-paid employment - Higher growth in community’s income and wealth - A more sustainable economy, by technological innovation and off-shore investment; revitalization of traditional industry - Reinvestment of local capital into the local economy - Promotion of measured risk-taking – build entrepreneurial culture - Creation and innovation are central elements of its development - Constant connection between universities, enterprise and creators	Knowledge economy
Social and Culture	- Greater opportunities to share wealth through investment in the public domain and better funding of social safety nets - Creation of knowledge communities that will provide ‘just in time’ knowledge when it is needed - Better education services and connected network of school - Creation of a tolerant environment towards minorities and immigrants - Leader in cultural production and the cultural industry - Instrument that make knowledge accessible to citizen - Access to the new communication technologies for all citizens	Knowledge society and Knowledge democracy
Physical and environmental	- Leader in the incorporation premise of the digital area - Urban design and architecture that incorporate the new technologies - Uses and exploits its monumental, architectural and natural heritage to attract visitors - Improved capacity to enhance and repair natural and built environment - Greater community commitment to environmental decision making	Sociological transition

Sources: Carayannis et al., (2012), Etzkowitz and Leydesdorff (2000) and Yigitcanlar (2005)

The concept of ‘knowledge city’ may refer to all aspects of social, economic and culture of a city. Knowledge city as a city which aims for knowledge-based development by encouraging the continuous creation, sharing, evaluation, renewal and update of knowledge (Ergazakis et al., 2004). KCs are incubators of knowledge and culture, forming a rich blend of theory and practice within their boundaries driven by knowledge workers through strong knowledge production (Work Foundation 2002). The main benefit of KCs is that they function in such a way that is in favour of their knowledge-based development. Table 1 illustrates the benefits of knowledge city in the economic, societal and environmental contexts. KCs can be measured by the level of innovation, amount of patents and R&D spending that a city-region generates as technology, science and innovation are considered the ‘top section’ of the knowledge economy (van Winden et al., 2007).

UNIVERSITY–INDUSTRY STRATEGIC PARTNERSHIP

The significant symbiotic relationship between U-I fosters economic development as well as community development and nature conservation of a nation (Jonsson et al., 2015). Wright et al. (2008) examine the types of U-I interaction which include spin off company, licensing, contract research, consulting and graduate and researcher mobility. In contrast, Tapsir et al. (2011) used a different set of indicators i) industrial funding of university researches and collaborative projects, ii) patenting by universities, iii) start-up companies from universities, iv) joint-publication of articles from U-I research, and v) internship programmes between universities and industries. There are several stages or levels in the process of knowledge transfer between universities and industries contributing to innovation, economy, social and environment. Baraldi et al. (2013) created a typology of U-I interactions based on increasing depth, intensity and importance for the parties. From shallow 'contacts' (acquainted) to 'participation' in meetings and discussions (with minimal exchange of resources) to actual 'cooperation' (entailing knowledge exchange and joint activities). This is followed by deeper 'collaborations' (entailing closer combinations of resources towards a common goal) and finally 'full-blown relationships', characterised by extended interaction, resource adaptations and high levels of interdependence (Jonsson et al., 2015). The typology described the different levels of interaction between universities and industries to determine the impact achieved. For example, collaboration of Uppsala University and the National University of Agricultural Sciences (SLU) with industries formed a platform to stimulate industry with limited or no previous academic experiences to use the knowledge and expertise at the university for developing new methods and products. This project provided financial support to about 30 SMEs to establish academic collaborations with the assumption that they would benefit from academic research and thus stimulate economic growth (Jonsson et al., 2015).

Success Story of University-Industry (U-I) Strategic Partnership

There are various methods and practices in the management of U-I linkages to ensure a successful strategic partnership. A strong strategic partnership between universities and industry will positively impact economic, societal and environmental development.

Unites States of America (USA)

In the United States (US), the passage of the Bayh-Dole Patent and Trademark Amendments Act of 1980, followed by additional amendments in 1984 represent part of a broad policy shift towards more comprehensive intellectual property rights (Mowery and Sampat 2004). Universities in the US have generally embraced the goal of economic development in addition to their traditional missions of education, research, and public service. The prospect of supplementary earnings from patents, licensing, and industrial collaborations has acted as an additional lure in a period of tight public education budgets (Drucker and Goldstein, 2007). According to a survey, there may be upwards surge of 1,000 U-I linkage of various types in the US, accounting for a significant fraction of industry-supported academic research. Stanford University set up the Office of University Corporate Relation to manage U-I collaboration. Harvard University through Office of Technology Development (OTD) has brought technologies for public use and generated funds for continued research and accomplished mission while maintaining its academic standing, research activities and principles. Major products in a wide variety of industries have been developed through U-I partnership such as internet search engines, the Boyer-Cohen "gene-splicing" technique that launched the biotechnology industry, diagnostic tests for breast cancer and osteoporosis, music synthesizers, computer-aided design (CAD), and environmentally-friendly technologies (Siegel et al., 2004).

United Kingdom (UK)

The formation of the Alvay Programme in early 1980s was a significant attempt to ensure UK industries and academia catch up with the US and Japan in areas concerning Information Technology. During the 1990s, UK government increasingly focused on the impact of interactions between universities and industries. With the introduction of Realizing Our Potential: Higher Education - Business and Community Interaction Survey (HE-BCI), it highlighted an increase in the overall exchange of knowledge between UK higher education institutions and the public, private and third sectors with 5% financial growth rate from 3401 million in 2011–12 to 3570 million in 2012–13.

Japanese

Efforts concerning policy regulation to promote U-I collaboration started fairly early. The Ministry of Education, Culture and Sport, Japan, established the Office of Collaborative Research in 1982 and started the Collaborative Research Scheme in 1983. To facilitate interaction between universities and companies, the Ministry established Collaborative Research Centres in national universities in 1987. In 1995 and 1996 when Sciences and Technology Basic Law was passed and the 1st Science and Technology Basic plan was launched, the sum of public R&D expenditure was raised to 17 trillion yen within the following 5 years. Seven major programmes were launched with each managed by a special public cooperation. For instance, 'Comprehensive Joint Research' was managed by special Coordination Funds for Promoting Science and Technology of the Science and Technology Agency (STA); Exploratory for Advanced Technology of the Research Development Cooperation of Japan (JRDC) was similarly managed by STA; Large Scale Industrial Technology Research Development Programme of Ministry of International Trade and Industry (MITI) and the New Energy and Industrial Technology Development Organization (NEDO).

Malaysia

The idea of strategic partnership between U-I in Malaysia was first mooted in the mid-1980s, when researchers and academics need to commercialises their R&D product via related industry. The first national Science, Technology and Innovation (STI) policy was implemented in 1980s and Intensification of Research in Priority Area (IRPA) grant was established. In line with Malaysia's Vision 2020, the government planned to focus on the development of high value-added and technology based industries, with equal emphasis on agro-based and resource based industries. The National Mission in the 9th Malaysia Plan is to raise the country's capacity for knowledge, creativity and innovation. The total research funding was also increased to support R&D. Research funding for the 7th Malaysia Plan (1996-2000) was RM 1 billion while during the 8th Malaysia Plan (2001-2005) is RM 2 billion. The 9th Malaysia Plan allocated RM 3.9 billion for R&D activities and intend to focus on producing more Researchers, Scientist, and Engineers (RSE), targeting 50 RSEs in every 10,000 members of the labour force by 2010 (Tapsir et al., 2011).

Taking heed of the success stories from other developed countries, Malaysian Ministry of Higher Education has listed U-I collaboration as one of its critical agenda (MOHE, 2010). A range of initiatives have been accomplished such as The Lab2Market Commercialization Programme, the Cradle. One of the strategies in Eleventh Malaysia Plan (RMK 11) for translating innovation to wealth is the strengthening of industry-academia collaboration through intermediaries by encouraging local and international collaboration including strategic alliances with MNCs and SMEs to facilitate technology transfer.

DISCUSSION

The concept of generating innovation based on the QH Model can overcome existing challenges through the application of knowledge and know how as it focuses on the social exchange and knowledge transfer inside the subsystems of a specific state or nation state. There are five subsystems; i) *education system*, ii) *economic system*, iii) *natural environment*, iv*) media based and culture based public*, and v) *political system* (Carayannis et al., 2012; Etzkowitz and Leydesdorff, 2000). All systems in a QH Model influence each other to stimulate new knowledge. Knowledge is the most important 'commodity' to QH Model as well as in the making of knowledge city. In the knowledge city concept, city aims at knowledge based development by encouraging continuous creation, sharing, evaluation, renewal and update of knowledge (Ergazakis et al., 2004).

We will now discuss how all systems in the helix influence each other with knowledge through new, advanced and pioneering innovation. First subsystem is the *education system,* which refers to academia, universities, higher education system and school. Human capital in this helix of state is being formed by diffusion and research of knowledge, which is like students, teachers, scientist, researchers and academic entrepreneurs. When investment are put into *education system*, it will produce output such as new equipment, new places for scientists and teacher, and greater research opportunities. The output of new knowledge through human capital will turn to input in the helix of *economic system* which is the second subsystem referring to industry/industries, firm, services and bank. The helix focuses on the economic capital of a state like entrepreneurship, machines, products, technology and money. The input of new knowledge can develop opportunities for sustainable futureoriented, green economy, knowledge creation, new types of job, new green product and services, also new and decisive impulse for green and greener economic growth (Carayannis et al., 2012).

The natural environment as 3rd subsystem is crucial for a sustainable development and provides people with 'natural capital' such as resources, plants and a variety of animals. The goal of this helix should be to live in balance with nature, to develop regenerative technologies and to use available, finite resources sustainably and in a sensitive approach to form new green know-how for humans. This know-how as output of the subsystem of the natural environment can provide more environmental protection and quality of life to people. The development of new environmental friendly technologies can reduce the carbon dioxide (CO_2) emissions and can aid in diminishing climate change (Carayannis et al., 2012). Then the output is a green know-how (Barth, 2011).

The fourth subsystem, *media-based and culture-based* public, integrates and combines two forms of 'capital'. First, through the culture-based public such as tradition, and values which are forms of 'social capital'. Second, the helix of media-based public such as television, internet and newspapers contains also 'capital of information' such as news, communication and social networks (Carayannis and Campbell, 2010; Jonsson et al., 2015). Green know-how input should be spread through media especially information about a new green consciousness and the human lifestyle.

The political system, as a 5th subsystem, is also of crucial importance because it formulates the 'will', where the state is heading toward in the present and the future. This helix has a 'political and legal capital' such as ideas, laws, plans and politicians. The input of new knowledge in the political systems is necessary impulses for knowledge creation. The new output of knowledge and know-how of the political system leads across the circulation of knowledge back again into the *education, economic system, natural environment,* and *media-based and culture-based public*. (Carayannis et al., 2012).
It thus provides a step-by-step model to cover the quality and effective development, recover balance with nature and generate diversity on earth. (Barth, 2011) The QH innovation model has shown the socioecological transition where the natural environments of society and the economy also should be seen as drivers for knowledge production and innovation. That's why QH made possible a win-win situation between ecology, knowledge and innovation, creating synergies between economy, society, and democracy. Based on the discussion, the subsystem *education system* and *economic system* could be describing the relationship between U-I. The subsystem will be reflecting the impact of the economic, societal and environmental development based on knowledge creation and diffusion.

CONCLUSION

In summary, the QH Model demonstrates that investment on knowledge creation will have positive impact on all subsystems and on the society as a whole. Investment in knowledge and promotion of knowledge production make crucial impulses for innovation, know-how and the advancement of society. It is important to promote private financing of research, development, commercialisation and innovation by increasing access to private sources of financing, and developing a framework for risk mitigation and management of crowdfunding activities. U-I partnerships in Malaysia still requires a lot of efforts to foster effective collaboration for economic, societal and environmental development. A strong innovation ecosystem is important for the success of the urban development based on the innovation and knowledge.

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