THE RELATIONSHIP BETWEEN UNIVERSITY INCUBATORS, UNIVERSITY-INDUSTRY LINKAGES, FINANCIAL RESOURCES AND COMMERCIALISATION PERFORMANCE IN PAKISTANI UNIVERSITIES

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I dedicate this dissertation to my parents and family

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ABSTRACT

Commercialisation performance has emerged as an important objective of universities apart from teaching and research to contribute to the economic development. The main purpose for universities to engage in commercialisation of research is to generate revenue and to rely less on public funding. However, many universities are facing challenges to achieve the targeted level of commercialisation and showing low commercialisation output. Current literature reveals that university incubators and university-industry linkages can influence commercialisation performance. Nevertheless, there are a very few empirical studies on the effectiveness of university incubators and university-industry linkages for commercialisation performance. The study investigated the relationships of university incubators and university-industry linkages with commercialisation performance and the moderating effects of financial resources. A questionnaire-survey based on quantitative research design was used to collect data through multistage sampling procedure from 347 respondents of 118 tenant firms at ten Pakistani universities. Structural equation modelling (SEM) technique using AMOS 22 software was employed to test the validity of measurement and structural model of the study. Exploratory factor analysis and confirmatory factor analysis were used in testing the measurement model. The direct relationships between university incubators, university-industry linkages and commercialisation performance and interaction effects of financial resources were analysed in the structural model. The results of the study showed that university incubators and university-industry linkages have a positive relationship with commercialisation performance. Moreover, financial resources moderated the relationship between university incubators, university-industry linkages and commercialisation performance. Based on the findings of the study, it is suggested that university incubators and university-industry linkages can be stimulated with the provision of financial resources to raise commercialisation output. In addition, this study would be helpful for universities, government and industries to make strategic decisions to stimulate commercialisation performance at the optimum level for the benefit of society.

ABSTRAK

Prestasi pengkomersilan muncul sebagai objektif utama universiti selain daripada pengajaran dan penyelidikan dalam menyumbang kepada pembangunan ekonomi. Tujuan utama universiti untuk melibatkan diri dalam penyelidikan pengkomersilan adalah untuk menjana pendapatan dan untuk mengurangkan pergantungan terhadap pembiayaan awam. Walau bagaimanapun, banyak universiti menghadapi cabaran untuk mencapai tahap pengkomersilan yang disasarkan dan menunjukkan tahap pengkomersilan rendah. Kajian literatur sedia ada menunjukkan bahawa inkubator di universiti dan rangkaian universiti-industri boleh mempengaruhi output pengkomersilan. Walau bagaimanapun, terdapat beberapa kajian empirikal tentang keberkesanan inkubator universiti dan rangkaian universiti-industri terhadap pengkomersilan penyelidikan. Kajian ini mengkaji hubungan inkubator universiti dengan rangkaian universiti-industri terhadap tahap pengkomersilan, serta kesan penyederhanaan sumber kewangan. Tinjauan soal selidik berdasarkan reka bentuk penyelidikan kuantitatif digunakan untuk mengumpul data melalui kaedah pensampelan berbilang tahap daripada 347 orang responden dari 118 buah syarikat penyewa di sepuluh buah universiti Pakistan. Teknik pemodelan persamaan struktur (SEM) telah digunakan untuk menguji keesahan pengukuran dan model struktur kajian dengan menggunakan perisian AMOS 22. Analisis faktor penerokaan dan analisis faktor pengesahan digunakan dalam ujian pengukuran model. Hubungan langsung antara inkubator universiti dengan rangkaian universiti-industri terhadap tahap pengkomersilan, di samping kesan penyederhanaan sumber kewangan telah dianalisis dalam model struktur. Hasil kajian menunjukkan bahawa inkubator universiti dan rangkaian universiti-industri mempunyai pengaruh positif ke atas prestasi pengkomersilan. Selain itu, sumber kewangan mempunyai kesan penyederhanaan terhadap hubungan antara inkubator universiti, rangkaian universiti-industri dengan prestasi pengkomersilan. Berdasarkan dapatan kajian ini, dicadangkan agar inkubator universiti dan hubungan universiti-industri dapat dirangsang dengan penyediaan sumber kewangan untuk meningkatkan pengeluaran pengkomersilan. Di samping itu, kajian ini berguna kepada universiti, kerajaan dan industri dalam membuat keputusan strategik untuk merangsang pengkomersilan ke tahap optimum bagi manfaat masyarakat.

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LIST OF ABBREVIATIONS

AGFI	-	Adjusted Goodness of Fit Index
AMOS	-	Analysis of Moments Structures
ASEAN	-	Association of South East Asian Nations
AUTM	-	Association of University Technology Managers
AVE	-	Average Variance Extracted
BA	-	Business Angel
CFA	-	Confirmatory Factor Analysis
CFI	-	Comparative Fit Index
CIIT	-	COMSATS Institute of Information Technology
CMIN	-	Minimum Chi-square
CR	-	Composite Reliability
DF	-	Degrees of Freedom
EFA	-	Exploratory Factor Analysis
EU	-	European Union
GFI	-	Goodness of Fit Index
HE-BCI	-	Higher Education-Business and Community Interaction
HEC	-	Higher Education Commission
HEFCE	-	Higher Education Funding Council for England
HESA	-	Higher Education Statistics Agency
IBA	-	Institute of Business Administration
IP	-	Intellectual Property
IPO	-	Initial Public Offering
KMO	-	Kaiser-Mayer-Olking
LUMS	-	Lahore University of Management Sciences
MTDC	-	Malaysian Technology Development Corporation
NFI	-	Normal Fit Index

NGT	-	New Growth Theory
NUST	-	National University of Science and Technology
OECD	-	Organization for Economic Co-operation and Development
ORIC	-	Office of Research Innovation and Commercialisation
PCA	-	Principal Component Analysis
R&D	-	Research and Development
RBV	-	Resource-Based View
RMR	-	Root Mean Square Residual
RMSEA	-	Root Mean Square Error of Approximation
SEM	-	Structural Equation Modelling
SPSS	-	Statistical Package of Social Science
TLI	-	Tucker-Lewis Index
TTO	-	Technology Transfer Offices
UAF	-	University of Agriculture, Faisalabad
UBI	-	University Business Incubators
UET	-	University of Engineering and Technology
UI	-	University Incubator
UIL	-	University-Industry Linkages
UITSP	-	University-Industry Technology Support Program
UK	-	United Kingdom
UNITT	-	University Network for Innovation and Technology Transfer
UOG	-	University of Gujrat
USA	-	United States of America
UVAS	-	University of Veterinary and Animal Sciences
VC	-	Venture Capital

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CHAPTER 1

INTRODUCTION

1.1 Introduction

This chapter intends to explain the background of the research by focusing on the commercialisation performance of universities worldwide and especially in the Pakistani context. This section enlightens the issues relevant to commercialisation performance with the emphasis placed on University Incubators (UIs) and University-Industry Linkages (UILs). Moreover, the objectives of the research present the relationship of UIs and UILs with the commercialisation performance and moderating effects of financial resources. This chapter also covers the research questions addressed during the study. How this study helps the policy makers in government, universities, research institutes, and private investors to take strategic decisions about the adoption of financial policies favourable for UIs and UILs lead to commercialisation performance is also discussed.

1.2 Research Background

Over the years, the role of universities has been evolved. Initially, universities were focused on their traditional role of teaching and were responsible for educating a large part of population (Wang *et al.,* 2016). Later on, universities entered into the second phase having a dual role (i.e. teaching and research). During the second phase, universities were conceptualized to focus on promotion of research culture

apart from teaching (Casu and Thanassoulis, 2006; Worthington and Lee, 2005). However, the in-house development and external environment have indulged the universities to involve in the economic development apart from teaching and research (Etzkowitz *et al.*, 2000). During the last decade, the role of universities in the commercialisation performance has been argued worldwide to achieve economic development (Etzkowitz and Leydesdorff, 2000). Nowadays, universities are firmly recommended to produce consumable and saleable knowledge for rapidly commercialisation (Manathunga, 2017). Commercialisation performance of universities encourages economic development by facilitating the firms competitive advantage through the transformation of innovative ideas to products and services. The commercialisation of research from university to industry mutually benefits both to promote competitive economics (Cavaller, 2011). Specifically, many researchers agree with the argument that commercialisation is an effective means to stimulate economic development (Hewitt-Dundas, 2012; Ismail and Ajagbe, 2013; Wong *et al.,* 2007). The researchers acknowledge the contribution of commercialisation performance of universities in the components of economic development, such as unemployment, innovation and revenue generation (Audretsch *et al.,* 2013; Ismail and Ajagbe, 2013; Sugandhavanija and Sukchai, 2010; Welsh *et al.,* 2008). The initiative of entrepreneurial development through commercialisation helps to raise the employment opportunities in an economy (Braunerhjelm *et al.,* 2010). Indeed, the role of universities has evolved to contribute in the economic development of a country, still demanding better understanding of the success factors.

Nonetheless, two arguments are prevalent among the researchers regarding commercialisation activities. One school of thought believes that universities should focus on their fundamental objectives of teaching and research rather than involving themselves in the commercialisation of research (Bok, 2003). This approach also contradicts with the presence of intermediary institutions to support the commercialisation activities of universities (Cesaroni and Piccaluga, 2016). However, other researchers argue that universities should stimulate commercialisation activities by setting policies and procedures favourable for the benefit of the society and industry (Rasmussen *et al.,* 2006). The maximisation of social output has become crucial for universities due to the pressure of utilising public money and also to become self-sustainable (Markman *et al.,* 2008). The

knowledge generated at universities is not sufficient for the benefit of the economy until it is transferred to the society (Vinig and Lips, 2015). As a result, the involvement of society and industry becomes an area of concern for universities (Cesaroni and Piccaluga, 2016).

Several policies were also formed at the university and national level in taking initiatives to support research commercialisation. In the 1980s, a legislative reform was constituted by the United States of America (USA) to delegate the ownership and benefits of IPs to universities against the public grants (Grimaldi *et al.*, 2011). This most important and legislative policy reform, Bayh-Dole Act, has exhibited a noticeable change in commercialisation activities of universities (Rasmussen, 2008). Overall, this act helps in reducing the knowledge filter and promoting research and commercialisation activities (Audretsch, 2014). Furthermore, the contribution of this act in providing a guideline for strategic policy making and fostering commercialisation through university to the community is significant (Grimaldi *et al.*, 2011). Aaccording to the Association of University Technology Managers (AUTM, 2016), USA licensing activity survey FY2015 reported that new IPs were 15,953 in FY 2015 with an increase of 14.7% over FY2014. Similarly, 7,942 licenses were executed in FY 2015 with an increase of 15% over FY2014, and 1,012 new spin-off firms were created in FY2015 with an increase of 11.3% over FY2014. Apart from the USA, some other countries including both developed countries such as the UK, Finland, Germany, Denmark, Norway and developing countries such as China and Malaysia are also following the guidelines of Bayh-Dole Act (AUTM, 2014). Similarly, Pakistan has shown a progressive performance in commercialisation activities such as the number of patent applications increased from 46 to 146 during 2000-2014 (The World Bank, 2016a). However, these statistics are not satisfactory to compete and survive in the globally competitive world. Pakistani universities may need to be more efficient and sustainable in commercialisation activities for the economic development.

Another rationale for universities to get involved in commercialisation activities is to generate revenue (Siegel *et al.*, 2004). Many scientists support this idea of commercialisation of university research as being a revenue-generating

machine (Welsh *et al.,* 2008). Additionally, reliance on public funding and a threat of reductions in government budget is also mitigated by commercialising the university research results (Buenstorf, 2009; Landry *et al.,* 2013). For example, AUTM (2016) reported over $37 billion in cumulative licensing income generated in last 25 years and $2.5 billion only in FY 2015. Similarly, UK universities earned a revenue of £4.2 billion from commercialisation activities during year 2014/15 (HESA, 2016).

The revenue generated from commercialisation activities is shared between the inventor and the university, according to the terms that are generally specified by the university (Arqué-Castells *et al.,* 2016). In addition, such revenue from commercialisation activities lead to the development and sustainability of a university (Ahmad *et al.,* 2015) and thus promising to reduce their dependency on public funds (Buenstorf, 2009). Insufficient funding causes the universities to seek for additional revenue as to support the operational expenses of commercialisation activities (Ahmad *et al.,* 2015). More specifically, universities utilise such revenue to get the costly protection of IPs, to approach the industries for involving in research contracts and to support the creation and growth of university spin-offs (Molas-Gallart and Castro-Martínez, 2007; Sánchez-Barrioluengo, 2014). Thus, it reveals that commercialisation activities are amongst the important sources of revenue generation for universities.

The boost in commercialisation activities at universities is not restricted to the USA and European countries. Rather, commercialisation of research at universities is firmly acknowledged in the Association of Southeast Asian Nations (ASEAN) region as well. Singapore enjoys the strongest university-industry linkages to facilitate research commercialisation in the ASEAN region (Lee and Win, 2004) mainly due to the prominent role of Singaporean universities (Wong *et al.,* 2007). Malaysian universities also learned from Bayh-Dole Act (Ismail and Ajagbe, 2013). As a result, the Malaysian government aims to improve the national economy through accelerating research and development (R&D), and commercialisation activities at universities (Salleh and Omar, 2013). The budget allocated by the Malaysian government for commercialisation of research shows their concern. An amount of USD 54 million has been allocated for commercialisation activities in the 9th

Malaysia Plan (9MP) and USD 46.85 million in 10th Malaysia Plan (10MP) (MTDC, 2013). Another ASEAN country, Thailand has gained the knowledge from Silicon Valley model to commercialise their research output (Wonglimpiyarat, 2010). Accordingly, the Thailand government has initiated various policies targeting towards the promotion of R&D culture and commercialisation activities (Wonglimpiyarat, 2013b). Thus, it reveals that ASEAN countries have taken various initiatives and policies favourable for the success of commercialisation though still in their early stages.

Pakistani universities are also encouraged to play a dominant role in the production of new knowledge through teaching, research and commercialisation of their research to society (Mikulecký and Lodhi, 2005). However, university-industry linkage is the key means of university strengthening and commercialisation of research (Gul and Ahmad, 2012). Thus, productive efforts and commitment from all stakeholders including academicians, industrialist, government, and community can help to maximise the commercialisation of research. Besides, the research commercialisation may need intermediary channels to increase output (Ankrah *et al.,* 2013; Huggins, 2008). However, some researchers support the idea of the business incubation system and university-industry linkages being intermediary channels for commercialisation performance (Munkongsujarit, 2013; Santoro and Gopalakrishnan, 2001; Wonglimpiyarat, 2014a). Although business incubation system and university-industry linkages emerged as intermediary channels for commercialisation of universities' research, the effectiveness of these mechanisms still needs to be examined.

Commercialisation of research has become one of the primary objectives of the business incubation system of universities (Al-Mubaraki and Busler, 2013b; Bergek and Norrman, 2008; Hackett and Dilts, 2004). The business incubation system has been argued to contribute to economic development (Al-Mubaraki and Busler, 2013a; Bergek and Norrman, 2008). Earlier, the business incubation system has mainly focused on the provision of shared facilities and economical space. However, at the beginning of the 2000s and onwards, many other services such as networking, business development, and proactive support are also being offered

(Bruneel *et al.,* 2012). Nevertheless, the functions and services of business incubation systems needs to be reviewed for better performance.

On the other hand, the theoretical foundation of business incubation was laid down in 1959 in the USA (National Business Incubation Association, 2014a). Later on, the concept and its practical implementation spread to other countries in the world (Theodorakopoulos *et al.,* 2014). Meanwhile, several initiatives were taken in the 1980s and 1990s to contribute significantly towards stimulating business incubation. These initiatives include passage of Bayh-Dole Act for extending research commercialisation, the legislative framework for IP and revenue maximization through commercialisation (Hackett and Dilts, 2004). Thus, business incubation seems as a growing phenomenon.

Initially, most of the incubators were established at the universities or linked to universities (Mian, 1996). This association of incubators with universities resultantly helps to conceive a contemporary concept of university incubators (Etzkowitz, 2008). UIs are established in the universities based on the idea of the business incubation system (Cesaroni and Piccaluga, 2016; Phan *et al.,* 2005; Ratinho and Henriques, 2010). The development of UIs with similar missions rapidly increased in the late 1990s in the Asian region (Helen, 2008). UIs are among the important types of incubators due to their robust link with universities, researchers and management (Salem, 2014). The strategic outcome of university incubators does not restrict to financial sustainability for its own, but rather to generate resources for the university as well (Helen, 2008). Even though, incubators become emerging phenomena for universities over the period, still needs better understanding for the efficient performance.

On the other hand, UILs are esteemed to promote industrial development, enhance innovative capabilities, helps in poverty reduction, yield positive effect on teaching, bringing student closer to the university, improving the commercialisation performance of universities and economic development (Fiaz and Rizran, 2011; Johnston and Huggins, 2015; Muscio, 2013; Plewa *et al*., 2013a,b; Vaaland and Ishengoma, 2016; Wang *et al.,* 2016). Furthermore, the volume of UILs has

increased around the world (United Nations Educational Scientific and Cultural Organization, 2014).This is due to a competitive and innovative environment that indulges the universities and industries to create linkages with each other (Fischer et al., 2016). The escalation in UILs facilitated the universities to promote commercialisation activities (Muscio, 2013). The quality of linkages become more crucial than the quantity of connections (Fischer *et al.,* 2016). Concisely, the UIL has become an important factor for both universities and industries for their survival, growth and efficient contribution to the national economy.

However, some concerns exist regarding the importance of UILs. Firstly, some researchers argue that universities should focus on their traditional role of teaching and research rather than involving industries (Giuliani and Arza, 2009). Secondly, the measures of success of UILs vary in different phases. In addition, researchers suggested examining the UILs relationship with the outcome of both universities and industries (Plewa *et al.,* 2013a). Thus, it seems important to have a better understanding of university-industry linkages.

Several initiatives have also been introduced in Pakistan to promote the commercialisation of university research. These include the establishment of an Office of Research Innovation and Commercialisation (ORIC) at all universities and the introduction of Business Incubation Systems such as University Incubators (UIs) at major universities. Moreover, the strengthening of University-industry Linkages has been given a priority (HEC, 2015c).

1.3 Office of Research, Innovation and Commercialisation (ORIC) in Pakistan

Office of Research, Innovation and Commercialisation (ORIC) is an initiative of Higher Education Commission of Pakistan to promote the socioeconomic development through encouraging research environment and commercialisation. However, the commercialisation phenomenon is still in its early stage of development in Pakistan.

Currently, around thirty-seven ORICs are established at universities including nine at private Pakistan's universities with the aim to transform basic knowledge into innovative products and services. The idea of ORIC is to assist university's research in strategic and operational tasks for the overall society's well-being. ORIC also provides financial overhead cost of 15% of basic research projects for the purpose of its commercialisation (HEC, 2015a). Figure 1.1 shows the progress of ORICs over the years:

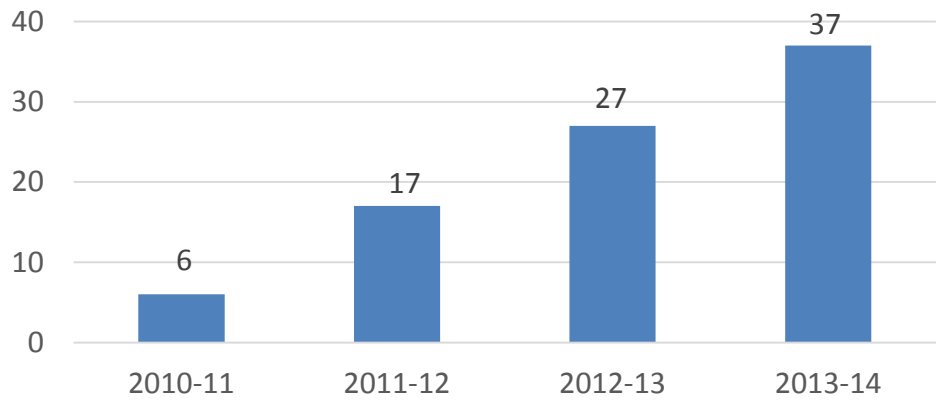

Figure 1.1: Number of ORICs in Pakistan (Year wise), Source: HEC (2015a)

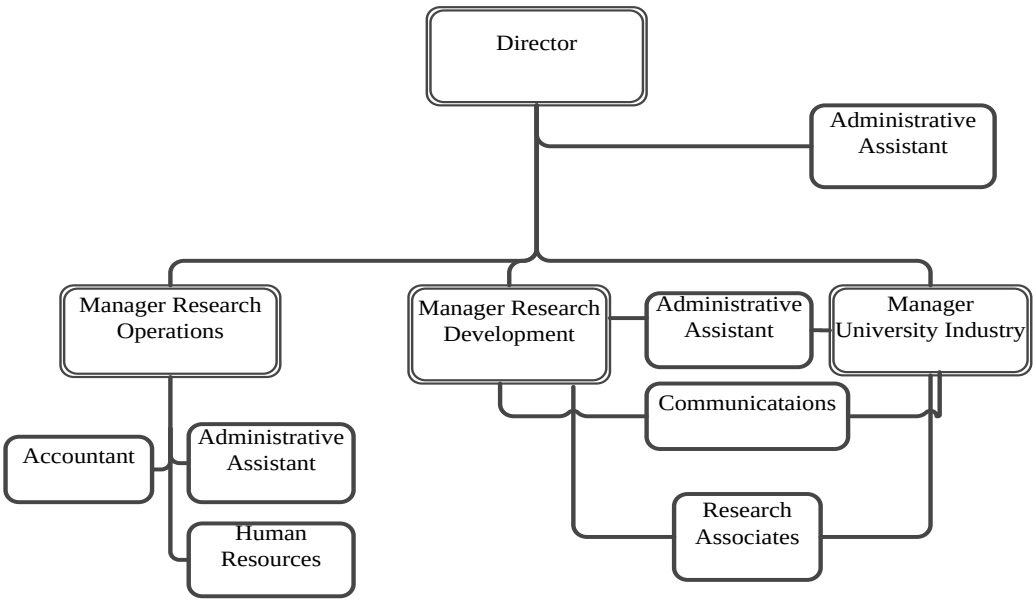

Figure 1.2: ORICs Organizational Chart in Pakistan, Source: HEC (2016)

Figure 1.2 shows the organizational chart of ORICs in Pakistan. The administrative structure of ORICs in Pakistan mainly comprises of director of the

ORIC and three managers categorized as research operations, research development and, technology transfer and university industrial collaboration. The Organogram (figure 1.2) seems reasonable for the initial stage of commercialisation activities. However, the evolvement of commercialisation activities at universities may need to enhance this Organogram.

1.4 Business Incubation System in Pakistani Universities

The business incubation system is at the initial stage of development in Pakistani universities. However, an initiative for the establishment of university incubators is undertaken to promote the business incubation mechanism. HEC (2015b) has laid down the objectives of establishing the university incubators in Pakistani universities. These objectives include stimulating the commercialisation culture, promoting and facilitating research, nurturing the formation of spin-off firms and creating an entrepreneurial society.

The government of Pakistan is incentivizing the incubation system to attract the international stakeholders. Initially, IT industry is being targeted to achieve this purpose. These incentives include low rent, 100% equity, income tax exemption, minimum depreciation rate, easy and economical internet access (PSEB, 2015). Local bodies such as HEC, Pakistan Software Export Board, Ministry of Science and Technology Pakistan, and many universities are interested in establishing and strengthening the incubation system in Pakistan. Even International organizations such as World Bank, World Technopolis Association and International Finance Corporation are also enthusiastic to promote the development and growth of incubation system in Pakistan (Hashmi and Shah, 2013). Thus, Pakistani universities are now focusing to establish and grow the business incubation system through UIs. One example of this is the financial support that HEC has provided to UIs over the period of 5 years as presented in Figure 1.3:

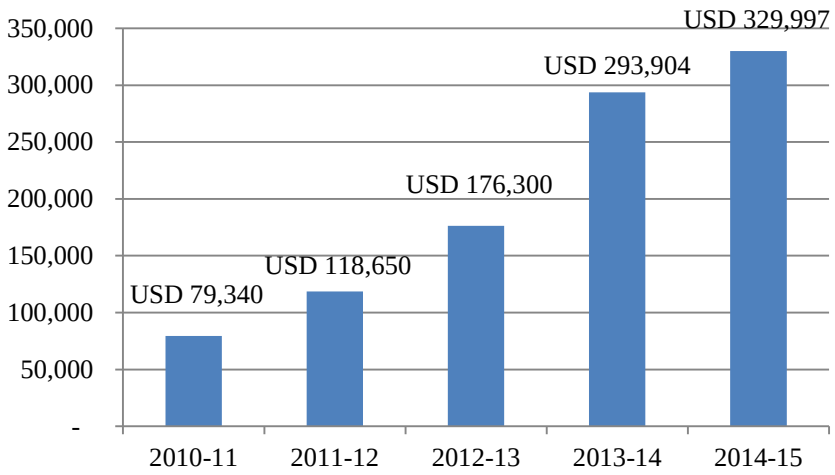

Figure 1.3: HEC's Financial Support to University Incubators in Pakistan
Source: HEC (2015b)

Figure 1.3 shows that the financial support for UIs has increased from USD 79,340 in FY 2010-11 to USD 329,997 in FY 2014-15. This indicates a positive trend for the support of UIs. The focus of the government is also diverting towards this concept.

1.5 Problem Statement

Universities are struggling to achieve the expected level of commercialisation performance even in developed economies (Huggins, 2008). Similarly, economies with high research output are also facing the problem of low commercialisation rate (Vinig and Lips, 2015). Moreover, the heterogeneity in commercialisation rate is not restricted, rather its spreads across universities (Vinig and Lips, 2015). The reasons for the lack of commercialisation performance include: current knowledge is not being fully commercialised and universities are not commercialising their research at the best level (Mueller, 2005). Rather, universities are more focused on basic research and less attentive to commercialisation activities (Sideri and Panagopoulos, 2016). This despite leads to low commercialisation performance that results in significant pressure on university budget as well (Ito *et al.*, 2015). In the developing countries context, Wonglimpiyarat (2014b) observed the low commercialisation output rate in Thailand while Hutabarat and Pandin (2014) found the same in

Indonesia. Another developing country, Russia is also facing the challenges of converting the university research into saleable products for commercialisation (Carayannis *et al.,* 2016). More or less, the same context prevails in Pakistan as the commercialisation performance of universities' research is very low (Haq *et al.,* 2014). In Pakistan, universities are found weak in their efficient role for commercialisation performance instead, they are more focused on the traditional role of teaching (Saeed *et al.,* 2015). The antecedents of such a situation include several challenges and hurdles; Pakistan is facing for commercialisation of research (Noor *et al.,* 2014). Thus, improving the commercialisation performance seems the growing concern for the universities.

Internationally, governments have taken several initiatives to promote commercialisation at universities by enhancing R&D investment (Huggins and Kitagawa, 2012). Even so, it is not sufficient to fulfil the purpose. Rather, researchers suggested the induction of intermediaries as key facilitators to improve the commercialisation performance (Ankrah *et al.,* 2013; Huggins, 2008). Wonglimpiyarat (2014a) supported university incubators as an intermediary to improve the commercialisation performance. From a resource-based view, UIs add value to the resources of universities (Rothaermel and Thursby, 2005b; Somsuk and Laosirihongthong, 2014). However, uncertainty exists about whether incubators achieve their specified goals (M'Chirgui *et al.,* 2016). Many universities of the world still lack experience of establishing and operating UIs (Wann *et al.,* 2017). Moreover, UIs are suffering from several challenges to stimulate commercialisation performance. Grimaldi and Grandi (2005) identified the main problems UIs have to face are 1) Insufficient funding 2) lack of management expertise and 3) operational support for daily functions. Thus, it reveals that the interaction of UIs and financial agents to sort out the issue of access to funding remained less attentive. In addition, lack of financial resources confines the efficacy of incubation systems (Chandra *et al.,* 2007; Wonglimpiyarat, 2016). The consensus on the collaboration of incubators and a financial agent such as venture capitalists towards contribution in spin-offs development remains scarce due to diversified results (Chen, 2009). In Pakistan, UIs are also struggling due to financial constraints and lack of integration with university environment (Salman and Majeed, 2009). These challenges may lead to failure of incubation model.

On the other hand, the output of university-industry linkages are often not as good as expected (Lai and Lu, 2016). Besides, university-industry linkages are also struggling to contribute to the commercialisation performance of universities (Plewa *et al.*, 2013b; Welsh *et al.*, 2008). Regarding commercialisation of research, Giuliani and Arza (2009) argued that some UILs are more productive than others are. Similarly, in Pakistan, weak linkages have been found between the university and industry (Khan and Anwar, 2013). UILs are struggling to stimulate the commercialisation in Pakistan (Kirmani *et al.*, 2014). Hence, this raises the concern to have a better understanding of UILs for improving the commercialisation performance. To identify these challenges, researchers observed underinvestment in UILs as a major constraint in the way of commercialisation (Franco and Haase, 2015; Hamdan *et al.*, 2011; Patarapong and Schiller, 2009; Schiller and Liefner, 2007). Universities especially in developing countries are encouraged to get involved with industries (United Nations Educational Scientific and Cultural Organization, 2014). In a developing economy like Pakistan, the importance of the development of UILs for commercialisation through university platform to promote competitiveness, regional and national innovation is imperative (Gul and Ahmad, 2012; Hashmi and Shah, 2013). This leads to assert that the better understanding of UILs with respect to commercialisation performance is needed.

Furthermore, the turning of research idea into the market place has to go through various stages of commercialisation and financial resources are needed to cross the "valley of death" (Nätterlund and Lärkert, 2014). Valley of death is the transitional period when financing conditions deteriorate most due to government and private finance policy (Ford *et al.*, 2007; Markham, 2002). Financial resources at the valley of death are required at a level that is even multiple times greater than the basic research (Cao *et al.*, 2013). The transition of government R&D investment into developing technology or making prototypes has to face troubles (Jung *et al.*, 2015). According to a report of House of Commons (2013), the challenge is to ensure that appropriate types of finances are available at all stages of commercialisation for their best usage. Thus, the availability of financial resources appears as one of the important aspects for crossing the valley of death.

Indeed, availability of financial resources is an important component for a better commercialisation performance of universities (Lee and Osteryoung, 2004; Wonglimpiyarat, 2014b). In addition, researchers suggest the studying of financial resources for the efficacy of commercialisation output (Croce *et al.,* 2013; Sánchez-Barrioluengo, 2014). Whereas, a lack of financial resources also influences the performance of incubators (Chandra *et al.,* 2007; Grimaldi and Grandi, 2005). Consequently, this demands a compatible model as a research call to improve the efficiency of UIs (Chen, 2009). Similarly, researcher have highlighted that UILs are facing several challenges including lack of financial resources (Patarapong and Schiller, 2009; Sofouli and Vonortas, 2007). In another study, financial resource have been claimed to facilitate the development of strong UILs for improving the commercialisation performance of universities (McAdam *et al.,* 2012). As a result, the research to address the financial constraints of UIs and UILs, and to suggest the funding policy for commercialisation performance of universities becomes an area of concern. A three-way interaction seems feasible to provide better understanding and new insights about the strategies of financial resources. Financial resources have been used as successful moderator (Chen, 2009; Cho and Lee, 2013; Wiklund and Shepherd, 2005). However, access to financial resources can mitigate the issue of resource constraints in other areas as well (Wiklund and Shepherd, 2005). The contribution of financial resources towards enhancing the commercialisation performance of universities through UIs and UILs also demands the attention of researchers. Thus, financial resources are conceptualised in this research as a moderator between the relationships of UIs with the commercialisation performance of universities and UILs with the commercialisation performance of universities.

Primarily, the financial resources available for university incubators and university-industry linkages that lead to commercialisation performance are government grant, business angels' investment, venture capital, loans from banks and internal financial services (Chandra *et al.,* 2007; Chandra and Silva, 2012; Somsuk and Laosirihongthong, 2014; Wonglimpiyarat, 2013a,b). Some researchers focus on a single financial source for commercialisation (Bertoni *et al.,* 2011; Langeland, 2007). However, it seems unfitting for the long run sustainability to stand on a single financial pillar. Government grant alone is not enough to bring the research idea to the market place (Chandra and Silva, 2012; Wonglimpiyarat, 2013) Hence,

researchers argue the provision of multiple financial sources (Bonnet and Wirtz, 2012; Huggins and Kitagawa, 2012; Zane, 2011). The lack of financial resources such as angel financing and venture capital financing also restricts the process of efficient commercialisation (Wonglimpiyarat, 2014b). Thus, the integration of public and private sector to commercialise university knowledge and R&D into an economic return is encouraged (Huggins, 2008). Furthermore, a better financial capital scheme is demanded to support professionals for a proficient commercialisation output (Bozkaya and Potterie, 2008; Grimm and Jaenicke, 2012). Simply, financial resources from both public and private sectors support the commercialisation performance.

Pakistan is looking forward to become a knowledge-based economy (Planning Commission, 2014). Researchers have emphasized that the government policy makers should initiate actions for economic development (Gul and Ahmad, 2012; Rahman *et al.,* 2005). However, Pakistan faces the problem of lack of availability of financial resources (Afzal *et al.*, 2014; Haque, 2007; HEC, 2011; Shakeel and Khan, 2008). As a result, other sources are required to identify with activation of existing ones for an attractive and sustainable financial model. Although incubators in Pakistan are acknowledged as a public policy tool (Shahzad *et al.,* 2012), they still lack empirical examining as compared to other developing countries such as India, Malaysia, Thailand.

In addition, it seems unclear whether university incubators and university-industry linkages are essential to improve the commercialisation performance of universities. This is despite several indications in the literature that some university incubators and university-industry linkages are more successful than others (Huggins and Strakova, 2012; M'Chirgui *et al.*, 2016; Mian, 2014; Vaaland and Ishengoma, 2016; Wann *et al.,* 2017). Besides, researchers have emphasized to study the incubators due to its promising future and rich opportunities of research (Mian *et al.,* 2016). Furthermore, the availability of financial resources might influence the performance of university incubators and university-industry linkages (Lai and Lu, 2016; Somsuk and Laosirihongthong, 2014; Wonglimpiyarat, 2016). Finally, the relationship may very especially for developing countries such as Pakistan. Thus,

suggests to examining the factors for improving the commercialisation performance of universities. In particular, this study examines the relationship of university incubators and university-industry linkages with commercialisation performance and the moderating role of financial resources.

1.6 Research Questions

This study aims to answer the below questions

1. What is the relationship between university incubators and commercialisation performance of Pakistani universities?
2. What is the relationship between university-industry linkages and commercialisation performance of Pakistani universities?
3. Do financial resources moderate the relationship between university incubators and commercialisation performance of Pakistani universities?
4. Do financial resources moderate the relationship between university-industry linkages and commercialisation performance of Pakistani universities?

1.7 Research Objectives

The following research objectives are the essence of this study

1. To investigate the relationship between university incubators and commercialisation performance of Pakistani universities.
2. To investigate the relationship between university-industry linkages and commercialisation performance of Pakistani universities.
3. To investigate the moderating effect of financial resources between the relationship of university incubators and commercialisation performance of Pakistani universities.

4. To investigate the moderating effect of financial resources between the relationship of university-industry linkages and commercialisation performance of Pakistani universities.

1.8 Scope of the Study

Universities are acknowledged as significant contributors to economic development (Audretsch, 2014; Miller *et al.,* 2016). Many of the universities involve in commercialisation activities to generate revenue and to transfer the benefits of research to society. In the existing scenario, university incubators and university-industry linkages become crucial to stimulate the commercialisation performance of universities. Specifically, the current study focused on university incubators, university-industry linkages, financial resources and commercialisation performance of Pakistani universities. The direct relationships of university incubators and university-industry linkages with commercialisation investigated in the study. Moreover, the study examined the moderating effect of financial resources between the relationship of university incubators and university-industry linkages with commercialisation. The theoretical framework of the study based on new growth theory and resource based view theory. The respondents of the study are senior management as representatives of the incubatee firms at Pakistani universities. The target population of the study is all universities in Pakistan that have incubatee firms.

1.9 Significance of the Study

A review of literature revealed that commercialisation performance of universities has been a critical agenda for the last decade both for researchers and policy makers. The commercialisation of research benefits the university, industry, government and society in the way of revenue generation, innovation, economic development and social well-being (Miller *et al.,* 2016; Wonglimpiyarat, 2014b). The understanding and implications of financial policies are important to overcome the valley of death. Furthermore, university incubators and university-industry

linkages are crucial to ease the commercialisation activities by ensuring infrastructure facilities and creating linkages with industries (Santoro and Bierly, 2006; Wonglimpiyarat, 2014a, 2016). However, financial resources might improve the effectiveness of university incubators and university-industry linkages for successful commercialisation performance, intellectual property, research contracts, and spin-offs.

This study contributes both theoretically and practically. Theoretically, the current study examines the relationship of university incubators, university-industry linkages and commercialisation performance using financial resources as moderator. This study contributes to the new growth theory and resource based view theory. Practically, this research is beneficial for improving the university-industry linkages and for strengthening the role of university incubators in commercialisation. Pakistani universities with good commercialisation performance would help to generate revenue for their self-sustainability and would ultimately contribute to economic development. Therefore, this study enlightens academicians, professionals and bureaucrats to take strategic decisions about the adoption of financial policies favourable for UIs, and UILs, and leads to successful commercialisation performance.

1.10 Limitations of Study

UIs and UILs are the new phenomena for developing countries, especially Pakistan. Specifically, this study provides new insights of university incubators, university-industry linkages, financial resources and commercialisation performance in Pakistani universities. The study is cross-sectional though relying on the research problem for a particular period. The current study investigates direct and moderating effects among the variables but not reciprocal relationship. In a geographical context, this study is limited to Pakistan due to its significant knowledge gap with respect to its inefficient commercialisation performance, and time and cost constraints.

1.11 Operational Definition of Terms

This study focuses on the commercialisation performance of universities under new growth theory and resource-based view approach. This section explains the operational definitions of the variables of interest for a clearer understanding of the concept.

1.11.1 Commercialisation Performance

Commercialisation is the exploitation of academic research through formal mechanisms such as intellectual property, research contracts, licensing and spin-offs (Cesaroni and Piccaluga, 2016). Based on the literature review, the current study operationalized the commercialisation performance as a mechanism of intellectual property, research contracts and spin-offs.

1.11.2 University Incubator (UI)

The university incubator is an incubator set up by the university to provide office space, equipment, mentoring services as well as other administrative supports to assist the formation of new ventures (Wonglimpiyarat, 2016). The current study conceptualized the university incubators as a mechanism to provide the infrastructure facilities, networking, human and technical expertise, faculty and student, and institutional reputation to the incubatee firms.

1.11.3 University-Industry Linkages (UIL)

UILs is linkages between university and industry entities, established to enable diffusion of creativity, ideas, skills and people with the aim of creating mutual value over time (Plewa *et al.*, 2013,b). In the current study, these linkages reflect in

the form of trust, understanding and communication between university and industry, geographical proximity to the university and, research and development of the university.

1.11.4 Financial Resources

Financial resources is the provision of money to run efficiently and manage the business operations to promote success through either borrowing, equity or revenue (Dollinger, 2008). The current study conceptualized the financial resources as the sources of funding available to tenant firms at universities in the form of government grant, business angels (BAs), venture capitals (VCs), banks and in-kind financial support.

1.12 Outline of the Thesis

The outline of the thesis explains five chapters. The remainder of the thesis is as follows. Chapter 2 highlights the key literature of commercialisation, university incubators, university-industry linkages and financial resources that are pertinent for the formulation of the model. The literature review of university incubators and university-industry linkages helped to identify the key factors that affect the commercialisation. The chapter discusses the rationale of financial resources as a moderator. The pertinent theories, new growth theory and resource-based view theory, are discussed in the light of the model. Hypotheses of the study have been formulated to address the research questions and to achieve the objectives. In the final section, the conceptual model developed from previous literature is presented.

Chapter 3 presents the research design with information on data collection methods, techniques and procedures. Firstly, the population, unit of analysis, sample size, sampling procedure and measurement instrument are elaborated. Subsequently, the chapter presents the explanation of the measurement model along with convergent and discriminant validity. The next section discusses the structural model

used to measure the interrelationship between the constructs. Finally, the last section explains the interaction effect of the moderator between the exogenous and endogenous variables.

Chapter 4 explains the analyses and findings of the collected data. The researcher used Statistical package for the Social Sciences (SPSS) to process the collected data and AMOS for Structural Equation Modelling. In the first section, data filtration, normality and outliers were analysed. Afterwards, the common method bias was tested. Then, the researcher conducted the SEM for the measurement model along with validation tests. In the last section, structural model of the study were tested.

Finally, chapter 5 focuses on summarizing the empirical results and discussing the findings of the study. In the first section, the research process of the study is explained. Then, the chapter discusses the findings of the study based on each research question to achieve the objectives. Next section explains the theoretical, policy and managerial implications along with contributions to the study. Finally, future recommendations and conclusion of the study are provided. .

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