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¿Es importante la colaboración universidad-industria para la innovación?

Does University-Industry Collaboration Matter for Innovation?

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RESUMEN.

El objetivo del estudio es examinar el impacto de la colaboración universidad-industria sobre la capacidad de innovación. Este estudio se ha basado en datos sobre países recopilados a través de los informes anuales de Competitividad Mundial publicados por el Foro Económico Mundial. A diferencia de estudios anteriores, utilizamos datos cruzados de 112 países (países desarrollados y en vía de desarrollo) en diferentes regiones (África, Asia, Europa, Oceanía, América del Norte y América del Sur) desde 2006 a 2015. Medimos la innovación como la capacidad de innovación del país y las relaciones universidad-industria como colaboración entre universidad-industria en I + D. Después de utilizar diferentes variables de control (gasto en I + D de la empresa, extensión de la capacitación del personal, tasa de matriculación en la educación, producto interior bruto, IED y transferencia de tecnología y adquisición gubernamental de tecnología avanzada), las estimaciones de regresión sugieren que la colaboración universidad-industria tiene un impacto estadísticamente significativo en la capacidad de innovación del país. Además, los países con fuertes relaciones universidad-industria tienen una mayor capacidad de innovar, en comparación con países con una relación universidad-industria débil. Asimismo, también encontramos que el impacto de la relación universidad-industria sobre la capacidad de innovación es mayor en los países en vías de desarrollo que en los países desarrollados. Todos los resultados anteriores derivan de una comprobación robusta para la cual se han empleado diferentes índices para medir la colaboración universidad-industria y encontrar resultados consistentes.

PALABRAS CLAVES.

Colaboración universidad-industria, capacidad de innovación, países desarrollados, países en desarrollo.

ABSTRACT.

The objective of study is to examine the impact of university-industry collaboration on capacity for innovation. This study relied on country level data collected through annual Global Competitiveness Reports published by World Economic Forum. Dissimilar to earlier studies, we use cross-country panel dataset of 112 countries (developed and developing countries) across different regions (Africa, Asia, Europe, Oceania, North America, and South America) with time frame from 2006 to 2015. We measure innovation as country's capacity for innovation and university-industry relationship as university-industry collaboration in R&D. After using diverse range of control variables (company R&D spending, extent of staff training, education enrollment rate, gross domestic product, FDI and technology transfer, and government procurement of advanced technology), OLS regression estimates suggest that university-industry collaboration in R&D has positive and statistically significant impact on country's capacity for innovation. Moreover, countries with strong university-industry relationship have higher impact on capacity to innovate as compare to countries with weak university-industry relationship. Interestingly, we also find that the impact university-industry relationship on capacity for innovation is higher in developing countries as compare to developed countries. All above estimated results are further robust check by using diverse proxies of university-industry collaboration, and find consistent results.

KEY WORDS.
University-Industry Collaboration, Capacity for Innovation, Developed Countries, Developing Countries.

1. Introduction.

Innovative entities are engaged in the system of strategic associations (technological/scientific connections), through which they can attain competitive edge over market rivals (Owen-Smith & Powell, 2004). In current knowledge based and highly competitive economies, entities have to explore new knowledge sources to become innovative and successful. Yet it is extremely hard for entities to discover new technologies solely by their own, because of limited knowledge, resources and expertise. Nowadays, universities are considered as a key source for creative knowledge (Scandura, 2016), which can satisfies consumers' demands and enhances industrial innovations (Guan & Zhao, 2013). In other words, the process of knowledge exchange between university and industry, is a crucial way to convert science (ideas) into marketable innovation (reality) (Publishing, OECD., 2002). Along with innovation, university and industrial collaboration also has capability to convey economic development, through generating knowledge and talent (Brundenius et al., 2009; Jauhari et al., 2013). Such collaboration can be elaborated as bi-directorial collaboration (among university and industry), which enables idea creation, technology diffusion and mutual alliance (Plewa et al., 2013).

Industrial innovation is widely associated with firms' skills to grasp external knowledge, information and technologies. The most recent tendency among industrial innovative performance is due to active R&D collaboration between firms and institutions (other firms, customers, suppliers, research organizations, academia etc.) (Fritsch & Lukas, 2001; Tether, 2002). Such associations can be evaluated by three approaches. Firstly, transaction cost approach suggests that R&D cooperation reduces cost and risk, because of shared projects and skills. Secondly, strategic management approach advocates that co-operative attitudes help to attain more resources and consequently competitive edge. Thirdly, industrial organizational approach recommends that R&D collaboration facilitates knowledge and technology spillover (Segarra-Blasco & Arauzo-Carod, 2008). Entities can perform such collaboration with many counterparts (other firms, competitors, suppliers, and customer). But among all, academic institutions have unique status due to diverse research groups and potential (Huang & Chen, 2016; Lin, 2016; Santoro & Chakrabarti, 2002).

Universities are important source for human capital development (D'este & Patel, 2007; Huang & Chen, 2016). Separately from their traditional purposes (teaching and research), academic institutions play versatile role in knowledge transformation and technology spillover. On the bi-directorial collaboration (as mentioned above), knowledge generally moves from academia to industry, because academic institutions perform knowledge development and industrial sector converts those knowledge into marketable products (Maietta, 2015). University industrial relationship can be derived by various means of knowledge transfer (Azagra-Caro et al., 2017; Fernández-Esquinas et al., 2015; Mowery, D. & Sampat, 2005). Some of them are:

- Decisions and workshops
- Informal summits
- Combined R&D ventures
- Appointments of academic graduates
- Licensed academic patents
- Mutual publications
- Training and seminars
- Research consultancy and contracts
- New industrial units by academic associations

Various researchers explain multiple channels through which academic institutions impact on industrial innovation (as describe above). Even though the significance of academic institutions, but only few information regarding university-industry relationship are available (Conti & Gaule, 2008). Numerous past studies discuss university-industry relationship, but most of them use cross sectional data, usually collected through survey techniques (Jack et al., 2012; Vaaland et al., 2016). Such kind of data mainly focused on size or existence of academic institutions and their impact on innovational activities. These studies presented strong relationship among above stated indicators. But actually, it is quite difficult to withdraw robust conclusions and policy implications based on cross sectional data, for a phenomena which happens overtime. Traditionally, the knowledge drifts from university to firm naturally in developed economies. Because of intensive competition and consumer demands, firms have to look forward for more radical knowledge, which are usually found at academia (Freeman, 1992). However in emerging countries, relationship between universities and industries are still in growing phase, because of slow development in academia and industrial sector.

The aim of current study is to determine the impact of university-industry relationship on innovation. More specifically, this study fills the existing gap by using rich dataset, which contains cross country panel data of 112 countries with the time span of 10 years (2006-15). Furthermore sample countries are segregated into developed and developing countries. We measure innovation as country's capacity for innovation and university-industry relationship as university-industry collaboration in R&D. We also use diverse range of control variables (company R&D spending, extent of staff training, education enrollment rate, gross domestic product, FDI and technology transfer, and government procurement of advanced technology) together with country fixed effect and robust standard error technique. All above mentioned variables are gathered by using Global Competitiveness Reports issued by World Economic Forum.

Regression results propose positive and statistically significant impact of university-industry collaboration in R&D on country's capacity for innovation. Moreover, countries with strong university-industry collaboration have greater impact on capacity to innovate as compare to countries with lesser university-industry collaboration. These outcomes recommend that university-industry collaboration contributes in human capital development, minimizes cost of innovation, reduces risk of projects and enhances competencies. Furthermore, we also find that the impact university-industry relationship on capacity for innovation is higher in developing countries as compare to developed countries. These results elaborate that contrary to developing countries, developed countries have diverse means to foster innovative capacity e.g. technological transformation offices, research organization, technological parks etc. All above estimated results are further robust check by using different proxies of university-industry collaboration, and find similar results.

This study is organized as follows; section 2 elaborates related review of literature. In section 3, hypothesis development is discussed. Section 4, deals with study methodology in terms of data sources, variables measurement, and empirical modeling. In section 5, we present empirical evaluation and discussion of results. Lastly, section 6 contains concluding remarks and policy implications.

2. Literature review.

Although, research work on innovation grows rapidly nowadays (Chang, 2017), but sill the fundamentals of all innovation are based on Schumpeter study, in which he presented a theoretical evidence that innovation, and other social factors behind it, are the mainspring of economic growth (Fagerberg et al., 2012). Such innovations are depicted as vigorous force, which continuously transform formal and informal structure, and economic development. On the bases of that initial work of Schumpeter, innovation can be divided into product, organizational and process innovation. In the same line, OECD. (2002) described innovation as new or improved product/process, marketing technique, organizational structure, and workplace relations. Strategy builders vastly observe academic intuitions as instrument of economic development, because they create and commercialize intellectual property via technological transformation, joint collaborations, and academia startups (Siegel & Phan, 2005).

Many studies explored the participation of academic institutions to foster innovation among industrial entities. Among these studies, mostly are directed by Mowery, D. C. et al. (2004) and Mowery, D. and Sampat (2005) in USA and other international corporate environment. Contrary to the general assumption about university industry relationship among developed countries, Cohen et al. (2002) only found slight evidence of academic research to foster business R&D schemes among USA corporate environment. Furthermore, in a study from developed countries like US, European countries, and japan, Hershberg et al. (2007) observed weak and insignificant association between academic institutions, local firms and new startups. However, Scandura (2016) investigated the association between university-industry relationship and firm level R&D among firms operating in United Kingdom. Author hypothesized, positive relationship among academia-industry collaboration and innovation. By using control group and robust analysis, outcomes of the study presented positive and statistically significant association among aforementioned indicators.

Heading towards university industry relationship among emerging countries, Brimble and Doner (2007) evaluated such environment among Thai industries. Similar like previous studies on developed countries, results revealed that Thai academia displays no enhancement for university industry linkage. The reason for such relationship, was due to the lack of research environment in academic institutions among developing countries. However, Meredith and Burkle (2008) found positive relationship among university-industry liaison to attain shared advantages in Mexican corporate environment. Consistent results are found by Gagoitseope and Pansiri (2012) and Egbetokun (2015) from Botswana and Nigeria respectively. Egbetokun (2015), suggested that young individuals are more involved in managerial and entrepreneurial innovation as compare to old one.

In a study on newly industrialized economies, Freitas et al. (2013) explored the impact of university industrial linkage on innovational expansion among developed and developing industries. To observe such relationship, study used 24 examination clusters of sciences and industrial academic departments, along with public research institutes. Outcomes advocated that university-industry relationship is different among developed and developing industries. Differ from developed industrial environment, developing industries are characterized as weak flow of knowledge and lack of availability of funds for innovative projects. Moreover in recently industrialized economies, government plays a significant role to foster university-industry link and consequently innovation (OECD, 2010). Strategy makers in developed and recently industrialized economies, struggling hard to design strategies that can help to foster the role of academic and research institutions in technological innovative activities (Wong et al., 2007).

Cowan and Zinovyeva (2013), empirically evaluated the impact of increase in academic institutions on innovation among 20 Italian regions for the time span from 1984 to 2000. Results showed that expansion in academic institutions foster regional innovation and patents. These results confirmed that newly established academic institutions bring knowledge and research, which subsequently foster innovation and patent activities. These results were consistent with the study of Jack et al. (2012). In that research Jack et al. (2012), examined the relationship among higher academic institutes and open innovation among firms operating in UK. Results found diverse linkages of firms with academic institutions based on firm location and type. Perkmann and Walsh (2007), also analyzed industry-university relationship in terms of open innovational environment. Authors concluded that such relationship needs to be evaluated more deeply and fundamentally.

Technological transformation workplaces are the key sources to establish university and industry cooperation. In the same way, R&D contracts between academia and industry create win-win situation for both of them. To explain such phenomena, Berbegal-Mirabent et al. (2015) inspected the impact of structural and formal characteristics to explain university-industry cooperation in Spain. The results specified that R&D agreements relay on academic institutions and technological transformation workplaces. These results were in-line with the study of Lu et al. (2008), which explored the impact of technological transformation agencies as a dynamic force to transmit knowledge and expertise from academic institutions to industry. Results of the study demonstrated that technological transformation agencies are the primary source through which firms can create and commercialize innovation and earn surplus profits.

Segarra-Blasco and Arauzo-Carod (2008), determined the factors which have an impact on university-industry partnership among Spanish corporate environment. Authors broadly estimated determinants that effect on five types of partnership i.e. entities from similar group, clients and contractors, opponents, academic institutions, and research organizations. More specifically, study concentrated on the factors effecting R&D coordination within innovative organizations and academic institutions. Final results revealed that industry and firm specific factors have deep impact on above stated coordination. In the same way, Maietta (2015) also scanned the factors which govern the firm-academic R&D cooperation, and meanwhile the elements that have an impact on innovation among low technological industries. By utilizing exclusive dataset consisted of "Capitalia Survey" and other academic data sources, results proposed that firm-academia R&D cooperation impact on process innovation. However, geographic location of university has positive and classified information has negative impact on product innovation.

In the most recent studies, Lin (2016), evaluated the impact of industrial linkage to foster innovation output. By using dataset of 110 American academic institutions over 19 years, results confirmed curvilinear relationship among industrial linkage and innovation. In the same mode, Azagra-Caro et al. (2017), examined formal and informal ways of academia-industry relationship and its impact on local economy. Outcomes of the research revealed that both formal and informal networks are important for knowledge transfer, which subsequently induces innovation in terms of patents. Chen et al. (2016), also found that industry-academia relationship accelerate innovation among Biotechnological firms. Vaaland et al. (2016), examined the relationship between university-industry linkage and innovation among developing countries. To examine such interaction, researchers used survey based analysis technique. Overall 404 respondents were approached and multinomial logit regression model was used. The results revealed that, university industry linkage is the key to enhance innovation among developing nations. More specifically, outcomes suggested that such collaboration among university and industry is higher in terms of student-industry closeness, faculty consultancy and research arrangements.

3. Hypothesis Development

Procurement of knowledge form outside of the organization is essential for innovational activities. Contemporary studies on innovation spillover identified that organizations can't merely depend upon inner knowledge to innovate new products/processes (Frenz & Ietto-Gillies, 2009), but they have to acquire knowledge from outer world. Influential research of Griliches (1984) and Adams (1990), exposed the function of academic knowledge for industrial innovation. Additionally, it is also confirmed that relationship between academic institutions and organizations is helpful to minimize cost of research projects, distributes associated risk and enhances competencies (Li, 2000).

According to researchers, academic institutions play an important part to enhance the ability to innovate (Alves et al., 2007; Ball, 1995). Similarly, administration in industrialized economies have introduced several ways to boost academia-industry collaboration, such as: technology parks, business collaboration units, capital venture funds etc. (Mowery, D. & Sampat, 2005). In line with aforementioned arguments, it can be observed that collaboration

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between academic institutions and industrial organizations are the fundamentals to enhance innovation and economic growth (Fernández-Esquinas et al., 2015; Hansen & Lehmann, 2006). Industrial organizations are the prime sources of innovation, which network with other partners (other entities, institutions) (Lorentzen & Barnes, 2004). Some of them are academic institutions, which deliver basic knowledge to innovate via research projects, graduates, training programs, technological ventures etc.

Jauhari et al. (2013), explored the way to develop an effective relationship among universities and industries. Authors identified two arguments, through which aforesaid relationship can be explained. Firstly, academic institutions desire to see the influence of their research on particle field. To fulfill such aim, academic institutions transfer knowledge to industries via their graduates, training programs, events, research publications and social interactions. Secondly, to enhance university industry collaboration, policy makers introduce incentives (funded projects, subsidies, allowances) to motivate potential contributors in exchanging knowledge.

Although, there is an enduring research conducted in academic institutions, but it is not only such research which impact on innovation. In fact along with research, graduates from academic institutions also matter a lot (Brundenius et al., 2009). Past studies (Nielsen, 2007) confirmed that university graduates (both engineering and management) have positive and significant impact on product and administrative transformation. However, such relationship is very critical in developing economies, where firms have low absorption capacity (Brundenius et al., 2009). Internship opportunities and undergraduate training schemes are also very much effective to bring academia and industry closer. It helps students to aware of new and modern tactics used in practical fields, which subsequently effect on their ability to introduce innovation (Ball, 1995). In the same way, consultancy services and lectures are also helpful to formulate new strategies and techniques in building innovative atmosphere (Suraweera, 1985).

Two views in literature are exhibited with respect to academia and innovation. The first one places academic institutions as an integrated part of "tripe helix model", which elaborates that together with traditional purposes, innovation is an integral part of academia purpose (Etzkowitz, 2002). The second one ranks academic institutions as a part of "national innovation system", under which such institutions play evolving part to join factors and strengthen national innovation system (Brundenius et al., 2009). These literature also highlighted the key role of academic institutions to build skillset, which subsequently augments innovation. Such role of academic institutions are strong in developed countries, where universities have skillful staff, research funds, and robust infrastructure (Chiara Cantù et al., 2015; Perkmann & Walsh, 2007). On the opposite side, in developing/emerging countries such role is significantly hindered by resource limitations, brain drainage, and unemployment (Mpehongwa, 2013).

In industrial economies, expansion in academic institutions is considered as a tool to foster innovative actions. As, Hall et al. (2001) reported that, in the decade of sixties United States patent office issued 45 (000) patents. However, in the decade of nineties, due to the expansion of academic institutions, number of patents reached to 160 (000). Nowadays, maintenance of competitive advantages and enhancement of innovation via knowledge management are the hot topics. Most of the former studies suggested that institutes of "triple helix model" (academia, industry and government) are the sources to encourage flow of knowledge and innovativeness. University-industry collaboration improves corporate activities and workers capabilities, which result in innovation and technical revolution (Debackere & Veugelers, 2005). These arguments are harmonized with the study of Santoro and Chakrabarti (2002), which stated that industry and academic relationship is a sort of collaboration to produce innovative technological products.

The study of Berbegal-Mirabent et al. (2015), explained two methods (direct and indirect) for transmitting knowledge from university to industry. Direct method passes by the way of academic entrepreneurship, through which academic research can be commercialized. Moreover, indirect method consists of contracts, R&D collaborations and consultancy facilities, by which industry and academic institutions can collaborate. No matter which method is adopted, the purpose of such relationship is to minimize time span from knowledge creation (idea) to technological innovation (reality) (Wright et al., 2008). Lee and Win (2004), also explored the advantages of university-industry relationship. Authors reported that academic institution shorten the time period between knowledge creation and its implication. By evaluating all aforementioned literature review and discussion, we can hypothesized as;

H: Relationship between academia and industry has positive impact on innovation.

4. Methodology.

4.1. Data Structure.

Our study hypothesis relays on country level data, which gather through Global Competitiveness Reports (GCR). GCR is an annually published report by World Economic Forum, which represents data regarding diverse pillars of economy i.e. institutions, infrastructure, macroeconomic environment, health, education and training, capital, labor and financial market efficiency, and technological progress. To examine countries' economic situations, World Economic Forum combines data collected through two ways: national and international organizations/sources, and Executive Opinion Survey (EOS). This survey is only used for data which aren't available on global scale. The main purpose of current study is to evaluate the impact of university industry collaboration on innovation. To observe such relationship, we gather data for 112 developed and developing countries across different region of the world. Time span of the study is from 2006 to 2015 (10 years) along with 1120 country-year observations. Table 1, presents the sample of study (countries) with respect to regions.

Table 1: Sample distribution with respect to región

Region	No. of Countries	Countries Name
Africa	23	Algeria, Botswana, Burundi, Cameroon, Chad, Egypt, Ethiopia, Gambia, Kenya, Lesotho, Madagascar, Mali, Mauritania, Mauritius, Morocco, Mozambique, Namibia, Nigeria, South Africa, Tanzania, Uganda, Zambia, Zimbabwe.
Asia	28	Bahrain, Bangladesh, Cambodia, China, Hong Kong SAR, India, Indonesia, Israel, Japan, Jordan, Kazakhstan, Korea, Kuwait, Kyrgyz Republic, Malaysia, Mongolia, Nepal, Pakistan, Philippines, Qatar, Russian Federation, Singapore, Sri Lanka, Taiwan, Thailand, Turkey, United Arab Emirates, Vietnam.
Europe	37	Albania, Armenia, Austria, Azerbaijan, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Georgia, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Macedonia, Malta, Netherlands, Norway, Poland, Portugal, Romania, Slovak, Slovenia, Spain, Sweden, Switzerland, Ukraine, United Kingdom.
North America	12	Canada, Costa Rica, Dominican, El Salvador, Guatemala, Honduras, Jamaica, Mexico, Nicaragua, Panama, Trinidad and Tobago, United States.
South America	10	Argentina, Bolivia, Brazil, Chile, Colombia, Guyana, Paraguay, Peru, Uruguay, Venezuela.
Oceania	2	Australia, New Zealand.

4.2. Variables Measurement.

Dependent variable of the study is a country level measure for innovation. On the scale of 1 to 7 (best), this variable shows the overall capacity of country to involve in innovative activities. Independent variable of current study is university industry relationship. To measure such relationship, we use university-industry collaboration in R&D activities, reported in GCRs and has value range from 1 to 7 (best). In addition, we also use a dummy variable of strong (weak) university-industry collaboration in R&D. This variable represents value of 1 if country's university-industry collaboration is more than mean value, and 0 otherwise. Figure 1, presents the overall capacity to innovate and university industry collaboration in R&D among sample regions. Additionally, figure 2 displays the innovative capacity and university-industry collaboration among developed and developing countries across study time period.

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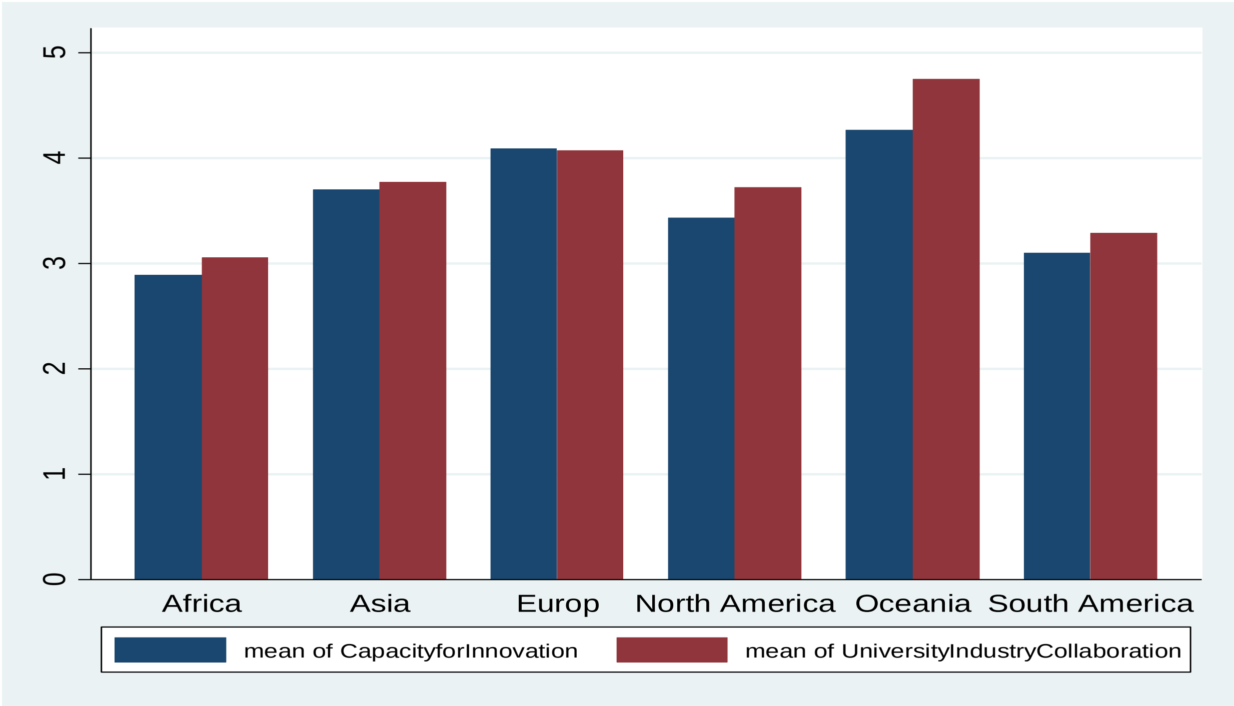

Figure 1: Region Wise Capacity to Innovate and University-Industry Collaboration

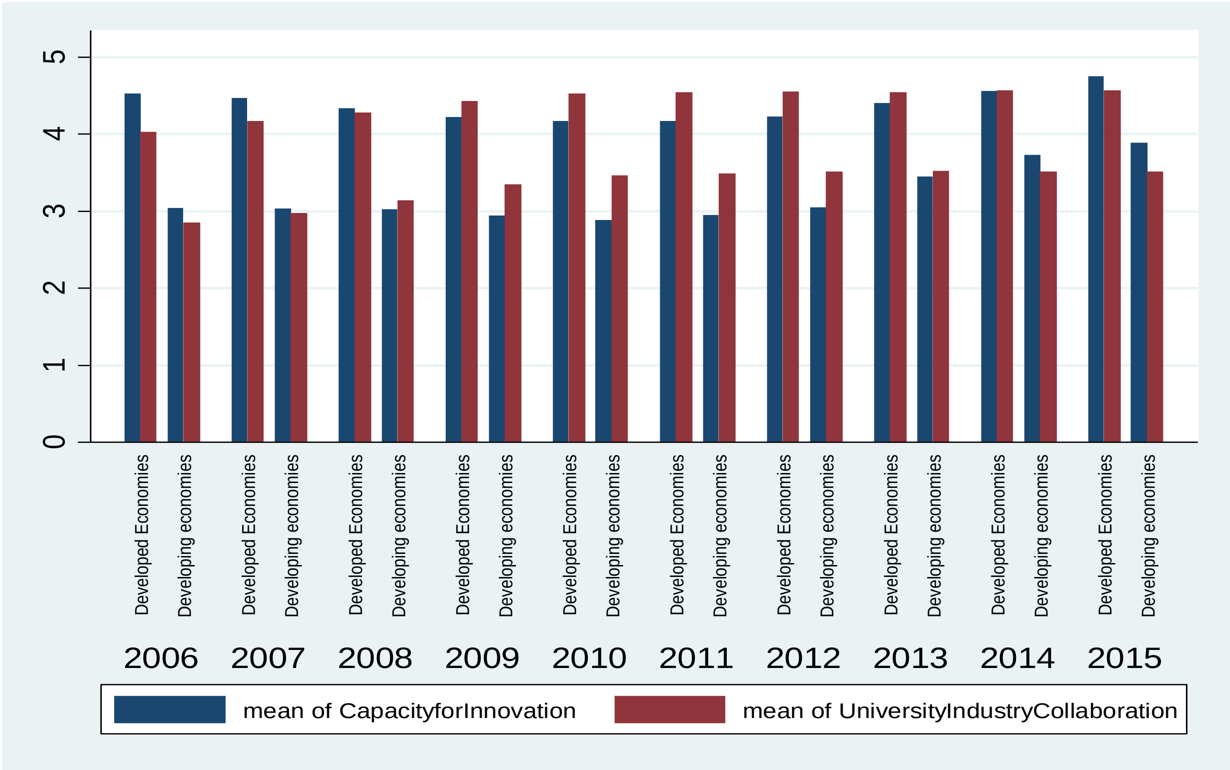

Figure 2: Development Status & Year Wise Capacity to Innovate and University-Industry Collaboration

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As for as control variables are concerned, we use company R&D expenses, staff training, education level, FDI and technology transfer, Government obtaining advanced technology, and gross domestic product. All aforementioned variables are country level indicators and measure through annual GCRs. Table 2, brings the detail of each variable and its measurement with data sources.

Table 2: Variable Definition

Name	Notation	Measurement	Source
Dependent variable:			
Capacity for innovation	CFI	In your country, to what extent do companies have the capacity to innovate? [1 = not at all; 7 = to a great extent]	EOS
Independent Variable:			
University-Industry collaboration in R&D	UIC	In your country, to what extent do business and universities collaborate on research and development (R&D)? [1 = do not collaborate at all; 7 = collaborate extensively]	EOS
Strong (weak) University-Industry collaboration in R&D	SWUIC	Dummy variable, contains value of 1 if country's University-Industry collaboration is more than mean and 0 otherwise.	EOS
Control Variables:			
Company Spending on R&D	CRD	In your country, to what extent do companies spend on research and development (R&D)? [1 = do not spend on R&D; 7 = spend heavily on R&D]	EOS
Staff training	ST	In your country, to what extent do companies invest in training and employee development? [1 = not at all; 7 = to a great extent]	EOS
Secondary Education	SE	Gross secondary education enrollment rate	UNESCO
FDI and technology transfer	FTT	To what extent does foreign direct investment (FDI) bring new technology into your country? [1 = not at all; 7 = to a great extent—FDI is a key source of new technology]	EOS
Govt. Procurement of Advanced Technology	GPT	In your country, to what extent do government purchasing decisions foster innovation? [1 = not at all; 7 = to a great extent]	EOS
Gross domestic product	GDP	Log of GDP US$ B	WDI

4.3. Econometric Model and Techniques

To estimate the relationship between university-industry collaboration and innovative capacity, we use ordinary least square (OLS) together with country fixed effect and robust standard error technique. Moreover, we divide dataset into developed and developing countries, and analyze the difference in aforementioned relationship with respect to country's development status. Furthermore, on the bases of university industry collaboration, we tabulate the whole sample into strong and weak relationship and explore more detail analysis. On the bases of variables structure (dependent, independent and control variables), we draw following econometric regression model.

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$$Capacity\ to\ Innovate_{kt} = \beta_0 + \beta_1 University\ Industry\ collaboration_{kt} + \sum_{j=1}^{6} \beta_j\ Control\ Variables_{kt} + \varepsilon_{kt}$$

Whereas, "k" donates country level indicators across time "t" and control variables consist of company R&D expenses, staff training, education level, FDI and technology transfer, government obtaining advanced technology and gross domestic product.

5. Empirical Evaluation.

5.1. Descriptive Analysis.

To observe the impact of academia-industry collaboration on innovation, we use country level data, collect through Global Competitiveness Report issued by World Economic Forum. Overall sample of study consists of 112 countries (developed and developing) from different regions (Africa, Asia, Oceania, North America, South America and Europe) with the time span of 10 year (2006-15). According to the descriptive statistics (table 3), capacity for innovation shows a mean value of 3.5897, with minimum as 1.7816 (Burundi) and maximum as 6.1368 (Germany).

Table 3: Descriptive Statistics

Variable	Obs.	Mean	Std. Dev.	Min	Max
Capacity for Innovation	1,120	3.5897	0.9625	1.7816	6.1368
University-Industry collaboration in R&D	1,120	3.6917	0.9480	1.6000	5.9681
Company Spending on R&D	1,120	3.4321	0.9244	1.6500	6.1203
Staff Training	1,120	4.0506	0.7581	1.6979	5.9454
Secondary Education	1,118	82.2627	26.4648	5.8722	150.3240
Log GDP	1,120	6.9328	3.5370	0.7939	16.4434
FDI and Technology Transfer	1,120	4.7070	0.6410	2.6850	6.4337
Govt. Procurement of Advanced Technology	1,120	3.6060	0.6447	1.6331	6.1805

On the scale of 1 to 7, university-industry collaboration in R&D displays an average value of 3.6917 with lower as 1.6000 (Mauritania) and higher as 5.9681 (Finland). As per data collected from GCRs, company spending on R&D activities shows mean value of 3.4321 with standard deviation of 0.9244. Extent of staff training and, FDI and technology transfer among sample countries represent average of 4.0506 and 4.7070, respectively. Education level and GDP in sample economies show an average of 82.2627% and 6.9328 respectively. Lastly, government procurement of advanced technology expresses mean value as 3.6060 with deviation of 0.6447.

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5.2. Correlation Analysis.

Table 4, reports the results of Pearson Correlation Matrix along with their significance level. It is necessary to observe the issue of collinearity before moving towards regression analysis. Because, sometime collinearity among variables lead to biased estimation. According to the results of correlation test (table 4), most of the estimates are in line with theories and statistically significant. We also unable to find collinearity issue among variables, which can cause biased estimation. However as per results, we observe the possible indication of correlation among university-industry collaboration, company R&D expenses and staff training. So that, we further explore this issue by using Variance Inflation Factor (VIF) and found no sign of collinearity between variables among all regression models (table 5, 6, 7).

Table 4: Pearson Correlation Table

	CFI	UIC	CRD	ST	SE	GDP	FTT	GPT
CFI	1.0000							
UIC	0.8526***	1.0000						
CRD	0.9173***	0.8872***	1.0000					
ST	0.7954***	0.8412***	0.8443***	1.0000				
SE	0.5433***	0.5365***	0.4792***	0.5651***	1.0000			
GDP	0.2234***	0.0736***	0.2833***	0.1370***	0.1482***	1.0000		
FTT	0.3768***	0.4929***	0.4576***	0.5591***	0.3303***	0.2825***	1.0000	
GPT	0.5894***	0.6419***	0.6957***	0.6712***	0.2837***	0.2250***	0.6156***	1.0000

CFI=Capacity for Innovation, UIC=University-Industry collaboration in R&D, CRD=Company Spending on R&D, ST=Staff Training, SE=Secondary Education, GDP=Natural Log of GDP, FTT=FDI and Technology Transfer, GPT=Govt. Procurement of Advanced Technology, *@10%, **@5%, ***@1%

5.3. Regression Analyses.

Furthermore, we use regression analysis techniques to explore in depth evaluation of study hypothesis. We divide independent variable (university-industry collaboration in R&D) into four categories i.e. based on full sample, developed countries, developing countries and dummy variable for strong (weak) collaboration. According to the regression results reported in table 5, there is positive and significant relationship between university-industry collaboration in R&D and country's capacity for innovation. These estimates suggest that academic institutions contribute in human capital development (D'este & Patel, 2007), which subsequently impacts on corporate innovation and enhance the capacity to involve in innovative activities. Additionally, we find that such impact is higher in developing countries as compare to developed countries. The possible reason behind such interesting results may be the other influential factors in developed countries, which have an impact on country's innovative capacity. Past literature also exhibited few factors other than academic institutions, which have an impact on country's capacity for innovation i.e. technological transformation offices (Berbegal-Mirabent et al., 2015; Lu et al., 2008), clients and contractors, opponents, and research organizations (Segarra-Blasco & Arauzo-Carod, 2008).

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We segregate study sample on the bases of strong and weak university-industry collaboration in R&D, and then analyze its impact on country's capacity for innovation. As per the results presented in table 5, we find that countries with strong university-industry collaboration in R&D have higher impact on capacity to innovate as compare to weak university-industry collaboration. These results recommend that strong relationship among academic institutions and industrial organization minimizes time span between knowledge creation (idea) and technological innovation (reality) (Lee & Win, 2004; Wright et al., 2008). In addition, strong relationship between academic institutions and industrial organizations is helpful to minimize cost of research projects, distributes associated risk and enhances competencies (Li, 2000).

As per the results of control variables, company spending on R&D has positive and statistically significant impact on capacity for innovation. These results are in accordance with theoretical and empirical evidences, which suggested that higher R&D investment enhances ability to acquire latest technologies, fund innovative projects and employee skillful workforce, which subsequently fuel country's innovative capacity. Similar like company R&D spending, staff training has positive and significant relationship with capacity for innovation. Higher extent of staff training will equip industrial workforce with creative knowledge and latest technologies, which ultimately encourage industrial and country's capacity to innovate (Lin, 2016). Secondary education enrollment has positive impact on country's capacity for innovation. It is a proven fact that higher level of education will enhance knowledge productivity and skillful labor, which ultimately increase innovational aptitude.

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Table 5: Regression Analyses

	Full Sample		Developed Economies		Developing Economies		Full Sample (Dummy)	
Dependent Variable: Capacity for Innovation	**Coefficient**	**VIF**	**Coefficient**	**VIF**	**Coefficient**	**VIF**	**Coefficient**	**VIF**
Independent Variables:								
University-Industry collaboration in R&D	0.1947***	6.90	0.1636**	5.52	0.2119***	5.17		
	(3.62)		(2.35)		(2.87)			
University-Industry collaboration in R&D (Dummy)							0.1190***	2.37
							(3.63)	
Control Variables:								
Company Spending on R&D	0.6599***	8.35	0.5289***	7.81	0.6737***	6.27	0.8884***	5.48
	(9.58)		(4.49)		(8.08)		(32.50)	
Staff Training	0.2679***	5.06	0.4592***	5.55	0.2148***	4.05	0.0466	4.95
	(5.19)		(5.05)		(3.07)		(1.37)	
Secondary Education	0.0142***	1.61	0.0048	1.25	0.0164***	1.38	0.0045***	1.58
	(7.59)		(1.05)		(7.46)		(8.19)	
LGDP	0.0158***	1.50	0.0154***	1.52	0.0167***	1.55	-0.0042	1.30
	(3.48)		(2.50)		(2.86)		(-1.15)	
FDI and Technology Transfer	-0.1809***	2.01	-0.1457*	1.30	-0.1799***	2.47	-0.0985***	1.98
	(-2.99)		(-1.80)		(-2.48)		(-4.00)	
Govt. Procurement of Advanced Technology	-0.1769***	2.59	-0.3524***	2.60	-0.1257**	2.91	-0.0775***	2.59
	(-3.98)		(-6.14)		(-2.11)		(-2.60)	
_cons	-0.4965		0.3707		-0.7059*		0.5868***	
	(-1.45)		(0.44)		(-1.65)		(6.51)	
Number of Observations	1,118		370		748		1,118	
F-Stat	284.87		363.43		72.78		1400.81	
Prob. > F	0.0000		0.0000		0.0000		0.0000	
R-squared	0.9071		0.9395		0.7920		0.8633	

*@10%, **@5%, ***@1%, (z-stat)

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Table 6: Regression Analyses (Robust Check).

	Full Sample		Developed Economies		Developing Economies		Full Sample (Dummy)	
Dependent Variable: Capacity for Innovation	**Coefficient**	**VIF**	**Coefficient**	**VIF**	**Coefficient**	**VIF**	**Coefficient**	**VIF**
Independent Variables:								
Availability of Research and Training	0.3137***	5.88	0.1785***	4.57	0.3540***	3.93		
	(5.99)		(2.44)		(5.31)			
Availability of Research and Training (Dummy)							0.1863***	2.24
							(5.51)	
Control Variables:								
Company Spending on R&D	0.6394***	6.55	0.5593***	6.84	0.6335***	4.51	0.8816***	5.01
	(9.21)		(4.85)		(7.48)		(32.73)	
Staff Training	0.2273***	5.22	0.4293***	5.77	0.1756***	4.21	0.0322	4.99
	(4.46)		(4.70)		(2.61)		(0.96)	
Secondary Education	0.0134***	1.80	0.0061	1.22	0.0147***	1.46	0.0041***	1.63
	(6.97)		(1.31)		(6.46)		(7.48)	
LGDP	0.0121***	1.25	0.0099*	1.14	0.0126***	1.37	-0.0051	1.25
	(3.07)		(1.78)		(2.36)		(-1.44)	
FDI and Technology Transfer	-0.1658***	1.99	-0.1336*	1.24	-0.1671**	2.54	-0.1092***	1.99
	(-2.66)		(-1.62)		(-2.22)		(-4.34)	
Govt. Procurement of Advanced Technology	-0.1850***	2.60	-0.3536***	2.64	-0.1301**	2.91	-0.0706***	2.59
	(-3.95)		(-6.27)		(-2.05)		(-2.36)	
_cons	-0.8567***		0.0500		-1.0522***		0.6272***	
	(-2.49)		(0.06)		(-2.42)		(6.87)	
Number of Observations	1,118		370		748		1,118	
F-Stat	272.52		339.05		78.97		1404.19	
Prob. > F	0.0000		0.0000		0.0000		0.0000	
R-squared	0.9104		0.9398		0.8012		0.8659	

*@10%, **@5%, ***@1%, (z-stat)

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Table 7: Regression Analyses (Robust Check).

	Full Sample		Developed Economies		Developing Economies		Full Sample (Dummy)	
Dependent Variable: Capacity for Innovation	**Coefficient**	**VIF**	**Coefficient**	**VIF**	**Coefficient**	**VIF**	**Coefficient**	**VIF**
Independent Variables:								
Availability of Scientists and Engineers	0.1205***	2.62	0.0939*	2.04	0.1331**	2.05		
	(2.85)		(1.63)		(2.29)			
Availability of Scientists and Engineers (Dummy)							0.0595**	1.68
							(2.13)	
Control Variables:								
Company Spending on R&D	0.7262***	5.37	0.6051***	5.18	0.7280***	4.15	0.9139***	4.88
	(10.53)		(5.26)		(8.34)		(34.33)	
Staff Training	0.2900***	5.04	0.4563***	5.48	0.2628***	3.92	0.0569*	5.02
	(5.94)		(4.78)		(4.12)		(1.68)	
Secondary Education	0.0139***	1.69	0.0046	1.18	0.0159***	1.44	0.0045***	1.63
	(7.24)		(0.99)		(7.01)		(8.27)	
LGDP	-0.0013	1.31	-0.0005	1.28	0.0007	1.42	-0.0082***	1.27
	(-0.38)		(-0.09)		(0.14)		(-2.34)	
FDI and Technology Transfer	-0.1894***	1.93	-0.1281	1.24	-0.2094***	2.46	-0.0881***	1.93
	(-3.19)		(-1.46)		(-2.99)		(-3.46)	
Govt. Procurement of Advanced Technology	-0.1779***	2.66	-0.3616***	2.64	-0.1133*	3.00	-0.0867***	2.61
	(-3.87)		(-6.00)		(-1.87)		(-2.87)	
_cons	-0.5859*		0.5403		-0.8166**		0.5465***	
	(-1.72)		(0.65)		(-1.93)		(6.04)	
Number of Observations	1,118		370		748		1,118	
F-Stat	273.95		358.20		64.62		1355.47	
Prob. > F	0.0000		0.0000		0.0000		0.0000	
R-squared	0.9067		0.9390		0.7913		0.8623	

*@10%, **@5%, ***@1%, (z-stat)

FDI and technology transfer, and government procurement of advanced technology have negative impact on country's capacity for innovation. The probable reason for such adverse relationship is that FDI, technological transfer and technology procurement increase latest technologies in country without its own expertise (creativity). Such imported technologies or FDIs may enhance innovation only for short run, but for long run it may adversely impact on country's own capacity to innovate. Gross domestic product exhibits positive impact on capacity to innovate among sample countries. Higher GDP provides a suitable economic environment to produce knowledge and technology, which eventually foster innovative capacity (Xiao, 2013).

5.4. Robust Check.

For robust evaluation, we use two diverse proxies to estimate university-industry collaboration i.e. availability of research and training, and availability of scientists and engineers. Both proxies are measured through GCRs data. Furthermore, similar like main regression models, we divide both proxies into four sub-categories i.e. based on full sample, developed economies, developing economies and dummy variable for higher (lower) availability of research and training/scientists and engineers. Results (table 6 and 7), show that academia-industry relationship fosters country's capacity for innovation. Moreover, such relationship is higher in developing economies as compare to developed economies. Lastly, countries with higher availability of research and training/scientists and engineers have higher capacity to innovate as compare to lower availability.

6. Conclusion.

The main focus of study is to determine the impact of university-industry collaboration on innovation. To fulfill such objective, we hypothesize that there is positive impact of academia-industry relationship on innovation. This study relied on the data collected through annual Global Competitiveness Reports published by World Economic Forum. Unlike previous studies, we use cross-country panel data set to testify above mentioned hypothesis. More specifically, our dataset consists of 112 countries (developed and developing countries) across different regions (Africa, Asia, Europe, Oceania, North America, and South America) with the time period from 2006 to 2015 (10 years). We measure innovation as country's capacity for innovation and university-industry relationship as university-industry collaboration in R&D.

Furthermore, we use diverse range of control variables (company R&D spending, extent of staff training, education enrollment rate, gross domestic product, FDI and technology transfer, and government procurement of advanced technology) together with country fixed effect and robust standard error techniques. All the above stated variables (dependent, independent and control variables) are country level indicators and measured through GCRs. To find more detail analyses, we segregate university-industry collaboration into four sub-divisions (based on full sample, developed countries, developing countries, and dummy variable represents strong/weak university-industry collaboration). We use ordinary least square regression technique to analyze study hypothesis.

The results suggest that university-industry collaboration in R&D has positive and statistically significant impact on country's capacity for innovation. Moreover, countries with strong university-industry relationship have higher impact on capacity to innovate as compare to countries with weak university-industry relationship. These results support study hypothesis and recommend that university-industry relationship contributes in the development of human capital, minimizes cost and risk of innovative projects and enhances country's competencies. Furthermore, we also find that the impact university-industry relationship on capacity for innovation is higher in developing countries as compare to developed countries. These results elaborate that contrary to developing countries, developed countries have diverse means to foster innovative capacity e.g. technological transformation offices, research organization, technological parks etc. All above estimated results are further robust check by using different proxies of university-industry collaboration, and find same results. Policy implication recommends that to enhance country's capacity for innovation, it is highly required to strengthen university-industry collaboration activities. Such activities are not only important for innovation but also essential for global competitiveness and economic development.

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