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Innovation is crucial for a country's economic growth and development as it stimulates productivity and enhances the competitiveness of the firms. R&D investments are one of the most significant inputs to a firm's ability to innovate. Many studies of firms in developed countries have verified the R&D to innovation relationship; however, there is a void in the literature of studies focusing on the R&D to innovation relationship in developing countries. This dissertation explores and compares the effect of R&D relationships among firms in two developing countries: Bangladesh and Malaysia. Using probit models, I estimate the marginal effect of R&D on the likelihood of a firm being innovative. I find that R&D affects Bangladeshi firms' innovative behavior more than Malaysian firms. This finding is consistent with the law of diminishing marginal returns and the theory of economic convergence. Namely, this finding implies that after reaching a certain optimum level of innovative capacity, an additional level of R&D input can produce a smaller increase in innovation output, which happens to Malaysian firms. Additionally, the study also finds that larger-sized firms are more innovative. The dissertation concludes with some policy suggestions for Bangladesh's public sector to consider for the country to be more innovative.

INNOVATION ACTIVITIES IN DEVELOPING COUNTRIES

by

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Dr. Albert N. Link
Committee Chair

DEDICATION

This dissertation is dedicated to my wife, Shampa, and two sons, Shayan and Shabab.

APPROVAL PAGE

This dissertation written by Md Rashedur Rahman Sardar has been approved by the following committee of the Faculty of The Graduate School at The University of North Carolina at Greensboro.

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CHAPTER I: INTRODUCTION

Innovation is crucial for a country's economic growth and development as it stimulates productivity and enhances the competitiveness of firms. Investment in research and development (R&D) is one of the most significant inputs to a firm's ability to innovate.

Many scholars have studied the covariates associated with the innovative activities of developed countries; however, the study of innovation in developing countries has only recently expanded. Furthermore, there is a void in the literature on comparative innovation studies among developing countries. This dissertation contributes to the academic literature by studying innovative activities in two developing countries. More specifically, the scholarly contributions of this dissertation are:

1. A review of the extensive literature on innovation measures and the covariates of innovation activities in firms.
2. A complete background discussion of two developing countries: Bangladesh and Malaysia.
3. A statistical measure of the effect of R&D on innovative activity in each country.
4. A discussion of policy recommendations for Bangladesh.

The dissertation is organized as follows. Chapter II reviewed the academic literature related to the covariates of innovative activity in firms. Key findings from the empirical studies are presented from the perspective of developed and developing countries.

Chapter III discusses the two developing countries studied in this dissertation. One of the developing countries is Bangladesh. The choice to study innovative activity in Bangladesh is primarily based on personal interest (Bangladesh is my home country), and firm data on innovative activity have yet to be studied. Furthermore, Bangladesh has recently asserted more importance on the country's competitiveness. The other country is Malaysia, also a developing country, but one that is more competitive than Bangladesh. The 2019 Global Competitiveness Report[1] ranks Malaysia 25th and Bangladesh 105th among 141 economies in terms of global competitiveness. Additionally, the 2021 Global Innovation Index 2021[2] ranks Malaysia 36th and Bangladesh 116th in terms of their innovation ecosystem performance compared to 132 economies.

Chapter IV describes the data used for the comparative innovation studies. The data used in this dissertation come from the World Bank Enterprise Survey (WBES).

Chapter V describes the variables used in the econometric models and the models themselves. Univariate and bivariate probit models are used to quantify the relationship between R&D and innovative activity.

In Chapter VI, the empirical findings from the estimation of the models in Chapter V are presented and discussed.

Chapter VII discusses the policy implications of the empirical findings in Chapter VI. To summarize, it will be suggested that Bangladesh should initiate an R&D strategy that can help initiate R&D programs and provide incentives for the firms by investing more in R&D if the country is to become more competitive in the world markets.

The dissertation concludes in Chapter VIII with a discussion of the limitations of the analysis and possible future research to refine the policy recommendations offered.

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[1] Due to global pandemic 'COVID19,' World Economic Forum has published special editions in 2020 and 2021 which do not contain comparative country rankings on the Global Competitiveness Index. Thus, the Global Competitiveness Report 2019 has been used in this study.
[2] The Global Innovation Index (GII) is published by WIPO in partnership with other organizations such as the Portulans Institute and some other corporate and academic institutes.

CHAPTER II: LITERATURE RELATED TO COVARIATES OF INNOVATIVE ACTIVITY IN FIRMS

Schumpeter (2017) discussed innovation as a source of stimulating the productivity and competitiveness of firms and is thus a driving force of economic growth. Since his writings, many firm-based studies have analyzed and explored covariates with innovative activities. The related literature is reviewed in this chapter using the common framework posited by Link (2020).

$$Innovation = f\,(R\&D, \mathbf{X}), \tag{2.1}$$

where *Innovation* is measured in a few ways, *R&D* represents an investment in R&D, and **X** is a vector of controls. Table 1 lists the relevant empirical literature, innovative activity measures, and the covariates considered. Also included in the table is a summary of the key findings from each study.

Table 1. Literature Review of the Empirical Papers[3]

Author (by year)	Data	Measure of Innovation	Measure of R&D	Variables in **X**	Comments/ Key findings
Link & Neufeld (1986)	A cross-sectional study used US data collected from telephone interviews with the R&D vice presidents of 76 R&D active manufacturing firms listed in Fortune 500 companies in 1980.	If a firm follows an R&D strategy for innovation, it is innovative and equal to '1' and '0' if it is imitative.	R&D intensity, measured by R&D expenditure per unit of sales.	Firm size, measured by the log value of 1980 sales in millions of dollars; Market share, measured by the firm's involvement in the operation of various industries; Market concentration ratio, measured by the sales-weighted average that characterizes the industries in which a firm function.	Monopoly power and firm size are significantly correlated with innovative behavior, while a firm's innovative behavior is determined based on R&D strategy.
Acs & Audretsch *(1987)	A longitudinal study used data from the U.S. Small Business Administration database on innovation, the U.S.	The number of total innovations; Innovations from the large firms; Innovations from the small firms.	R&D intensity, measured by the percentage of scientists and engineers engaged in R&D, a proxy for	Market concentration; Capital-Labor ratio; Advertising-Sales ratio; Human capital, measured by the total wages of unskilled labor divided by	R&D intensity acts positively on the innovation performances of a large firm.

[3] A number of elements of this table are paraphrased from the original sources.

Author (by year)	Data	Measure of Innovation	Measure of R&D	Variables in **X**	Comments/ Key findings
	Department of Commerce, the Bureau of the Census, the Annual Survey of Manufactures, different journal articles, and other sources.		higher technological opportunities.	the total payroll; Unionization.	
Hirsch & Link (1987)	A cross-sectional study used data from an industrial technology survey in 1985, and the Technology and Information Policy Program group of Syracuse University conducted the study.	Two measures of product-innovative activity: INNOV1 and INNOV2. INNOV1 measures a firm's comparative advantage from product-related technological innovation, while INNOV2 measures a firm's leadership in developing innovative products.	R&D is a binary variable; if the firm's expenditure on R&D exceeds more than 10,000 USD, then '1' and otherwise '0.'	Several binary variables: Union, if more than half of the firm's workforce is reported as unionized then '1' and otherwise '0'; Profit, measured by the level of profit made by the firms; Foreign Competition; Concentration Ratio; Size, measured by the value of the natural log of total personnel.	Product innovative activity is negatively associated with unionized firms.

Author (by year)	Data	Measure of Innovation	Measure of R&D	Variables in **X**	Comments/ Key findings
Acs & Audretsch (1988a)	A cross-sectional study used innovation data from the US Small Business Administration dataset, while the R&D data comes from the business line report of the 1977 Federal Trade Commission.	Log value of the total number of innovations; innovations from the large firms and small firms, separately; the share of small-firm innovations.	Total (Federal + Company) R&D expenditure; Company's R&D expenditure.	Capital intensity; Market concentration; Share of employees belonging to a union; Advertising expenditures; Employment share in the large firms; Skilled labor; Size of the industry.	Innovation is closely related to R&D expenditures when federal R&D is excluded.
Acs & Audretsch (1988b)	A cross-sectional study used innovation data from the 1982 U.S. Small Business Administration dataset.	The innovation rate of large/small firms, measured by the ratio of the large/small firm's number of innovations and total employment; Highly/low innovative, measured by when	R&D intensity, measured by the percentage of scientists and engineers engaged in R&D among the total staff.	Capital-Output ratio; Concentration; Union, measured by the mean percentage of workers belonging to a union; Advertising/Sales ratio; Skill, measured by the share of professional and kindred workers, managers and administrators,	The firms which belong to capital-intensive, concentrated, and highly unionized industries and produce differentiated goods are more innovative. However, small firms enjoy a relative innovative advantage

Author (by year)	Data	Measure of Innovation	Measure of R&D	Variables in **X**	Comments/ Key findings
		the firm's innovation rate exceeds/underperforms the mean innovation rate.		craftsmen and kindred workers.	if they utilize more skilled labor.
Acs & Audretsch (1991)	The longitudinal study used data from the 500 largest U.S. industrial corporations on the Fortune's list in 1955 and the data used by Scherer (1965) and Soete (1979).	Firm's number of innovations; Log of the number of innovations.	Log value of R&D expenditure of a firm; Log value of R&D and Sales ratio of a firm.	Firm's sales in a million USD; Firm's size; Number of employments in the firms.	R&D is not evident as a tool of economies of scale to produce innovative output.
Link & Bozeman (1991)	A cross-sectional study used data from 284 firms in New York State through an industrial technology survey conducted by the Technology and	Three measures of innovativeness: an index based on firm-specific behavior of information acquisition (TECHKNOW); a binary variable	A binary variable that identifies whether a firm has in-house R&D.	Firm size; A weighted four-firm concentration ratio; A factor of foreign competition a firm faces.	Firm size plays an important factor in determining the level of the development of new products and production processes and the adoption of new production

Author (by year)	Data	Measure of Innovation	Measure of R&D	Variables in **X**	Comments/ Key findings
	Information Policy Program at Syracuse University	based on the firm’s adoption of new production process technologies (PROTECH); firm’s status on product innovativeness compared to other competitors (PRODINNO).			process technology, especially among small-sized firms.
Acs et al. (1994)	A cross-sectional study used data from different journal sources and the innovation database of the US Small Business Administration.	The number of innovations in large and small firms in a particular state and technological area, separately.	Log value of R&D expenditure by private corporations and universities, separately.	Log value of the multiplication of geographic coincidence and university research; Firm size; Log value of the population of a region.	Small firms tend to receive more knowledge from R&D centers of universities, while larger firms receive knowledge through R&D spillovers to promote innovative activity.
Audretsch & Feldman (1996)	A cross-sectional study used the innovation database	Gini-coefficient of innovations across states; The number	R&D intensity, measured by the ratio of industry R&D	Industry scale, measured by the mean size of the largest establishment in a	Knowledge spillover in a cluster of

Author (by year)	Data	Measure of Innovation	Measure of R&D	Variables in **X**	Comments/ Key findings
	of the U.S Small Business Administration.	of innovations in the industry across states; A weighted measure of national innovation count; and others.	expenditure and sales; University research expenditure.	particular year; Transportation cost; Skilled labor.	industries plays a role in innovation.
Brouwer & Kleinknecht (1996)	A cross-sectional study used the Community Innovation Survey (CIS) data of the Netherlands, which covered 8,000 firms with ten and more employees.	Dummies for sales from 'New to the firm' and 'New to the Sector'; the percentage share of innovative products in total sales for 'New to the firm' and 'New to the sector.'	R&D man-years, measured by product-R&D intensity as a percentage of a firm's total employment; Dummies: permanent R&D; information technology-based R&D; biotechnology-based R&D.	Firm's sales growth; Small business presence, measured by the share of small firms with more than 50 employees; Log value of the numbers of employees in service firms and manufacturing firms, separately; Dummies: Firm consulted an innovation center; Firm belongs to high technological opportunity sectors; Firm belongs to the service sector.	Larger firms have more probability of selling innovative products, while smaller businesses enhance imitative innovation.

Author (by year)	Data	Measure of Innovation	Measure of R&D	Variables in **X**	Comments/ Key findings
Arvanitis (1997)	A cross-sectional study used data from a survey on Swiss manufacturing firms' innovative activities conducted by the Swiss Federal Institute of Technology in 1993.	Innovation projects in machinery; Ordinal measures of technological assessment for innovation and economic assessment of innovation.	R&D expenditures; Ordinal variable for an overall measure of input requirements.	The intensity of price and non-price competition, separately; Firms' concentration; Firms' appropriation; Technological potential; External knowledge; Firm size, measured based on the number of employees and sales.	Economies of scale do not play any role in innovation activities in Swiss manufacturing.
Feldman & Audretsch (1999)	A cross-sectional study used data from the innovation database of the U.S Small Business Administration.	Product innovation, if the firm has any of the following four: (1) the innovation is an entirely new product; (2) the product innovation is the first of its type in the market, but that category is already in existence; (3) product	R&D expenditure of a firm in 1975 (there were a 7 years lag between innovation counting year and R&D investment year).	Specialization, measured by the ratio of total employment in a city's specific industry to that of the US; Science-based diversity, measured by the ratio of the share of science-based city employment and the share of employment in the same sector in the whole United States; Competition,	Diversity brings complementary activities together, which helps to promote innovation better than specialization.

Author (by year)	Data	Measure of Innovation	Measure of R&D	Variables in **X**	Comments/ Key findings
		innovation representing a significant improvement of existing technology; and (4) the product innovation brings a modest improvement to the existing one.		measured by the ratio of the number of firms per worker in the industry of a city to that of the per worker number of firms in the United States.	
Hadjimanolis (2000)	A cross-sectional study using survey data from Cyprus collected through questionnaire-based personal interviews with the manufacturing firms' owners or managers.	Innovativeness scale, measured by an ordinal scale (1-5) of how often a new product is introduced.	R&D expenditure, measured as a percentage of sales.	The number of scientists and engineers employed; Use of technological information; Cooperation with technology providers; Intensity of competition; External barriers to innovation; Intensity of horizontal networking	Significant innovation determinants are R&D expenditure, external technology cooperation, technological information, strategy, and the firm's overall performance.
Oerlemans et al. (2001)	A Cross-sectional study used data from a survey conducted in	Natural log value of the number of innovations by firms	R&D effort, measured by the share of man-years in R&D as a	Utilization of internal resources: transformation function (TF), measured by	Higher regional embeddedness increases the

Author (by year)	Data	Measure of Innovation	Measure of R&D	Variables in **X**	Comments/ Key findings
	1989 in the Netherlands on R&D, networks, and innovation.		percentage of the total workforce; Technology policy, measured by the total number of technology policy instruments used by an innovator firm as a proxy of financial means; R&D cooperation, measured by the number of R&D relationships of an innovator firm.	the extent to which the production and the R&D function are utilized for innovation, transaction function (TA), measured by the extent to which the production and the R&D function is utilized for the purchase and marketing/sales function.; Value chain- utilization of suppliers, buyers, and competitors in the innovation process; Pavitt sector dummy.	innovation networks through spatial concentration, though R&D effort was found ineffective.
Bhattacharya & Bloch (2004)	A Longitudinal study used data from the Confidentialized Unit Record File (CURF) database of Business Longitudinal Survey (BLS), Australia.	The dichotomous variable 'INNOV' equals one if the business entity can develop or introduce new or substantially changed products or	R&D intensity, measured by the ratio of R&D expenditure and sales.	Business size, measured by sales (in thousands of dollars); Profit; Sales growth; Four firm concentration ratio; Effects of international competition, measured by	High-tech firms' innovation is positively impacted by size, R&D intensity, market structure, and trade shares, while those variables do not

Author (by year)	Data	Measure of Innovation	Measure of R&D	Variables in **X**	Comments/ Key findings
		services; otherwise, it is zero.		the ratio of export and sales, and import and sales;	show significant results for low-tech firms.
Lynskey (2004)	A cross-sectional study used data from an extensive questionnaire survey conducted in 1999 under Japan's National Institute of Science and Technology Policy (NISTEP).	New product's number; Patent application number.	The number of joint R&D projects with universities; technological capability, measured by total researchers to employees ratio in 1998.	Sales, measured by the log value of total sales; Share of venture capital funds in total initial funds; Firm age; Age of CEO; Some dummies: Location; Postgraduate degree of CEO; R&D experience of CEO; CEO as a founder; CEO's engagement with other researchers.	Technological capability, availability of internal funds, venture capital funding, university-industry linkages, and the CEO's educational background are the major determinants of firm-level innovation.
Mairesse & Mohnen (2004)	A Cross-sectional study used data from the CIS-3 survey, which covers the French manufacturing enterprises from 1998 to 2000.	Product new to the firm; Product new to the market; Process innovation, Patent application; Patent holdings.	R&D intensity, measured by the log value of R&D expenditures per employee.	Firm size, measured by the log value of the number of employees.	R&D has a positive correlation with all measures of innovation output; however, innovation in low-tech sectors is more sensitive to

Author (by year)	Data	Measure of Innovation	Measure of R&D	Variables in **X**	Comments/ Key findings
					R&D than high-tech sectors.
Belderbos et al. (2004)	A longitudinal study used Community Innovation Surveys (CIS) data of the Netherlands conducted in 1996 and 1998 and relevant information from the production statistics of the same year's database.	Innovation sales productivity growth, measured by sales growth value per employee of products and services new to the firm/market.	R&D cooperation with stakeholders such as competitors, suppliers, customers, universities, or research institutes.	Firm size, measured by the log value of the number of employees; Dummies for multinational and domestic industries; Demand-pull innovation; Cost-push innovation; 2-digit industry dummies.	Competitor and Supplier cooperation is crucial for incremental innovation, while university and supplier cooperation is important for innovation new to the market.
Becker & Dietz (2004)	A Cross-sectional study used German manufacturing industry data from the first wave of the Mannheim Innovation Panel.	Product innovation dummy, measured by whether there are product innovations during the period from 1990 to 1992.	Dummy variable of joint R&D- firms and institutions; Number of R&D cooperation with other institutions and partners.	Variables on goals and barriers of innovation activities, appropriability conditions; Firm size; Degree of diversification; International sales intensity; Variables for technological opportunities; Herfindahl index for industrial sectors.	The intensity of in-house R&D increases the probability of innovation, while more joint R&D activities enhance innovation output.

Author (by year)	Data	Measure of Innovation	Measure of R&D	Variables in **X**	Comments/ Key findings
Negassi (2004)	A Cross-sectional study used data from different sources such as the European Community Innovation Survey, the Science and Technics Observatory, and the Ministry of Finance.	Sales of innovative products, measured by a turnover-based measurement of innovation.	R&D intensity, measured by R&D expenditure over the total sales of the firm; R&D and cooperation subsidies from the French government and international institutions.	Human capital, measured by the ratio of qualified labor; Market share; National pure spillover; Inward foreign direct investment in the firm's industry; National rent spillovers; Firm's machine tool import; Payments for foreign technologies (patents, licenses, qualified foreign labor); Technological opportunities, measured by the number of patents granted in an industry; Legal protection for innovation process;	The size of the firms, market share, R&D intensity, and human capital plays a vital role in French firms' commercial success. At the same time, inward FDI from industrialized countries also positively and significantly affects innovation.
Parisi et al. (2006)	A panel data study used the two waves of comprehensive surveys in 1995 and	Process (product) innovation, measured by dummies that are	R&D investment, measured by yearly R&D investment as per the Frascati Manual;	Production, measured by total sales, capitalized costs, and the change in work-in-progress and	R&D investment has a strong relationship with introducing a new product, while

Author (by year)	Data	Measure of Innovation	Measure of R&D	Variables in **X**	Comments/ Key findings
	1998 on Italian manufacturing firms conducted by Mediocredito Centrale (MCC).	equal to one if the firm introduced at least one process (product) innovation in 1992 to 1994 or 1995 to 1997, and “0” otherwise.	R&D capital, measured by the stock of real R&D capital at the end of the period.	finished goods inventories; Materials, measured by the cost of materials for a net increase over the raw materials inventories; Investment, measured by yearly fixed investment on plant and machinery; Firm’s Age; Area dummies; Industry dummies;	fixed capital investment enhances the probability of introducing a process innovation.
Chudnovsky et al. (2006)	A Longitudinal study used data from surveys conducted by Argentina’s National Statistical Institute from 1992 through 1996 and 1998 through 2001.	Product/Process/ Product and Process innovators, measured by dummies. Those are equal to 1 if the firm introduced new products/new processes/product or process innovation, and 0 otherwise.	Dummy variables: Continuous/Non-continuous R&D equals 1 if the firm reported positive R&D/non-continuous R&D expenditure, and zero if otherwise; R&D sector.	Skill, measured as average share of professional labor; Size, measured by the number of employees; Dummy for labor and scale intensive sector.	In-house R&D and expenditures on technology acquisition are positively associated with introducing new products or processes to the market, and larger firms have more propensity to be innovators.

Author (by year)	Data	Measure of Innovation	Measure of R&D	Variables in **X**	Comments/ Key findings
Cabrer-Borras & Serrano-Domingo (2007)	A panel data study used New Cronos's homogeneous data of Eurostat for 17 Spanish regions from 1989 to 2000.	Innovation, measured by per gross added value (GAV) number of patent applications in 1995; Temporal lag for innovation; Spatial lag for innovation, measured by a weighted sum of innovation activity in the regions.	R&D expenditures over GAV; Spatial lag for R&D efforts.	The number of employees having minimum secondary or higher levels of schooling; Specialization index; Concentration index (Herfindhal–Hirschman).	Socio-economic and regional development is necessary for making an effective R&D policy.
Goedhuys (2007)	A cross-sectional study used Tanzanian data from the World Bank Investment Climate Survey (ICS) for 2003.	A binary variable, Product innovation, equals one if the firm introduced a major new product line in 2000–2002 and zero otherwise.	A binary variable, R&D, equals one if the firm invested in design or R&D in 2002 and otherwise zero; R&D intensity, measured by the ratio of R&D expenditure and sales.	Skill, measured by the ratio of the number of skilled production workers to that of unskilled production workers; Share of sales that is sold to multinationals in Tanzania; Log of the value of the firm's total employees; A dummy	Foreign innovative firms invest more in both human and physical capital and have substantial vertical linkages with other foreign firms. In contrast, local firms emphasize more on in-

Author (by year)	Data	Measure of Innovation	Measure of R&D	Variables in **X**	Comments/ Key findings
				variable, training, equals one if the firm has offered formal training to its permanent employees, in 2002, and zero otherwise; Dummy for collaboration with local firms.	house R&D and connectivity and collaboration with other local firms.
Schmiedeberg (2008)	A cross-sectional study using data from the German manufacturing sector CIS.	Sales share from the new products; Binary variable, patent, equals one if the firm has any patent application, and otherwise zero.	Binary variables: Internal R&D; Contracted R&D; Participation in R&D cooperation	Firm size; Medium low tech; Medium high tech; High tech; Export intensity; High skilled staff; Industry dummies.	Internal R&D and R&D cooperation are found complimentary, while there are doubts about the complementarity between internal R&D and contracted R&D.
Vega-Jurado et al. (2008)	A cross-sectional study used Technological Innovation in Companies Survey (TICS) data conducted by Spain's	Three scales of novelty degree of product innovations introduced from 1998 to 2000: no innovation, innovation new to	A scale of R&D measurement (no, low, medium & high); R&D cooperation with other firms of the same group; Cooperation with customers/	A scale of size is measured based on the level of sales.	In-house R&D-based technological competencies are the key to product innovation, while the determinants of product innovation

Author (by year)	Data	Measure of Innovation	Measure of R&D	Variables in **X**	Comments/ Key findings
	National Statistical Institute.	the firm, and innovation new to the market.	suppliers/competitors/ universities/ laboratories/experts and consultants in R&D; Scale of technological intensity, measured by R&D spend/innovation spend; R&D intensity.		vary with the firm's industrial sector and the product's degree of novelty.
Hall et al. (2009)	A longitudinal study used three survey data from the 'Survey of Manufacturing Firms' conducted by a commercial bank in Italy in 1998, 2001, and 2004.	Process/Product innovation equals one if the firm introduced a process/product innovation during the three years of the survey and zero otherwise; Innovator, a dummy variable, equals one if the firm has a process or product	R&D engagement, a dummy variable, equals one if the firm has positive R&D expenditures over the three years of each survey wave; R&D intensity, measured by the R&D expenditures per employee in real terms and logs.	Labor productivity, measured by the log value of per-employee real sales; Investment intensity, measured by the log value of the per-employee investment in machinery; Public support, a dummy variable, equals one if the firm has received a subsidy during the three years of the survey; Size classes; Age classes; Capital stock.	International competition promotes the growth of R&D intensity, especially for high-tech firms, while the firm size, R&D intensity, and investment in equipment enhance both process and product innovation.

Author (by year)	Data	Measure of Innovation	Measure of R&D	Variables in **X**	Comments/ Key findings
		innovation and zero otherwise.			
Frenz & Ietto-Gillies (2009)	A longitudinal study used the Second and the Third U.K. Community Innovation Survey data.	Innovative sales in thousands of pounds per employee	The log value of the amount spent on in-house R&D in thousands of pounds; the log value of the amount spent on bought-in R&D (external R&D + external knowledge) per employee in thousands of pounds.	Firm's cooperation with other domestic firms; Firm's cooperation with international firms; Firm belongs to a company group; Log value of the enterprise size; Industry dummies; Log value of the proportion of engineers and scientists; Perceived risk hindered innovation.	The intra-company knowledge sources, own-generation, and bought-in R&D positively impact innovative performances; however, the effect of joint or cooperative innovation is opaque.
Un et al. (2010)	A longitudinal study used Spanish data from a survey of manufacturing firms for five years (1998-2002).	Binary variable, product innovation, equals one if the firm has achieved any product innovation during the year; Number of product innovations during the year.	Binary variables of different R&D collaborations: R&D with customers; R&D with suppliers; R&D with competitors; R&D with universities; R&D intensity, measured by the ratio of internal	Size, measured by the natural log of the number of employees; Affiliation with the domestic company or foreign firms; Slack resources, measured by a free cash flow indicator over equity times 100;	R&D collaborations with suppliers and universities positively affect product innovation, while R&D collaborations with customers do not seem to have any effect. However, R&D

Author (by year)	Data	Measure of Innovation	Measure of R&D	Variables in **X**	Comments/ Key findings
			R&D expenditures and total sales of the firm times 1000.	Industry dummies; Year dummies.	collaborations with competitors have a harmful effect.
Corsino et al. (2011)	A longitudinal study used data from various trade, engineering, and technical journals accessed via the Gale Thompsons PROMT database of 95 international companies, the Markets, Industry News database, and the One Source database from 1997 to 2004.	A binary variable of product announcements, a proxy of a firm's innovative performance, equals one if the firm has a product announcement and zero otherwise.	R&D intensity, measured by per employee R&D spending in the firm.	Firm size, proxied by the (logarithm of) the total number of employees at year ends; Firm age; Dummy variable, Fabless measures whether the company manufactures the commercialized components in-house; Diversification, measured by the share of product sales over total revenues of the firm.	Product innovation finds a decreasing return with the increase of a firm's size; however, firms with more extensive product portfolios have more likelihood of introducing new products.
Schmiele (2012)	A longitudinal study used data from the German Innovation Survey.	A binary variable for any planned internationalization of innovation equals	Dummy variable measures whether the firm conducted in-house R&D	High-skilled employees, measured by the share of graduate employees in the total number of employees;	R&D design/ conception of new products and implementing new

Author (by year)	Data	Measure of Innovation	Measure of R&D	Variables in **X**	Comments/ Key findings
		one if a firm has any design or preparation of innovations, manufacturing new processes outside of Germany in 2006 or 2007, and zero otherwise.	continuously from 2002 to 2004	Dummy variable: Experience in innovation cooperation with foreign partners; Export experience; Experience in successful protection of intellectual property (IP); Financial resources, measured by the firm's profit margin; Technological advantage, measured by the firms' application for at least one patent/ trademark.	processes are the potential driving forces to increase the probability of executing innovative activities abroad. However, international R&D cooperation is essential for innovations in developing countries.
Cappelen et al. (2012)	A longitudinal study used Norwegian microdata on firms from Statistics Norway, covering 1999 to 2004.	Dummy variables: introduction of a new product for the firm; introduction of a new product for the market; introduction of a new production	Amount of annual R&D investment; A dummy variable for R&D investment which measures whether the firm has invested in R&D at least once in the last three years;	A dummy variable for subsidy equals one if the firm has obtained a subsidy for at least one year during a corresponding subperiod.	Firms that receive tax credits develop new production processes and products; however, the effect of a tax credit on innovations new to the

Author (by year)	Data	Measure of Innovation	Measure of R&D	Variables in **X**	Comments/ Key findings
		process; firm's application for a patent.	Dummy variable for Firm's cooperation which measures whether the firm has R&D cooperation with a university; R&D capital stock, measured by using a constant rate of depreciation; R&D capital intensity; Academic education, measured by the number of man-hours worked by employees with M.A./Ph.D, divided by the total number of man-hours in the firm.		market or patent is not observed.
Hall et al. (2013)	A longitudinal study used Italian data from four waves of a manufacturing firm's	Binary dependent variables: process innovation, product innovation, process-	R&D engagement, a binary variable, equals one if the firm has positive R&D	Percentage of the sales that come from new or significantly improved products; per employee	R&D and ICT positively affect innovation and productivity; however,

Author (by year)	Data	Measure of Innovation	Measure of R&D	Variables in **X**	Comments/ Key findings
	survey, and the survey was conducted by an Italian commercial bank known as Medicredito-Capitalia.	related organizational innovation, and product-related organizational innovation.	expenditures over the three years of each survey wave and 0 otherwise; R&D intensity, measured by per employee R&D expenditures (1000 euros), in real terms and logs.	investment in machinery (1000 euros), Investment in ICT per employee (1000 euros); Public support, measured by whether the firm has received a subsidy during the three years of the survey; Age; Industry dummies; Region dummies; Number of employees.	R&D is more important for innovation, while ICT investment is crucial for higher productivity.
Cappelli et al. (2014)	A cross-sectional study used German's Mannheim Innovation Panel (MIP), 2003data.	Innovation new to the market, measured by the sales amount from products that were newly introduced to the market; Innovation new to the firm, measured by the sales amount from products new to the firm's product	R&D intensity, measured by the share of R&D spending over total sales; Logarithm of the R&D amount at the industry level.	Share of import over domestic production; Employment in thousands; Capital intensity, measured by per employee physical assets in a million; Export-sales ratio; Patent stock per employee.	R&D spillovers from the competitor firms help produce imitative innovation, while customer input and collaboration with research institutions enhance original innovation.

Author (by year)	Data	Measure of Innovation	Measure of R&D	Variables in **X**	Comments/ Key findings
		portfolio; Share of sales from market novelties; Share of sales from market imitations.			
Tavassoli (2015)	A cross-sectional study used Swedish data from the 4th Community Innovation Survey (CIS).	Log value of per-employee sales income from innovative products.	Per-employee innovation investment, where investment includes the expenditure for engagement for intramural and extramural R&D, acquisition of machinery, external knowledge, training, and market introduction of innovation; a dummy variable of continuous R&D.	Cooperative-innovative activity as a dummy variable.	The innovation propensity and intensity determinants vary in importance in different stages of the industry's lifecycle.
Maietta (2015)	A longitudinal study used data from four	Among various dependent variables:	Dummy variables: R&D collaboration	Firm size; Firm age; Subsidies; Skilled	R&D collaboration between universities

Author (by year)	Data	Measure of Innovation	Measure of R&D	Variables in **X**	Comments/ Key findings
	waves of the "Survey of Italian manufacturing firms" covering 1995 to 2006.	Product innovation dummy; Process innovation dummy.	with universities and/or public research labs, private firms; R&D intensity.	employees; Non-standard jobs; and other control variables	and firms affects process innovation, while a firm's proximity to the university affects product innovation. However, the university's intent to commercialize research output negatively impacts local firms' product and process innovations.
Raymond et al. (2015)	A longitudinal study used data on the manufacturing sector, except for the food industry, from three Dutch and French CIS waves.	Binary variable, product innovator, equals one if the firm introduces product innovations at least once over the sample period and zero otherwise.	R&D intensity, measured by the log value of per employee R&D expenditure; Lagged dummy variable for non-continuous R&D performing firms to	Firm size; Logarithm of the ratio of total sales over total employees; Share of innovative sales; Market share, measured by the three-digit industry level, can reflect market power.	Lagged R&D activities significantly affect the intensity and occurrence of product innovation, which also enhances labor productivity.

Author (by year)	Data	Measure of Innovation	Measure of R&D	Variables in **X**	Comments/ Key findings
			compensate for no R&D expenditure.		
Belderbos et al. (2015)	A longitudinal study used Spanish data from the survey of technological innovation from 2004 to 2011.	Innovation performance, measured by the log value of per-employee sales from products that are new to the market.	Scaled innovation expenditure by sales.	Firm size, measured by the log value of a firm’s number of employees; Export status of the firm; Resource constraint, measured by different forms of bottlenecks such as financial resource constraints, the uncertainty of the market, shortage of qualified (R&D) personnel; Patent productivity, measured by the ratio of the number of patent applications over innovation expenditures; Different forms of collaborations.	There are systematic positive effects on innovation performance for a persistent collaboration compared to a discontinued one, except for the case of recently formed collaboration with universities and research institutes,
Minetti et al. (2015)	A longitudinal study used Italian data from	Product/ process innovation, binary	R&D expenditure, a binary variable, equals	Innovation expenditures but not for R&D; Owner type;	Ownership concentration and

Author (by year)	Data	Measure of Innovation	Measure of R&D	Variables in **X**	Comments/ Key findings
	four survey waves of manufacturing firms that covered three-year periods and ended in 1997, 2000, 2003, and 2006.	variable, equal one if the firm introduces product/process innovation in the last three years and zeroes otherwise.	one if the firm spends for R&D and zero otherwise; the percentage of the firm's employees employed in R&D activities.	Business type; Number of workers with a bachelor's degree; Percentage of the external manager in the firm; Financial concentration; Control of the main shareholder; Some controls: Group/Consortium; Sector; Credit rationing; Age of the firms;	large shareholder reluctance negatively affect innovation by reducing R&D effort; however, family ownerships support innovation more.
Guo et al. (2016)	A longitudinal study used Chinese data from the innofund program website (http://www.innofund.gov.cn), firm-level data from the 'Above-scale Industrial Firms Panel' 1998–2007 (ASIFP), and the	Sales from new products; Sales from newly granted patents.	Innovation fund, measured by the fund amount allocated for innovation of the firm; Dummy variables: Before Innovation fund, measures whether the firm received any fund before a specific time; After Innovation fund, measures whether the	Firm age; Firm size; Share of state ownership over total equity in a given year; Share of total liability over the total assets of the firm in a given year; Share of total investment in fixed assets over total GDP made by the local government; Total firms located in the	Firms backed by government R&D funds produce markedly higher technological and commercialized innovation outputs than those with no government R&D fund.

Author (by year)	Data	Measure of Innovation	Measure of R&D	Variables in **X**	Comments/ Key findings
	State Intellectual Property Office (SIPO) patent database.		firm received any fund after a specific time.	high-tech zone in a given year	
Broekaert et al. (2016)	A longitudinal study using data from two consecutive waves (2006-2008 & 2008-2010) of the Community Innovation Survey (CIS).	Product innovation new to the firm, measured by the share of turnover in a year from goods and services that were new to the firm in the total turnover during the last two years; Product innovation new to the market, measured by the share of turnover from goods and services that were new to the market in a year in the total	R&D, measured by the ratio of a firm's internal R&D expenditures in a year and its turnover in that year.	Family ownership, measured by the percentage of company shares owned by one person or one family; Organizational flexibility, measured by summing three binaries for new business practices for organizing tasks or procedures, new methods for organizing responsibilities and powers of a decision within the enterprise or new methods for organizing the external relations with other companies or public	Although family firms are less engaged in R&D, they are more flexible in how they organize, enabling them to develop new products successfully compared to non-family-owned businesses in process innovation.

Author (by year)	Data	Measure of Innovation	Measure of R&D	Variables in **X**	Comments/ Key findings
		turnover during the last two years.		institutions; Firm size; Firm age.	
Beck et al. (2016)	Longitudinal data used in this study, which comes from the Swiss Innovation Survey, covers the manufacturing and service sectors.	Radical innovation performance, measured by the sales amount that comes from the radically innovative products; Incremental innovation performance, measured by the sales share that comes from significantly improved products;	Dummy variables: R&D subsidy receiving firm within last three years; R&D subsidy receiving firm within last three to five years; R&D cooperation; R&D collaboration with vertical partners (Customers, suppliers); R&D collaboration with horizontal partners (competitors); R&D collaborations with science partners (universities, research institutions).	Firm age; Natural log value of total full-time employees; Number of patent applications per 1000 employees; Natural log value per employee sale's share; Share of workforce with tertiary education; Share of exports in total turnover.	Private R&D expenditures play a significant role in both radical and incremental types of innovation, while policy-induced R&D only plays a substantial role in radical innovation.
Frank et al. (2016)	A longitudinal study used data from an innovation survey	A factorial matrix for quality improvement of	R&D internal activities; External acquisition of R&D.	External acquisition of knowledge; Software acquisition; Machinery and	The market-orientation strategy plays a significant role

Author (by year)	Data	Measure of Innovation	Measure of R&D	Variables in **X**	Comments/ Key findings
	conducted by the Brazilian Institute of Geography and Statistics (IBGE) from 2009 to 2011.	products; Expansion of the variety of the product offered.		equipment acquisition; Training; Commercialization and product launch activities.	in adopting internal and external R&D activities, commercialization, and product launch activities that incur innovation output. In contrast, the technology-acquisition strategy that focuses on industrial machinery and equipment acquisition usually has a negative effect on innovation output.
Baumann & Kritikos (2016)	A longitudinal study using data from the KfW SME panel (KfW-Mittel stands panel), a representative survey	A binary variable, Product innovation, equals one if the firm reports the introduction of product innovation	R&D engagement, a binary variable, equal to one if the firm reports a continuous /occasional R&D engagement; R&D	Public support, a binary variable, equals one if the firm received subsidies last year and zero otherwise; Investment intensity, measured by investment in	Micro-firms' R&D, innovation, and productivity are not vastly different from larger firms. However, the predicted R&D

Author (by year)	Data	Measure of Innovation	Measure of R&D	Variables in **X**	Comments/ Key findings
	that covers micro, small and medium-sized firms with an annual turnover of up to EUR 500 million for 2005-2012.	(within the last three years); process innovation equals one if the firm reports the introduction of process innovation (within the last three years); innovator, a binary variable, equals 1 if the firm reports product and or process innovation.	intensity, measured by R&D expenditures per FTE (Full Time Employment) employee in logs (last year).	machinery per FTE employee last year, in logs; High skilled employees, measured by the share of employees with a university degree last year; Dummy variable for Regional/national/ international, which indicates the location of the main sales market (last year); Size.	intensity correlates positively with the probability of reporting innovation, but the effect size is larger for product innovation than for process innovations.
Cowling (2016)	A cross-sectional study used data from Small Business Survey, UK	Binary variables: Product or service innovation; Process innovation; Completely new product or service innovation;	R&D tax credit as a binary variable.	Age; Size; Sector; Legal form; Family ownership; Board size; International market presence; Use of accountants; Growth orientation; Planning; Capability.	Tax credit shows little evidence of additional product–service innovation for SMEs. Still, the tax credit can enhance radical process innovations, particularly when

Author (by year)	Data	Measure of Innovation	Measure of R&D	Variables in **X**	Comments/ Key findings
		Completely new process innovation.			there is a combination of solid capability and planning at the firm level.
Hadhri et al. (2016)	A cross-sectional study using data from National Council for Scientific Research (CNRS) of Lebanon.	Binary variables: product innovation, process innovation, organizational innovation, marketing innovation.	A binary variable of R&D.	The ordinal categorical variable of Age, Size, and Technological intensity. Export intensity, measured by the share of export in total sales; Skill, measured by the number of employees with tertiary degrees among the total number of employees; Foreign capital share; Binary variable of Firm's location; Partnership; Technology transfer.	The firm's size plays a significant role in innovation decisions for smaller economies. However, R&D plays a crucial role in innovation, and the interaction of R&D and skill is highly significant for innovation.
Protogerou et al. (2017)	A cross-sectional study used EU data from a survey of "Advancing	Innovation output, measured by the degree of radicalness or	R&D experience, measured by the prior working experience of one of the founders in a	Human capital, measured by educational attainment using an ordinal variable; Professional experience;	The founder's R&D experience positively impacts the firm's innovative output

Author (by year)	Data	Measure of Innovation	Measure of R&D	Variables in **X**	Comments/ Key findings
	Knowledge-Intensive Entrepreneurship and Innovation for Economic Growth and Social Well-Being in Europe" (AEGIS) in 2010 and 2011.	novelty of product innovation by using an ordinal variable which can take four possible values depending on the novelty: 0 (=no innovation); 1 (=new to the firm); 2 (=new to the market); and 3 (=new to the world).	university or research institute/lab.	Prior industry-specific experience; Team diversity in terms of expertise; Team diversity in terms of occupational background; Female representation; Team foundation; Firm size; Sales in international markets; A Likert type variable of Networking with universities; Multi-type Likert variable of Technology collaboration;	through different means, such as R&D collaboration, networking with universities, technology collaboration, and others.
Baum et al. (2017)	A longitudinal study used Swedish firm-level data from three consecutive CIS surveys conducted in 2008, 2010, and 2012.	Innovation, measured by the log value of per-employee innovation sales.	R&D expenditure per employee.	Capital, measured by the log value of physical capital per employee; Market share; A dummy variable for the firm's location in Stokholm; A latent variable for capturing unobserved factors.	The study finds evidence of sectoral heterogeneity while addressing the issue of market failure for R&D and innovation.

Author (by year)	Data	Measure of Innovation	Measure of R&D	Variables in **X**	Comments/ Key findings
Szczygielski et al. (2017)	A cross-sectional study used data from Community Innovation Survey (CIS), 2010, for Turkey. Additionally, a longitudinal study using data from two editions (2008 & 2010) of the CIS for Poland.	A few binary variables: Process innovation equals one if the firm introduced process innovation; Product innovation equals one if the firm introduced a new product innovation; Radical innovation equals one if the firm introduced a new product innovation to the market.	Binary variable: R&D support equals one if the firm received public support covering R&D expenditures or expenditures related to cooperation with the science sector (for Poland only).	Capacity support equals one if the firm received public support for capacity building; EU support equals one if the firm received public support from EU funds; Govt. Support equals one if the firm receives public support from the central government; Local support equals one if the firm receives public support from the local government.	Public support for R&D activities enhances innovation performance by firms in Turkey and Poland; however, the grants for upgrading physical and human capital are ineffective for fostering innovation, particularly in Poland.
Le & Jaffe (2017)	A longitudinal study used data from New Zealand's Longitudinal Business Database.	A few dummy variables: Any innovation, Product innovation, Process innovation, and New product to the world.	R&D grant, measured as a binary variable.	Age; Size; A few dummy variables: Foreign ownership, Non-R&D government assistance, IP protection, Exporter, State-owned enterprise, Existence	Govt. R&D grants substantially affect innovations that are more novel than incremental innovation.

Author (by year)	Data	Measure of Innovation	Measure of R&D	Variables in **X**	Comments/ Key findings
		Amount of sales due to a new product; Number of New patents; Number of New trademarks.		of monopolistic competition, Perfect competition, Easy access to capital, Difficult access to capital.	Additionally, project-based grants that are larger in amount are more effective in advancing innovation than non-project-specific and small grants.
Steinberg et al. (2017)	A longitudinal study used the Dafine database, produced by Bureau van Dijk, which contains annual accounts of German companies for 2005, 2007, 2009, and 2011.	Innovation performance, measured by the share of sales over total sales that come from new or significantly improved products in the domestic market.	Contract offshoring R & D, measured by the share of a firm's expenditure on R & D services taken from external foreign parties over the firm's total R&D expenditure; Captive offshoring R&D, measured by the share of a firm's spending on R&D services affiliated with a foreign country over	Control variables: Foreign, measured as a dichotomous control variable, equals one if the firm has a foreign owner and zero otherwise; Log value of firm's size, measured by firm's total employees; Log value of firm's age; No of R&D employees; Year dummy.	Contract offshoring positively affects a firm's innovation performance, while R&D intensity leverages the captive R&D offshoring performance. Thus, firms with more knowledge stock can take advantage of both the captive and contract offshoring.

Author (by year)	Data	Measure of Innovation	Measure of R&D	Variables in **X**	Comments/ Key findings
			the firm's total R&D expenditure; R&D intensity, measured by the share of firm's total R&D expenditure over total sales.		
Waheed (2017)	A cross-sectional study used data from Bangladesh from the World Bank Enterprise Survey Data from 2003 to 2006.	Binary variables: Product innovation and Process innovation.	R&D intensity, measured by the log value of the ratio of R&D expenditure and sales.	The log value of the number of full-time employees; Ratio of export sales to the total number of sales; Ratio of imports in the total annual purchase of material inputs and/or supplies; Firm age.	Research intensity does not play a significant role in product innovation, while it is a negative and significant factor for process innovation. However, process innovation has a positive effect on firm sales.
Barasa et al. (2017)	A cross-sectional study using data from the World Bank Enterprise Survey for 2010-12 for Kenya,	Binary variables: Product innovation and service innovation.	R&D, measured by a dummy variable, equals one if the firm has R&D and zero otherwise.	Employee level of education; Skilled labor; Managerial experience; Regional institutional quality; Control variables:	Firm innovation varies with firm-level resources and depends on the institutional environment.

Author (by year)	Data	Measure of Innovation	Measure of R&D	Variables in **X**	Comments/ Key findings
	Tanzania, and Uganda.			Firm age; Firm size; Legal status; External financing; Technology licensed from a foreign-owned company; Sector dummy variable; Country dummy variable.	Furthermore, regional institutional quality positively affects firm-level resources.
Seenaiah & Rath (2018)	Panel study used data from a primary survey for 190 manufacturing firms located in the cities of Hyderabad and Bengaluru in the southern part of India, the CMIE (Center for Monitoring Indian Economy) database, and the Bombay Stock Exchange for the period of 2011 to 2013.	Innovation, a binary variable, equals one if a firm either makes a new product, makes the same product in a new process, or follows new marketing or organizational strategies.	R&D dummy, measured by R&D presence.	Firm age; Firm size, measured by the ratio of real sales and real gross fixed assets; Capital intensity, measured by the ratio of Gross Fixed Assets (GFA) and the number of employees; Export intensity, measured by Total Export/Total Sales; Import Intensity, measured as Total Import/Total Sales; Dummy of Manager's education, whether the firm has managers with engineering/technical	The study suggested concentrating more on export-oriented policies and R&D investment through subsidizing or creating more R&D incentive projects can boost innovations.

Author (by year)	Data	Measure of Innovation	Measure of R&D	Variables in **X**	Comments/ Key findings
				background; Manager’s experience, measured by manager’s foreign experience; Employee training.	
Ayalew et al. (2019)	A cross-sectional study used the World Bank data on 29 African countries from 2011 to 2016.	Four binary innovation variables: Product innovation equals one if the firm introduced new or significantly improved products or services during the last three years; Process innovation equals one if the firm introduced a new or significantly improved process during the last three years; Core innovation equals	Dummy variable for R&D activity;	Variables for firm’s openness variables: Export, Competition, Foreign ownership, Technology transfer; Resource-based factors: Access to finance, Human capital, Employee training, Top manager’s experience; Gender.	Firm size, openness, and resource-based factors, including R&D, mainly affect the firm’s innovativeness. Large firms tend to invest more in R&D, and larger firms are more efficient in using R&D expenditure than smaller firms.

Author (by year)	Data	Measure of Innovation	Measure of R&D	Variables in **X**	Comments/ Key findings
		one if there exists either process innovation or product innovation; Innovation new to the market equals one if the product/process innovation is new to the market/industry.			
Véganzonès-Varoudakis & Plane (2019)	A cross-sectional study used the World Bank Enterprise Survey for Indian manufacturing data.	Innovation, measured by the number of innovations and takes a value of 0 to 4.	R&D, as a binary, measures if the firms have conducted any R&D.	Binary variable, Training, measures if the firms have implemented a training program; labor productivity, measured by the ratio of firms' sales to the total number of workers; Share of production exported; Control variables: Investment climate; Foreign licenses; Competition.	Three components of innovation, such as two innovation inputs and the innovation output, have a virtuous relationship among those. However, the two innovation inputs are R&D and training.

Author (by year)	Data	Measure of Innovation	Measure of R&D	Variables in **X**	Comments/ Key findings
Cirera & Cusolito (2019)	A cross-sectional study used South Asian data from the World Bank Enterprise Survey.	Binary variables: Technological (product/process) innovation equals one if the firm introduced any new or significantly improved product, service, or process introduced in the last three years; Innovation sales, measured by the share of sales that can be attributed to the introduction of new or upgraded innovation.	R&D dummy, measured by whether the firm invests in Intramural or extramural R&D.	Log value of the size of a firm; Log value of a firm's age; Educational obstacles, a dummy, equals one if a firm found inadequately educated workforce presents major or severe obstacles; ICT Index, a composite index that measures the intensity of internet adoption and the intensity of use of computers and software; Firm export; Demand pull effect, measured by whether a firm's demand has increased by evaluating revenue or employment growth; Business city, equals one if the establishment's location is in the central business city;	R&D plays a crucial role in enhancing the intensity of innovation. However, R&D adoption is found as a negative role player in technological innovation in Bangladesh and India, and a larger amount of incremental innovation explains that negative association.

Author (by year)	Data	Measure of Innovation	Measure of R&D	Variables in **X**	Comments/ Key findings
				Spillover, measured by the share of other innovators in the same region and sector.	
Le (2019)	A panel study used data from an SME survey conducted in Vietnam in 2008, 2010, 2012, and 2014.	Categorical variables that capture innovation outcomes: (1) Non-innovators, (2) Product innovators, (3) Process innovators, and (4) Product and process innovators.	Innovation investment intensity, measured by the log value of per employee total investment in technology acquisition (equipment/machinery) and R&D.	Dummy variables: Competition from domestic enterprises; Competition from legal imports/foreign enterprises; Export; Government assistance; Lack of capital; Categorical variable of Firm size class; Firm age in logarithm;	The predicted investment for innovation measured by the CDM model sparks innovation outcomes for Vietnamese small- and medium-sized enterprises.
Sharma (2019)	A cross-sectional study used Bangladeshi data from the World Bank Enterprise Survey from April 2013 to September 2013.	A dummy variable of innovation measures whether the firm introduced a new or significantly improved product.	R&D, measured by a dummy variable, equals one if the firm has R&D and zero otherwise; R&D intensity, measured by the ratio of the total cost of internal R&D to sales; Log value of the	Log value of the firm's total sales amount; Labor productivity, measured by sales per employee; Dummy variable of foreign technology, measures whether the firm uses technology licensed from	The probability of product innovation is higher when the firms are engaged in R&D; however, the study finds that product innovation is negatively associated with using foreign

Author (by year)	Data	Measure of Innovation	Measure of R&D	Variables in **X**	Comments/ Key findings
			total cost of internal R&D; Log value of the total cost of external R&D.	the foreign-owned company; Size.	technology. Additionally, R&D capital and R&D intensity do not have a significant effect on innovation.
Link (2020)	A cross-sectional study used the World Bank Enterprise Survey for data on 40 countries (various years).	Percent of firms in a country that introduced a new product or service to the firm; percentage of firms that introduced a new product or service to the market.	Percent of firms in a country that has investment in R&D	Development status of the country; mean age of the firm; mean level of experience of top management in the firm; mean number of employees in the firm	The developed economy shows a significant innovative output for an increase in R&D effort, while the significance is weaker for the transition economy and not relevant for the developing economy.
Audretsch & Belitski (2020)	A longitudinal study used a Community Innovation Survey (CIS), an annual business registry	Three binary variables: Make innovation/Ally (co-create) innovation/ Buy-imitate	R&D intensity, measured by the share of R&D expenditure over the total sales of the firm;	Knowledge spillover, measured by the ratio of the difference between R&D expenditure in industry and in-house R&D expenditure	R&D is an essential component for innovation and productivity, while knowledge spillovers

Author (by year)	Data	Measure of Innovation	Measure of R&D	Variables in **X**	Comments/ Key findings
	survey, and a business enterprise research and development survey on the firms of the UK from 1994 to 2018.	innovation, which measure whether the business introduced new or significantly improved products and services developed mainly by the business or enterprise/ by the business with other businesses or organizations/ by other businesses.		of the firm and R&D expenditure in the country for the 2-digit SIC industry. Firm size, measured by the log value of total employees in the firm; Human capital, measured by the share of employees who hold degree-level education or higher; Foreign-owned; Survival; Exporter.	are more necessary for a firm's productivity than R&D.
Medda (2020)	A cross-sectional study used the EU-EFIGE (European Firms in Global Economy) data for seven EU countries.	Dummy variables: Product Innovation; Process Innovation.	Average R&D intensity, measured by the share of total R&D expenditure over total turnover; Share of R&D acquired from external sources; Share of R&D supplied by Universities and R&D	Log value of the number of employees and the firm's age.	R&D intensity positively and significantly affects product, process, or both innovations. However, external R&D positively impacts process and product and process

Author (by year)	Data	Measure of Innovation	Measure of R&D	Variables in **X**	Comments/ Key findings
			centers; Share of R&D supplied by other firms/consultants.		innovation, while external R&D conducted by universities positively and significantly affects product innovation.
Audretsch et al. (2020)	A longitudinal study used IAB Establishment Panel (IAB-EP) data from Germany. IAB-EP is a representative annual German firm survey that offers information on all industries in all firm sizes and age classes.	Binary innovation variables: Product/Service innovation; Process innovation.	R&D activities, a binary variable, measured by the predicted probability of engaging in R&D following the CDM model.	Size of the firms, measured by the number of employees, as micro- (1-9 employees), small (10-49), and medium-sized establishments (50-249); Start-ups, measured by firms in an age class between 0 and 5 years; Middle-aged firms in an age class between 6 and 19 years; and Mature firms (20 years and older); Training; Technical state of equipment.	Knowledge-intensive services benefit the micro firms more through innovative activities than R&D for creating innovation output.

Author (by year)	Data	Measure of Innovation	Measure of R&D	Variables in **X**	Comments/ Key findings
Gómez et al. (2020)	A panel study used the Spanish Technological Innovation Panel (PITEC) data from 2003 to 2013.	Innovation performance, measured by the percentage of sales from new products; high-innovation novelty, measured by the percentage of new product sales that are new to the market; low-innovation novelty, measured by the percentage of sales of a new product that is new to the firm.	Extramural R&D, measured by the proportion of the stock of extramural R&D over the stock of total R&D expenditure (the sum of intramural and extramural R&D); Scientific R&D, measured by the investments in extramural R&D that universities perform; Non-scientific R&D, the investments from other than extramural partners.	Control variables: Export intensity; Size; Group; Industry and Temporal dummies;	Extramural R&D and sales from the new product have an inverted U relationship. However, extramural R&D investments that universities and research centers manage can enhance the sales of higher novel products than lower novel products.
Audretsch et al. (2021)	An unbalanced panel study used Community Innovation Survey (CIS) and the Annual	Innovation sales, measured by the percentage of the firm's total turnover from goods and	R&D intensity, measured as the share of internal R&D expenditure over total sales.	Knowledge spillovers, a measure of how important the information from various sources to innovation activities was;	R&D intensity plays a positive and significant role in innovation.

Author (by year)	Data	Measure of Innovation	Measure of R&D	Variables in **X**	Comments/ Key findings
	Business Survey data for the UK during 2002-2014.	services new to the market; Product innovator, equals one if the firm reports positive turnover from goods and services and zero otherwise;		Collaborations; Start-ups; Technology constraints; Scientists; Exporter; Herfindahl-Hirschman Index (HHI), a measure of the size of firms based on employment at two-digit SIC; reporting units; appropriability.	

Findings of the literature, Innovation measures, R&D measures, and measures of other covariates are summarized and discussed below. In addition, the key findings of some representative studies from developed[4] and developing[5] countries are also summarized.

Summarized Findings from Table 1

1. Many empirical papers on innovation studies are based on developed countries such as the United States and the European Union, while innovation studies based on developing countries are few.
2. The most common database used by studies based in the United States is the U.S. Small Business Administration data. At the same time, Community Innovation Survey (CIS) is the most common database for studies on European countries. However, innovation studies on developing countries have mostly used the World Bank Enterprise Survey (WBES) data.
3. Innovation variables are primarily binary, meaning innovation is not measured in number but rather focuses on whether the firm has produced any forms of innovation or not in a certain period.
4. There are different forms of innovations in terms of quality and geographical context. However, developed countries focus more on new to the market or significantly improved products, while the innovations in developing countries are mostly incremental or imitative in nature.

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[4] There is no such established convention in the United Nations system that designate a country as developed (United Nations, 2005); however, some international organizations have considered the OECD members as developed country though the OECD preamble has not used such country classification system (Nielsen, 2011).
[5] There is no such established convention that designates a country with a developing country status (United Nations, 2005); however, the World Bank has referred to the 'low and middle-income countries' as 'developing country' for publication purposes (Khokhar & Serajuddin, 2015).

5. The covariates of R&D play a significant role in a firm's innovative behavior, and a firm's innovation is highly associated with R&D expenditures and different forms of R&D cooperation.
6. R&D collaboration with universities has a significant positive impact on product innovation, while collaboration and cooperation with suppliers and competitors are important for incremental innovations.
7. Firms that receive public R&D funds, grants, or tax credits are more likely to produce higher technological and commercialized innovation outputs that are radical in nature. In contrast, private R&D plays a significant role in both radical and incremental.
8. Human capital is also an important determinant of innovation, and large firms are more likely to be innovators.

Innovation Measures

Firm-based studies have used different innovation measures based on the scope of the study and the availability of data. Hirsch & Link (1987), Link & Bozeman (1991), and Link & Neufeld (1986) applied qualitative measures of innovation. Link & Neufeld (1986) measured binary innovation variables based on the characterization of R&D strategy. Their study considered a firm as innovative when its R&D strategy is innovative and otherwise imitative. Hirsch & Link (1987) regarded a firm as product innovative based on the firm's comparative advantage of product-related technological innovation. However, Link & Bozeman (1991) applied a different approach to measure innovation. One approach used the firm-specific index of information acquisition behavior, where a binary variable is based on the firm's adoption of new production process technologies. The other approach used the firm's status on product innovativeness compared to the other competitors.

Acs & Audretsch (1987, 1998a, 1991) and Acs et al. (1994) measured innovation by the total number of innovations of a firm, while Acs & Audretsch (1998b) used the innovation rate as an explained variable where the innovation rate is measured by the ratio of the number of innovations to the total number of employees in the firm. Brouwer & Kleinknecht (1996) assessed firms' innovativeness in two ways. One way is by the sales amount from an imitative product that is new to the firm, and the other is by the sales amount of an innovative product that is new to the sector.

Belderbos et al. (2004) used sales productivity growth of products and services per employee as a measure of innovation. The authors measured the sales productivity growth from the product sales separately that are new to the firm and new to the market. Negassi (2004) & Schmiedeberg (2008) used the sales value of innovative products as a turnover-based measurement of innovation. Frenz & Ietto-Gillies (2009) also measured innovation intensity by innovative sales per employee, while Belderbos et al. (2015) used the per-employee sales value of the products that are new to the market.

Feldman & Audretsch (1999) applied four different measures of product innovation. Those measures are whether a firm in a particular city (a) creates an entirely new category of product, (b) is the first of its type on the market in a product category already in existence, (c) shows a significant improvement in a product in existing technology, and (d) makes a modest improvement designed to update an existing production. However, Cappelen et al. (2012) and Mairesse & Mohnen (2004) measured innovation by three types of innovativeness: innovations of products new to the firm, new to the market, and process innovation.

Bhattacharya & Bloch (2004) measured binary innovation variables by observing whether the firms or businesses have developed or introduced new or substantially changed products or services. Similarly, Hall et al. (2009) and Parisi et al. (2006) used binary variables to measure product and process innovation. Audretsch & Belitski (2020) applied three different measures of innovation. Those are make-innovation, ally (co-create) innovation, and buy-imitate innovation. The business introduced new or significantly improved products and services developed mainly by the business or enterprise is referred to as make-innovation. If the business makes that innovation with a collaboration of other businesses or organizations, then the innovation is classified as ally innovation. In contrast, if the business introduced new or significantly improved products and services developed mainly by other businesses, it was classified as buy-imitate innovation.

Vega-Jurado et al. (2008) employed the degree of novelty to measure product innovation using three scales: no innovation, innovation new to the firm, and innovation new to the market. Le & Jaffe (2017) used seven innovation measures, of which six are binaries. The binary measures determine whether there are any forms of innovation, product innovation, process innovation, new product to the world, new patent, and new trademark. The other non-binary variable is the percentage of sales due to new products or services. However, Corsino et al. (2011) applied product announcements by international companies as a proxy for firms' innovative performance.

To measure the geographical concentration of innovative activity, Audretsch & Feldman (1996) used the Gini coefficient of innovation, following the example of Krugman (1991). A weighted measure of industry count of innovations across different states of the U.S. Cabrer-Borras & Serrano-Domingo (2007) used spatial lag for innovation, measured as a weighted sum of innovation activity in the regions.

Conversely, Link (2020) used a different mode of counting units of observation. His study considered a country as the unit of observation rather than a firm focusing on cross-country analysis. The innovation measures are the percentage of firms in a country that introduced a product or service that was new to the firm and the percentage of firms in a country that introduced a product or service that was new to the main market.

R&D Measures

Numerous measures of R&D are observed throughout the literature related to innovative activities. Some studies considered a firm's expenditure for research and development as an R&D variable. Also, some studies have used R&D intensity as a measure of R&D, where the intensity is measured differently. Some studies considered federal and company R&D separately, and some of the studies focused only on firm R&D. For example, Acs & Audretsch (1988a) used federal and company expenditures on R&D, while Acs & Audretsch (1991) and Arvanitis (1997) used only firms' R&D expenditures. Parisi et al. (2006) measured the R&D investment by yearly R&D investment consistent with Frascati Manual.[6]

Along with the firm's research and development expenditure, some studies have focused specifically on universities, laboratories, or other institutions. For example, Acs et al. (1994) focused on university research expenditure in the empirical analysis to see how university research impacts the innovation of large and small-sized firms. Medda (2020) focused on the share of R&D acquired from external sources, the share of R&D supplied by universities and R&D centers, and the share of R&D supplied by other firms and consultants.

[6] Frascati manual is published by OECD (Organization for Economic Cooperation and Development) and provides guidelines for collecting and reporting data on research and experimental development.

Acs & Audretsch (1991), Audretsch et al. (2021), Audretsch & Belitski (2020), Audretsch & Feldman (1996), Bhattacharya & Bloch (2004), Broekaert et al. (2016), Cappelli et al. (2014), Link & Neufeld (1986), and Negassi (2004) have used R&D intensity as a measure of R&D where R&D intensity is measured as the ratio of R&D spending to total sales of a firm. Acs and Audretsch (1991) used the log value of the firms' R&D and sales ratio where the firms' sale is in a million U.S. dollars. Corsino et al. (2011), Frenz & Ietto-Gillies (2009), Hall et al. (2009), Hall et al. (2013), Minetti et al. (2015), and Raymond et al. (2015) measured the R&D intensity by the ratio of R&D expenditure to the total number of employees in the firm. Hall et al. (2013) measured R&D intensity by the log value and the real term of the ratio of R&D expenditures in thousand euros to the total number of employees.

Some empirical studies considered the share of technically knowledgeable employees as R&D intensity. For example, Acs & Audretsch (1987, 1988b), Brouwer & Kleinknecht (1996), and Oerlemans et al. (2001) measured R&D intensity by the percentage of scientists and engineers engaged in R&D as a proxy of higher technological opportunity. Parisi et al. (2006) used R&D capital as a covariate where the R&D capital measures the real R&D capital stock at the end of a year. Cappelen et al. (2012) used R&D capital stock and R&D capital intensity as explanatory variables. Using a constant depreciation rate, the authors measured R&D capital stock using the perpetual inventory method.

Some studies have applied binary variables to account for R&D expenditures. The binary variable of R&D implies whether the firm has at least some expenses for research and development. Hirsch & Link (1987) measured R&D as a binary variable where if the firm's expenditure on R&D exceeds more than $10,000, then it equals one and otherwise zero.

Baumann & Kritikos (2016), Cappelen et al. (2012), and Hall et al. (2009) also used binary variables of R&D if a firm has a positive expenditure for research and development.

Some studies have considered different forms of R&D cooperation as binary R&D variables. This binary variable of R&D implies whether the firm has R&D cooperation with other agencies like research laboratories, universities, and other firms. Belderbos et al. (2004) used binary variables for active R&D cooperation with competitors, suppliers, customers, universities, or research institutes. Becker & Dietz (2004), Maietta (2015), Schmiedeberg (2008), Un et al. (2010), and Vega-Jurado et al. (2008) also used binary variables for R&D cooperation with other firms and institutions, while Negassi (2004) used binary variables for R&D and cooperation subsidies from the government and international institutions.

Beck et al. (2016) referred to R&D cooperation in different ways. R&D collaboration with vertical partners such as customers and suppliers, R&D collaboration with horizontal partners such as competitors, and R&D collaborations with science partners such as universities and research institutions. Gómez et al. (2020) used extramural R&D, scientific R&D, and non-scientific R&D as a measure of R&D variables. Cowling (2016) employed R&D tax credit as a binary variable to see the impact on innovation in SMEs, and Szczygielski et al. (2017) and Le & Jaffe (2017) used public R&D support for the firms as a binary variable. Protogerou et al. (2017) considered founders' previous R&D experience as a binary R&D variable.

Other Covariates with Innovation

While the literature review in this chapter aims to appraise innovative activities, most studies have examined the R&D to innovation relationship. However, other studies have focused on non-R&D variables. For example, firm size is one of the explanatory variables widely used to explore its effect on firms' innovation. Firms' size is measured mainly by the number of employees, while firms are classified as large, medium, and small.

Hirsch & Link (1987), Acs & Audretsch (1988a, 1988b, 1991), Link & Bozeman (1991), Acs et al. (1994), Brouwer & Kleinknecht (1996), Arvanitis (1997), Mairesse & Mohnen (2004), Negassi (2004), Hall et al. (2009), and Baumann & Kritikos (2016) have used firm size as a covariate which is measured by the number of employees employed in the firm. Acs et al. (1994) defined a firm as large for having 500 employees in that firm, while a firm is considered as small if the firm has fewer than 500 employees. Bauman & Kritikos (2016) used a classification of firms' size provided by the European Commission (2003), which states that firms with fewer than 10 employees are micro-sized, small-sized firms have 10-49, and medium-sized firms have 50-249 employees. However, some studies measured firms' size based on sales value. For example, Link & Neufeld (1986), Bhattacharya & Bloch (2004), Lynskey (2004), and Vega-Jurado et al. (2008) used firms' sales value as a measure of firm size. Link & Neufeld (1986) measured firm size by the log value of the sales in millions of dollars.

Many studies have used human capital as a factor of innovation. Among those, some studies have used the share of employees with tertiary education, managerial experience, training facilities, and others as measures of human capital. For example, Audretsch & Feldman (1996) used the share of industry employment accounted for by professional and kindred workers, managers, and administrators, plus craftspeople and kindred workers as skilled labor, representing human capital. Cabrer-Borras & Serrano-Domingo (2007) used the relative number of employees with at least secondary or higher levels of schooling to understand the socioeconomic and development status for performing innovative activities. Baumann &

Kritikos (2016), Beck et al. (2016), Maietta (2015), Minetti et al. (2015), Protogerou et al. (2017), and some other studies have also used different measures of human capital.

Though many studies have focused on secondary or tertiary education as part of human capital for enhancing innovation, some have explicitly emphasized in-firm training. For example, using German data, Bauernschuster et al. (2009) found a strong association between training and innovation. In addition, Dostie (2018) explored Canadian Workplace and Employee Survey data and found that more training expedites product and process innovation. However, while working on developing country data, a few studies explored the impact of R&D and other innovation activities, such as training on innovation. For example, Ayalew et al. (2019), Frank et al. (2016), Goedhuys (2007), and Véganzonès-Varoudakis & Plane (2019) used employee training as input for innovation.

Some innovation studies focused on a firm's market share and its market concentration as covariates. Link & Neufeld (1986) used market share to represent firms' monopoly power, and that share is measured by firms' involvement in their various unit of operation. Baum et al. (2017), Negassi (2004), and Raymond et al. (2015) used market share as an explanatory variable. Link & Neufeld (1986) applied market concentration which is measured .by a sales-weighted average of the concentration. This market concentration characterizes various industries where each firm operates, while Acs & Audretsch (1987), Link & Bozeman (1991), and Bhattacharya & Bloch (2004) used a weighted four-firm concentration ratio.

The effect of unionization in a firm was also found to be a significant covariate in several studies. Hirsch & Link (1987) used unionization as an explanatory binary variable that measures whether half of the total workforce is reported as unionized, while Acs & Audretsch (1987, 1988a, 1989) used the percentage of the firms that have unions as an explanatory variable.

In addition, a few studies used firms' capital and capital-related measures as explanatory variables. For example, Acs & Audretsch (1987) used the capital-labor ratio to measure capital intensiveness based on the capital-output ratio used in Acs & Audretsch (1988b). Parisi et al. (2006) used capital costs during the production process as a covariate. Baurn et al. (2017) and Cappelli et al. (2014) used capital intensity as a covariate measured by the ratio of physical assets and the number of total employees.

Key Findings from Studies Based on Developed Countries

Link & Neufeld (1986) used U.S. cross-sectional data from telephone surveys and examined the relationship between market structure, firm size, and a firm's choice of an R&D strategy. The authors argued that the findings of this study support the Schumpeterian hypothesis that monopoly power and firm size correlate significantly with innovative behavior. Furthermore, the innovative behavior of a firm is determined based on R&D strategy. Acs & Audretsch (1991) also analyzed similar data from other sources to explain an apparent paradox. The study finds that though larger firms are more R&D intensive, the productivity of R&D falls as the firm's size increases. In addition, the evidence of economies of scale for R&D in producing innovative output is absent.

Acs & Audretsch (1988a) used the U.S. Small Business Administration database to explore how R&D and market characteristics influence innovative output. Their study finds that R&D positively impacts innovation while market concentration and unionization negatively affect it. However, the effect of these determinants is disparate on large and small firms. Hirsch & Link (1987) also find that unionization negatively correlates with innovation. Furthermore, Acs & Audretsch (1998b) reviewed the relationship between firm size and innovative activity among different industries. This study argued that large firms are more innovative in some industries but not all. Innovation activity in large firms gets promoted in the cluster of industries that are capital intensive, concentrated, and at the same time produce differentiated goods. On the contrary, small firms that utilize a substantial component of skilled labor tend to have a relative innovative advantage in highly innovative industries.

Brouwer & Kleinknecht (1996) explored Dutch cross-sectional data from a different perspective and measured innovation based on the sales value of innovative products in different-sized firms. The authors found that larger firms tend to sell more innovative products, whereas the smaller firms enhance imitative innovation; however, they argued that market concentration does not influence innovation output. Using Australian manufacturing business data, Bhattacharya & Bloch (2004) examined how firm characteristics and market structure influence innovative activity. Their study found that size, R&D intensity, market structure, and trade shares are conducive to further innovative activity. However, high-tech firms are more sensitive to explanatory variables than low-tech firms.

Acs et al. (1994) empirically tested how the effect of R&D on innovation varies with the size of the firms. The authors opined that small firms tend to receive more knowledge from R&D centers of universities while larger firms receive knowledge through R&D spillovers to promote innovative activity. Cappelli et al. (2014) used German data to explore the effect of R&D spillovers on sales from innovative and imitative products. The study finds spillovers from rivals help to produce imitative products while inputs from customers and research institutions enhance original innovation.

Audretsch & Feldman (1996) explored the spatial distribution of economic activity. The empirical analysis found that industries considering industry R&D, university research, and skilled labor as essential production elements have a greater propensity to innovate than industries where knowledge externalities are less important. Feldman & Audretsch (1999) explored innovation in U.S. cities based on science diversity, specialization, and localized competition. The authors asserted the notion that diversity promotes innovation better than specialization.

Some studies researched the effect of different forms of collaboration and R&D cooperation on firms' innovation. For example, Belderbos et al. (2004) analyzed cooperative R&D and firm performance using Dutch CIS data. The study found that both competitor and supplier cooperation are crucial for incremental innovation, while university cooperation and supplier cooperation are instrumental, novel, and new to the market. Negassi (2004) also studied French CIS data to explore R&D cooperation and innovation relationship. The study found that French firms' commercial success of innovations depends on different factors. For example, a firm's size, market share, and R&D intensity play a critical role, while human capital and inward FDI from industrialized countries positively and significantly affect innovation.

Frenz & Ietto-Gillies (2009) used the UK CIS data to explore the effect of different sources of knowledge on innovative performance. The study found that intra-company knowledge sources, own-generation, and externally used R&D are positively associated with innovation performance. Vega-Jurado et al. (2008) analyzed the effect of external and internal factors on a firm's product innovation in Spain. The study finds firm's technological competencies derived from in-house R&D are the primary determinant of product innovation; however, the determinants of innovation vary depending on the industrial sector and the degree of novelty of the product developed.

Belderbos et al. (2015) used Spanish data to examine the differential effects of different collaborations, such as how recently formed persistent and recently discontinued collaborations affect the firm's innovative performance. The study found persistent collaboration has a systematically positive effect on innovation performance compared to discontinued collaboration, except for recently formed collaboration with universities and research institutes. Audretsch et al. (2021) explored how start-ups and incumbent firms act on knowledge spillovers to innovation using a panel dataset of UK CIS. The study tested the differences in returns to knowledge spillover for innovation and found that start-ups are more innovative than incumbent firms.

Parisi et al. (2006) used panel data from Italian manufacturing firms intending to find the role of R&D and fixed capital investment on innovation. The study finds that R&D spending has a strong positive correlation with the likelihood of introducing a new product, while fixed capital spending tends to increase the probability of introducing a process innovation. However, using Norwegian data, Cappelen et al. (2012) measured the effect of the R&D tax credit on innovation and patents. Their result shows that the firms receiving tax credits are more likely to develop new production processes and, to some extent, can develop new products for the firm. However, the tax credit does not appear to contribute to innovations new to the market or patenting.

Similar to exploring an R&D tax credit, Le & Jaffe (2017) explored New Zealand's data to find the impact of R&D subsidy on innovation. The result of their study shows that government R&D grants have a more substantial effect on novel innovation than on incremental innovation. At the same time, larger project-based grants are more effective at promoting innovation than smaller, non-project-specific grants. However, Link (2020) explored the R&D and innovation relationship by considering the unit of observation of a country rather than a firm using the World Bank database on firm behavior. The study finds the developed economy shows a significant innovative output for an increase in R&D effort while the significance is weaker for the transition economy and not relevant for the developing economy.

Key Findings Based on Developing Countries

Innovative activity varies between developed and developing countries; however, it is still a leverage effect on economic growth and development (Fagerberg et al., 2010). However, many studies have explored and analyzed the firms' innovative activity in developed countries, but few studies have been done in developing countries. The scarcity of readily available data on firms' innovation activities is one of the major constraints of fewer studies on developing countries. A representative group of studies focused on developing countries is summarized below. The summary below is in greater detail than the summary of studies of innovation in developed countries above as a sequel to the empirical analysis in this dissertation.

Chudnovsky et al. (2006) explored Argentine manufacturing firms' behavior towards innovation and productivity using the CDM[7] framework. The study focused on firms that are product innovators, process innovators, or product and process innovators. A firm is quantified by a binary variable if it is a product innovator, process innovator, or product and process innovator based on whether it introduced new products, processes, or product or process innovation during a period. Binary R&D variables are continuous R&D and non-continuous R&D. Continuous R&D equals 1 if the firm reported positive R&D expenditure every year during a certain time period, while non-continuous R&D equals 1 if the firm reported non-continuous R&D expenditure. The other explanatory variables are technology acquisition, skills, size of the firms, foreign ownership, and other fixed effects. Technology acquisition is a dummy

[7] CDM framework was introduced in a seminal paper 'Research Innovation and Productivity: An Econometric Analysis at the Firm Level' by Crépon, Duguet and Mairesse, and the CDM comes after the initials of the three author's names (Crépon et al., 1998).

that equals 1 if the firm reported positive technology acquisition expenditures during a period and otherwise equals 0. However, the average share of professional labor measures skill, and the log value of total employees measures the size. Foreign ownership is also a dummy that equals 1 if the foreign capital share is greater than or equal to 10 percent. The authors find that R&D and technology acquisition expenditure have positive payoffs towards introducing new products and processes to the market, and larger firms have a higher probability of becoming innovators; foreign ownership does not significantly affect innovation.

Goedhuys (2007) explored cross-sectional data of Tanzania from the World Bank Investment Climate Survey (ICS). The study used innovation as a binary dependent variable which equals one if the firm introduced a new product line in 2000–2002. Two explanatory variables of R&D are binary variables of R&D and R&D intensity. The R&D variable equals 1 if the firm invested in design or R&D in 2002 and 0 otherwise. R&D intensity is measured by the percentage of R&D expenditure in total sales. The other explanatory variables are skills, backlinks, size, and other fixed effects. The variable, skills, is measured as the ratio of professional and skilled production workers to the number of unskilled and non-production workers. Backlinks measure the backward linkages with foreign firms and are computed by the proportion of output sold to multinationals located in Tanzania. The number of employees determines a firm's size. Firms with fewer than 10 employees are labeled as micro-sized, small firms have 10-29, medium-sized firms have 30-99, and large firms have more than 100 employees. However, the study concludes that foreign-innovative firms have stronger vertical linkages with other foreign firms and invest more in physical and human capital. In contrast, the local-only firms offset these disadvantages through in-house R&D, connectivity, and collaboration with other local firms.

Frank et al. (2016) used Brazilian longitudinal data to study how innovation is affected by two dominant innovation strategies, market orientation and technology acquisition. Along with other dependent variables, focused innovation variables are operational and product performance (OPP) output, process consumption reduction, and health and safety improvement (RED). These variables are measured by a rotated factor matrix formulated on an index. Nonetheless, this index is the weighted sum of the 17 innovation output scores for a specific industrial sector and attributes the same weight to all innovation output variables. This study's major explanatory R&D variables are internal R&D activities, the external acquisition of R&D, and the external acquisition of knowledge. Other explanatory variables are software acquisition, machinery and equipment acquisition, training, commercialization, and other fixed effects. These latter explanatory variables are measured by the proportion of the expenditure of specific innovation activity to the total expenditure of innovation inputs. The study finds that the market-orientation strategy prioritizes internal and external R&D activities and incurs innovation output. In contrast, the technology-acquisition strategy based on industrial machinery and equipment acquisition negatively affects innovation output.

Hadhri et al. (2016) used cross-sectional data from the National Council for Scientific Research of Lebanon to identify the determinants of innovative activities in both small and open economies. Four binary innovation variables were used in this study: product innovation, process innovation, organizational innovation, and marketing innovation. These binary innovation variables equal 1 if the firm has any form of product, process, organizational, and marketing innovations, respectively, and 0 otherwise. The explanatory R&D variable is also binary and is measured in terms of whether the firm has any R&D expenditures. The other explanatory variables are firms' age, size, skill, technological intensity, export intensity, and other fixed effects. Age and size are ordinal categorical binary variables; however, age is measured by the number of years, size is measured by the number of employees in the firm, and skill is measured as the number of employees with tertiary degrees among the total number of employees. Technological intensity is a categorical variable with four dummies (Low, Middle-Low, Middle-High, and High), while export intensity is a continuous variable measured by the export rate to total annual sales. The study finds that size matters more in innovation decisions for smaller economies, and R&D plays a significant role in innovation. Furthermore, the interaction of R&D and skill is highly significant for innovation.

Guo et al. (2016) used Chinese firm-level data to explore the impact of government-subsidized R&D on firms' innovation. Sales from new products, exports, and newly granted patents are considered innovation measures. The explanatory R&D variable is the firm's innovation fund measured by the financial research resources allocated by the government. The other explanatory variables are the share of total liability to total assets, the percentage of total investment in fixed assets to total GDP made by the local government where the firm is located, the number of firms registered in the high-tech zone, and firm size. Firm size is measured by the natural logarithm of the firm's annual sales in a given year. The study finds that firms backed by government R&D funds generate significantly higher technological and commercialized innovation outputs than counterparts with no government R&D fund.

Barasa et al. (2017) used cross-sectional data on Kenya, Tanzania, and Uganda from the World Bank Enterprise Survey to explore regional and institutional effects on innovation. Product innovation and process innovation are binary variables that equal 1 if a firm has introduced any new or significantly improved innovative product or service, respectively, and 0 if otherwise. The R&D explanatory variable is also binary. For example, if the firm conducted internal R&D from 2010 through 2012, the R&D variable equals 1 and otherwise 0. The other explanatory variables are employees' level of education, the share of skilled labor, managerial experience in years, regional institutional quality, and other control variables. For example, the percentage of employees who have completed secondary school education is used to measure the level of education attained by employees.

Furthermore, skilled labor is a binary variable that measures whether employees have formal training for developing or producing innovative products or services. Another variable, managerial experience, equals 1 if the top manager has more than 10 years of experience and 0 otherwise. The study finds that the effects of firm-level resources on innovation vary depending on the institutional environment. Furthermore, regional institutional quality positively moderates the impact of firm-level resources.

Seenaiah & Rath (2018) used a small set of Indian data to examine the effect of R&D and export on innovation. The study measures the binary innovation variable by observing whether a firm makes a new product, makes the same product in a new process or follows new marketing or organizational strategies. The R&D variable is a binary based on the presence of R&D. The other explanatory variables are firm age, firm size, capital intensity, export intensity, import intensity, and other fixed effects. Firm age is measured as the study year minus the firm's establishment year, and firm size is measured based on the real sales ratio to gross fixed assets. Capital intensity is measured as the ratio of a gross fixed asset (GFA) to the total employee of the firm, while import intensity is measured as the ratio of total imports to total sales. The study suggested concentrating more on export orientation policies and investing in R&D through subsidizing or creating more R&D incentive projects for more innovation.

Véganzonès-Varoudakis & Plane (2019) used Indian data on the manufacturing sector from World Bank Enterprise Survey to explore the interactions between firm-level innovation, exports, and productivity. Among other dependent variables, four types of innovation variables are used in this study following the Oslo Manual. There are two broader types of innovations: (a) technological, which mainly refers to product innovation and process innovation, and (b) non-technological innovation, which includes organizational, management, and marketing innovations. The explanatory R&D variable is binary, which measures whether the firm has conducted any R&D. The other explanatory variables are training, labor productivity, the share of production exported, and some control variables. Training is also a binary variable indicating if the firm has implemented a training program during the past three years. Labor productivity is calculated as the difference between a firm's sales and the cost of intermediate inputs on the total number of workers. The study finds a virtuous circle between innovation output and two innovation inputs (R&D and training). Training and R&D activities support innovation, strengthening firms' R&D and training.

Cirera & Cusolito (2019) analyzed South Asian (Bangladesh, India, Nepal, and Pakistan) data from the World Bank Enterprise Survey (WBES) to find the innovation pattern of South Asian manufacturing firms and the effect of firm-level productivity. The study used several explanatory variables; product innovation and process innovation are two of those. These variables were quantified based on whether the firm has any new or significantly improved product, service, or process. Innovation sales is another innovation variable measured by the share of sales attributed to introducing new or upgraded innovation. R&D is a binary explanatory variable and captures a firm's investment in both intramural R&D and extramural R&D.

Intramural R&D refers to the R&D done inside the firm. In contrast, extramural R&D is outsourced.

The other explanatory variables Cirera & Cuslito (2019) used are working capital, license of foreign technology, capital intensity, spillovers, and other fixed effects. Working capital is the share of working capital financed by internal funds and is a proxy to measure the firm's degree of external financial constraint. The license of foreign technology is a binary variable that measures whether a firm uses technology licensed by a foreign-owned company. However, capital intensity is defined as the log value of the firm's capital to labor ratio. Spillover is measured by the share of other innovators in the same region and sector. The study found that R&D plays a critical role in innovation intensity; however, R&D adoption appears negatively associated with technological innovation in Bangladesh and India. The authors opined that a large amount of incremental innovation had explained the negative correlation between technological innovation and R&D in the sample.

Sharma (2019) used cross-sectional data from Bangladesh from the WBES to explore the effect of R&D and foreign technology transfer on productivity and innovation. The binary variable of innovation measures whether the firm introduced a new or significantly improved product. The explanatory variables of R&D are binary variables of R&D, R&D intensity, and R&D capital. R&D intensity is measured by the percentages of the total cost of internal R&D to sales from the fiscal year 2010/2011 to 2012/2013, while R&D capital is the log value of the total cost of internal and external R&D from the fiscal year 2010/2011 to 2012/2013. The other explanatory variables are the firm's total sales, excluding raw material expenses, labor productivity, number of permanent full-time workers, size, and other fixed effects. The study finds that firms engaged in R&D have around a 30 percent higher probability of product innovation, but the effect of foreign technology on product innovation could not be established. The impact of R&D capital and intensity on innovation was also not found to be crucial.

Selected Studies that Measure Innovation by Patenting Activity

Some studies have considered patents as a measure of innovation, and the literature related to patents and other innovative activities is reviewed in terms of the following equation:

$$Patent = f\,(R\&D, \mathbf{X}), \qquad (2.2)$$

where *Patent* is an outcome variable, and *R&D* and **X** represent the covariates similar to the variables used in equation (2.1). Table 2 lists the empirical papers that have used different patent measures and sets of covariates.

Table 2. Literature Review Where a Patent is a Measure of Innovation

Author (by year)	Data	Measure of Innovation	Measure of R&D	Variables in **X**	Comments/ Key findings
Acs & Audretsch (1989)	A cross-sectional study used patented invention data from the Office of Technology Assessment and Forecast of the U.S, Patent office, Federal Trade Commission data for R&D	Log value of the number of patents (a proxy measure of innovation activity);	Log value of the total (Federal + Company) R&D; Log value of the company R&D;	Log value of the expenditure amount for advertising; Capital-output ratio; Unionization; concentration, Skilled labor; Industry size; large-firm employment share.	Patent counts can be considered a reliable measure of innovative activities.
Acs et al. (1992)	Different sources of US data and the data used by Jaffe (1989)	Log value of the number of patented inventions.	Private corporate expenditure for R&D; University research expenditure.	A measure of geographic coincidence.	University R&D spillovers are more useful for innovation than private-company R&D, especially in the electronics sector, when the patent is considered a measure of innovative activity.

Author (by year)	Data	Measure of Innovation	Measure of R&D	Variables in **X**	Comments/ Key findings
Deolalikar & Röller (1989)	A panel study used data from different secondary sources and the Indian Patent Office from 1975-1976 to 1979-1980.	Patent, measured by the number of patents granted to the firm.	Log value of the expenditure on R&D.	Log value of the number of employees with bachelor's and Ph.D. employees; Log value of the licensing fees for domestic and foreign technology and fixed assets.	R&D workforce is found as a significant contributor to influencing the patenting probability.
Audretsch & Vivarelli (1996)	A longitudinal study used a patent database comprised of 20 Italian regions from 1978 to 1986.	Patent number of all firms, small firms, medium-sized firms, and large firms.	Firm R&D expenditure; University research expenditure.		R&D expenditure of a firm is conducive to innovative output for all types of firms; however, university research spillovers are more critical for smaller firms.
Bilbao-Osorio & Rodríguez-Pose (2004)	A cross-sectional study used the New Cronos Data Set created by EUROSTAT, consisting of nine EU countries.	Patent, measured by the number of patent applications per million of the population in every region.	Public R&D/Private R&D/ Higher education R&D, measured as the percentage of investment in that specific category of R&D of GDP,	GDP per capita, which represents an initial wealth of the region and a proxy of the country's knowledge stock; Economic	Public R&D investment in higher education positively impacts the number of patent filings, and R&D investment in

Author (by year)	Data	Measure of Innovation	Measure of R&D	Variables in **X**	Comments/ Key findings
			respectively. However, public R&D includes R&D expenditure that includes research centers, agencies, and institutions.	structure, measured as the percentage of the population working in the high technology manufacturing and service sector; Employment rate; Skill, measured by the level of skills and educational attainment.	peripheral regions is also positively associated with innovation.
Fritsch & Franke (2004)	A cross-sectional study used German data from a postal survey conducted in 1995 on manufacturing enterprises.	Innovation equals one if the enterprise has registered at least one innovation for patenting and 0 otherwise; the number of innovations that are registered for patenting.	Log value of a firm's R&D expenditure; Variables for regional spillover: the Log value of R&D expenditure in the same industry, business-related services; Log value of the external funds attracted by public research institutions.	Regional dummies; Agglomeration index; Herfindahl index.	R&D cooperation is not the most significant issue as a medium of knowledge spillover towards innovation.

Author (by year)	Data	Measure of Innovation	Measure of R&D	Variables in **X**	Comments/ Key findings
Garcia-Vega (2006)	A longitudinal study used patent data and financial data from different sources. Patent data are taken from the German Patent and Trademark Office, while financial data comes from the Worldscope Global database and GDP deflators from the OECD database.	As a proxy of innovation, Patent equals one if the firm has at least one patent application between 1985 and 1990.	R&D, measured by the log value of R&D expenditures.	Sales, measured by the log value of sales; External spillover, measured by following Jaffe (1989); Diversity, measured based on Herfindahl index of concentration.	R&D is significantly important for innovation; however, patents increase with the degree of technological diversification of the firm.
Huang & Yu (2011)	A longitudinal study used data from a mailed survey on Taiwanese manufacturing firms in the information and communication technology sector between September	Firm's innovation performance, measured by the number of patent applications from 1996 to 2005.	In-house R&D, measured by the share of the number of R&D personnel to total personnel employed in the firm; R&D collaboration, measured by a dummy whether the firm has external,	Firm size; Industry difference; Competitive intensity; Intellectual property protection.	R&D collaborations, either non-competitive or competitive, positively impact innovation, but non-competitive R&D collaboration directly impacts a firm's

Author (by year)	Data	Measure of Innovation	Measure of R&D	Variables in **X**	Comments/ Key findings
	2002 and January 2003.		research institution/university, or inter-firm collaboration between 1996-2002 or not.		innovation performance.
Huang et al. (2012)	A longitudinal study used Taiwan Stock Exchange Corporation data, Over Counter data, government publications, and questionnaire surveys.	Firm innovation performance, measured by the firm's applications for patents to Taiwan's government from 2003 to 2008	In-house R&D capability, measured by three five-point Likert scales, consisted of different innovations (new to the firm, new to the industry, introduction of break-type product).	Firm size; Industry difference, measured by the outcomes based on the competitive intensity and R&D activities across industries; Public subsidies/support, measured by two five-point Likert scales; Dummies for Industry Park and Science Park.	The firms having relatively inferior in-house R&D capability can be more innovative if the firms are located in the science park, especially in emerging economies. However, smaller firms can do more innovation if located in an industrial park.
Chen et al. (2012)	A longitudinal study used data on corporate information from the database of the Securities and Futures	Innovation performance, measured by the number of citations of a firm's patents	R&D internationalization, measured by entropy measure, where the ratio of the number of patents developed by overseas	Organizational slack, measured by current assets divided by current liabilities. Foreign investment	The relationship between R&D internationalization and innovation follows an S-shaped pattern.

Author (by year)	Data	Measure of Innovation	Measure of R&D	Variables in **X**	Comments/ Key findings
	Commission (SFC), Ministry of Finance, Taiwan, and the patent information of the selected firms from the US Patent and Trademark Office (USPTO).	divided by patents granted to a firm.	subsidiaries and total patents of the firm is multiplied by the logarithm of the inverse of that ratio; R&D intensity measured as the ratio of R&D expenditure to total annual sales.	diversity, measured by the entropy formulae like R&D internationalization; Firm's size, measured by the log value of sales in thousand NT (Taiwanese currency); Industrial profitability; Industrial sales growth.	However, innovation performance increases in the decentralization stage while the performance decreases in the transition stage, which again increases in the recentralization stage.
Johansson et al. (2015)	A longitudinal study used the OECD database covering 18 industries of 11 knowledge-based European economies from 1991 through 2005.	Patent intensity, measured by the number of granted USPTO patents per 1000 employees.	R&D intensity, measured by the expenditure in R&D per 1000 employees.	Value-added share, measured by the ratio of value addition of industry and GDP; Stock market, measured as a percentage of the stock market value of the industry of GDP; Education expenditure, measured	Country-specific conditions play a crucial role in systematic differences in patent intensity among the studied EU countries.

Author (by year)	Data	Measure of Innovation	Measure of R&D	Variables in **X**	Comments/ Key findings
				by the ratio of the public expenditures on education per capita; Openness, measured by the sum of exports and imports divided by GDP times 100.	
Wu et al. (2019)	A longitudinal study used data from different Chinese sources, such as China Stock Market Accounting Research (CSMAR), China's State Intellectual Property Office (SIPO), and others, from 2008 to 2014.	Yearly patent count per company as a measure of innovation. Patents with the top 3% of patent citations have been termed radical innovations, while others are incremental inventions.	R&D resource, measured by a focal firm's total resources in research and development activities that include money invested in R&D activities (capital expenditure) and workforce and training related to R&D activities.	Imitation strategy, measured by the focal firm's number of citations of a patent made by the leader firm; Firm age; Firm size; Return on assets; State ownership, measured by the share of state-owned capital in total registered capital; Foreign ownership, measured by the share of foreign-owned capital	Imitation strategy positively affects incremental innovation but has an inverted U-shaped relationship with radical innovation.

Author (by year)	Data	Measure of Innovation	Measure of R&D	Variables in **X**	Comments/ Key findings
				in total registered capital; Marketing capability, measured by the share of marketing expenditure in total income; Market demand, measured based on information of the total sales of competitors that belong to the same industry of the focal firm.	

Summarized Findings from Table 2

1. Studies found patents as a reliable measure of innovation, and Table 2 reviews the studies where the patent is a measure of innovation.
2. Studies, where a patent is a measure of innovation have used developed countries' data and, more recently, Chinese data.
3. The covariates of patenting are very similar to the covariates of other innovation studies reviewed in Table 1.
4. R&D investment and different forms of R&D collaboration are also found to be significant contributors that influence the patenting probability.
5. Public R&D investment, especially in higher education, positively correlates with the number of patent filings, and some country-specific conditions also increase patenting intensity.

Key Findings Based on Selected Patent Studies

Acs & Audretsch (1989) explored the spillover effect of R&D among firms of different sectors in the United States. The number of patented inventions is one of the response variables of this study. The study results suggest that university research spillovers are more effective than private-company R&D in the electronics sector. Audretsch & Vivarelli (1996) focused on the linkages among R&D spillovers from different sources and different sizes of firms by using Italian panel data. This study found that the firm's R&D expenditure contributes to generating innovative output for all types of firms. At the same time, spillovers from university research significantly positively affect smaller firms. However, Garcia-Vega (2006) explored how technological diversity affects innovation by using the German patent database. This study found

R&D as a significantly important element for innovation; however, patents increase with the degree of technological diversification of the firm.

Bilbao-Osorio & Rodríguez-Pose (2004) studied data from nine EU countries to find the impact of R&D investment in the private, public, and higher education sectors on innovation. This study used the number of patent applications per million population in a region to measure innovation. The study found that while public R&D investment is vital for the EU, R&D investment in higher education in the peripheral regions of the EU is positively associated with innovation. Johansson et al. (2015) used data from 18 industries of 11 knowledge-based economies of the EU to explore European R&D efficiency. The study used patent intensity as a measure of innovation; patent intensity is measured by the number of USPTO patents granted per 1,000 employees. The study found systematic differences in patent intensity among the studied EU countries, and the performance of all the industries is affected by country-specific conditions.

Summary and Introduction to the Model Used

Based on the literature discussed above and the structure of equation (2.1), the variables related to a firm's innovative activity for this dissertation are presented below. A binary innovation variable *ProdInnovNMkt* is the dependent variable. *ProdInnovNMkt* equals 1 if the firm has introduced new or significantly improved products or services that are also new to the market in the last three years, and 0 otherwise. Similar binary innovation variables were previously used by Ayalew et al. (2019), Barasa et al. (2017), Bhattacharya & Bloch (2004), Cappelen et al. (2012), Chudnovsky et al. (2006), Goedhuys (2007), Hadhri et al. (2016), Hall et al. (2009), Minetti et al. (2015), and Parisi et al. (2006).

The key independent variable is an R&D variable, *RND. RND* equals 1 if the firm has invested in formal R&D activities, either in-house or contracted with other companies in the last three years, and 0 otherwise. Many firm-based studies have used such a variable to explore the impact of R&D on innovation (e.g., Cappelen et al., 2012; Chudnovsky et al., 2006; Goedhuys, 2007; Hadhri et al., 2016; Hall et al., 2013; Hirsch & Link,1987; Link & Bozeman, 1991; Schmiedeberg, 2008; Sharma, 2019; Véganzonès-Varoudakis & Plane, 2019).

Few studies have considered acquiring foreign technology as an innovative input for a firm. The variable *ForeignTechnology* is also binary, which equals 1 if the firm uses technology licensed from a foreign-owned company, excluding office software, and 0 otherwise. Several studies focusing on developing country analysis use this variable (e.g., Ayalew et al., 2019; Barasa et al., 2017; Hadhri et al., 2016; Sharma, 2019).

Human capital is also considered an input for innovation. Many studies have used the level of education of the employees and the managerial experiences of the top managers in a firm as human capital measures (e.g., Acs & Audretsch, 1987; Barasa et al., 2017; Chudnovsky et al., 2006; Goedhuys, 2007; Hadhri et al., 2016; Minetti et al., 2015; Negassi, 2004; Schmiele, 2012). The model in this dissertation uses two human capital variables, *AvgYrsEduc* and *MgmtExp,* as explanatory variables. The variable *AvgYrsEduc* measures the average years of education of a typical permanent full-time production worker employed in the firm. The other human capital variable *MgmtExp* measures the top manager's years of experience in the sector.

The empirical literature on the effect of firm size on innovation builds on the so-called Schumpeterian hypothesis. Many studies of firms have explored the effects of firms' size on innovation (Acs & Audretsch, 1991; Arvanitis, 1997; Becker & Dietz, 2004; Link & Bozeman, 1991; Link & Neufeld, 1986; Mairesse & Mohnen, 2004; Schmiedeberg, 2008). Generally, firm size is measured in terms of the number of employees, and some studies have used the amount of sales data as a firm's size. However, in this dissertation, due to data constraints, firm size is measured dichotomously- by employees greater than 100 (=1) or not (=0).

CHAPTER III: BACKGROUND ON THE COUNTRIES STUDIED

R&D and innovation activities of two developing countries are studied in this dissertation. The focal country of this study was Bangladesh; it moved out of low-income country (LIC) status to a Lower Middle-Income Country (LMIC) in 2015 per the World Bank classification. In 2018, Bangladesh met the United Nations (UN) criteria to graduate from the list of Least Developed Countries (LDC) to developing countries. Additionally, Bangladesh expects to graduate formally from the LDC status by 2024. The government of Bangladesh has also set a goal to be Upper Middle-Income Country (UMIC) by 2030 and Higher-Income Country (HIC) by 2041. The Bangladesh government has prioritized attaining competitiveness in all economic sectors to achieve these goals. Emphasizing the competitiveness of the manufacturing sector, the 8th Five-Year Plan of Bangladesh has stated the following:

> Bangladesh has now embarked on achieving a visionary goal of becoming a developed economy by 2041 and for which it has adopted the Perspective Plan (PP) 2041. Bangladesh will have to use its experience and success in traverse towards becoming a competitive manufacturing hub, with diverse export base (GED 2020-a, page 341)

The most recent 8th Five-Year Plan (8FYP) has mentioned the word “competitiveness” 84 times, while that word was used in the 7th, 6th, and 5th FYPs 52 times, 30 times, and seven times, respectively.

The other country studied in this dissertation for comparative purposes was Malaysia. This selection is based on global competitive performances among the developing countries of Asia. As per the Global Competitiveness Report 2019, Malaysia is one of the highest-ranking countries in the overall global competitive index among the developing countries of Asia, while Bangladesh is one of the least performing countries. Moreover, the Global Innovation Index also showcases a global innovation ecosystem and presents a global ranking of the countries. As per the Global Innovation Index 2021, Malaysia is ranked 36th, while Bangladesh is placed 116th.

The discussion in this chapter includes the evolution of industrialization and the innovation policies of the two countries. The last part of this chapter compares, in brief, the innovation capabilities of Bangladesh with Malaysia.

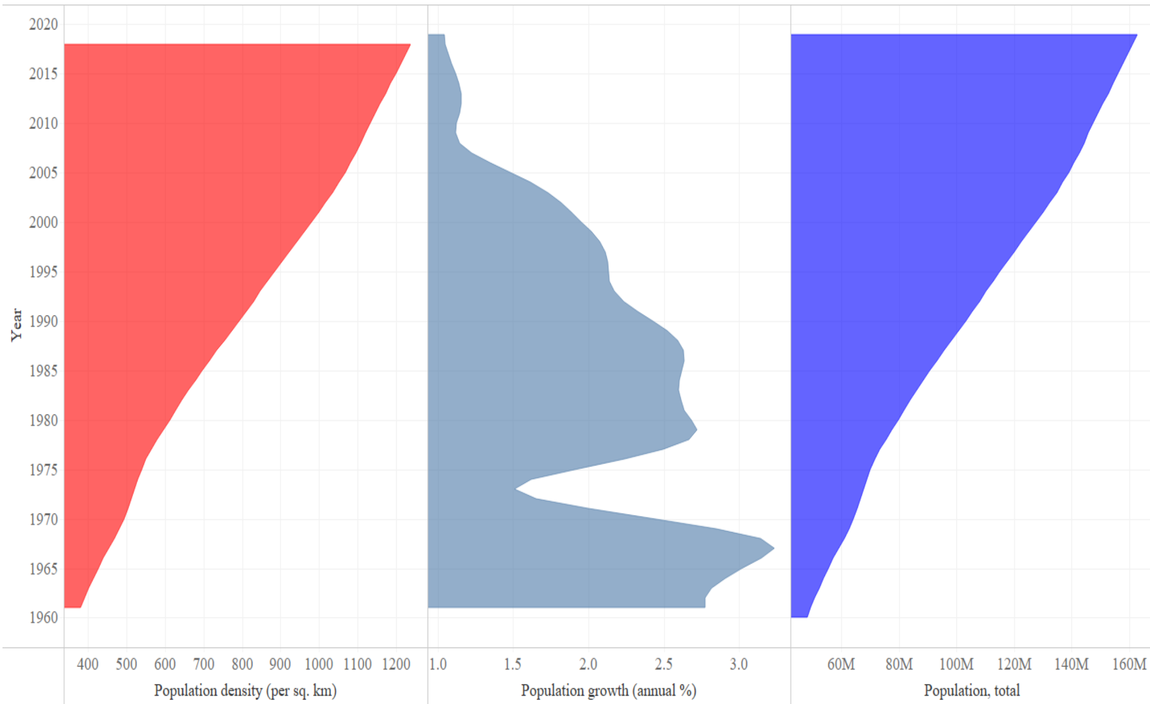
Bangladesh

Overview of Bangladesh

Bangladesh was a part of Pakistan when the Indian subcontinent was divided based on religion in 1947 into two independent states: India and Pakistan. After its independence from the British rulers, Bangladesh was known as East Pakistan, while the other part of Pakistan was known as West Pakistan. Pakistan was geographically separated into two parts by Indian territory by approximately 1,500 miles, where people of these two parts of Pakistan have very few similarities except for their religion. Since the independence of Pakistan, Bangladesh has become a victim of economic, political, and cultural exploitation (Ahmed, 2004; Jahan, 2012; Ludden, 2011). However, Bangladesh became independent after a 9-month war with Pakistan in 1971 (Jahan, 2012). Bangladesh has land borders with India and Myanmar. Indian territories mostly surround Bangladesh’s land area except for a minor border with Myanmar; however, the Bay of Bengal is in the southern part of Bangladesh.

Bangladesh is a populous country and the densest country in the world. In 2020, the total population of Bangladesh was estimated at 164.69 million people in an area of only 147,000 square kilometers. The then East Pakistan had 48 million in 1960, which rose to 50.3 million in 1971. After its independence in 1971, Bangladesh's population increased rapidly and reached 161 million in the last census of 2011. However, a few years after the independence, Bangladesh had higher population growth, which reached 2.7 percent per year in 1979. After 1979, the population started decreasing in the following decades, and the estimated population growth became 1.00 percent per year in 2020. Bangladesh's total population, population density, and population growth are presented in Figure 1.

Figure 1. Total Population, Population Density, and Growth of Bangladesh



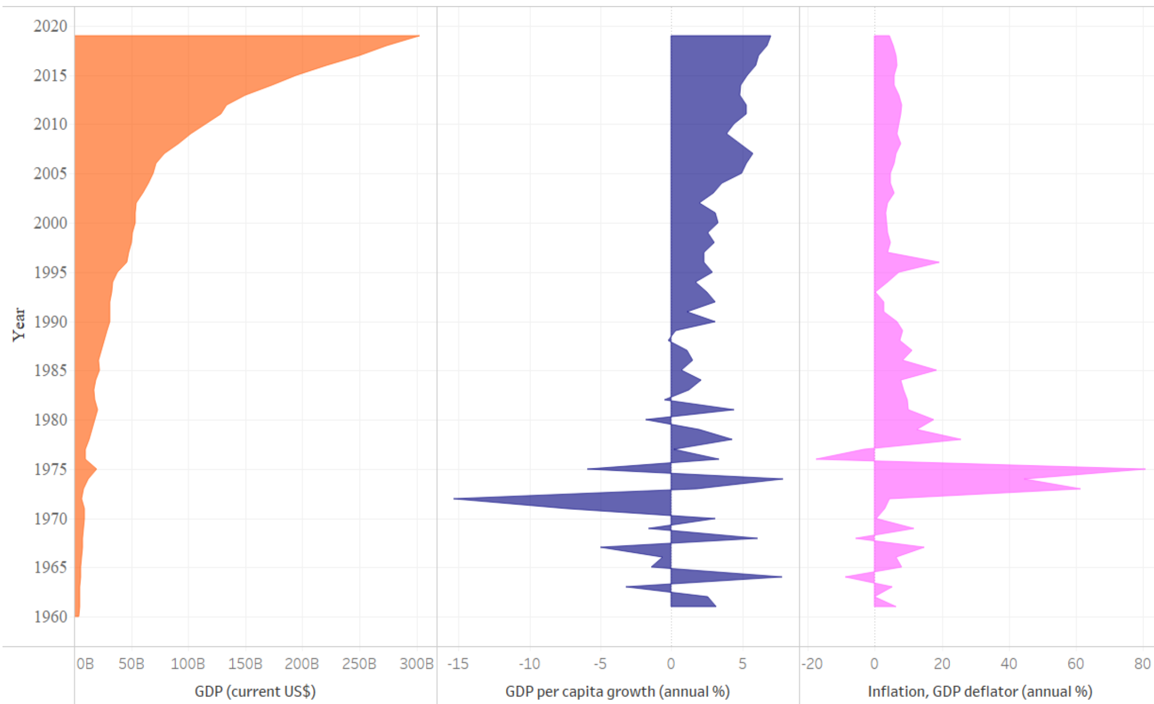
Note. Source: World Bank (2021).

Bangladesh has recently fulfilled the eligibility criteria for leaving the least developed country (LDC) status for the first time in 2018 and moved up from lower-income country (LIC) to lower-middle-income country (LIMC) status (Mujeri & Mujeri, 2020).[8] Bangladesh's GDP increased by 25 times in terms of local currency in the last 3 decades, and Bangladesh achieved the highest ever GDP growth from 2010 to 2019 (Alam et al., 2020). Though a steady growth of

[8] World economies have been divided into four income groups by the World Bank based on Gross National Income (GNI) per capita. Those income groups are high, upper-middle, lower-middle, and low. As of July 2021, countries with GNI per capita of 1,045 USD or less are the low-income economies; Lower middle-income economies should have GNI per capita between 1,046 USD and 4,095 USD; Upper middle-income countries should have GNI per capita between 4,096 USD and 12,695 USD; High-income countries should have GNI per capita of 12,695 USD or more. See Hamadeh et al. (2021).

GDP existed, Bangladesh's economy suffered from higher inflation until 1990. During the first half of the 1980s, Bangladesh experienced double-digit inflation though the growth rate was below 4 percent (Ahmed & Mortaza, 2010). On average, the GDP growth rate was a moderate range of 2 to 3 percent in the 1970s, which rose to around 3.5 percent in the 1980s (Helal & Hossain, 2013). Figure 2 presents GDP, GDP per capita growth, and inflation over the years.

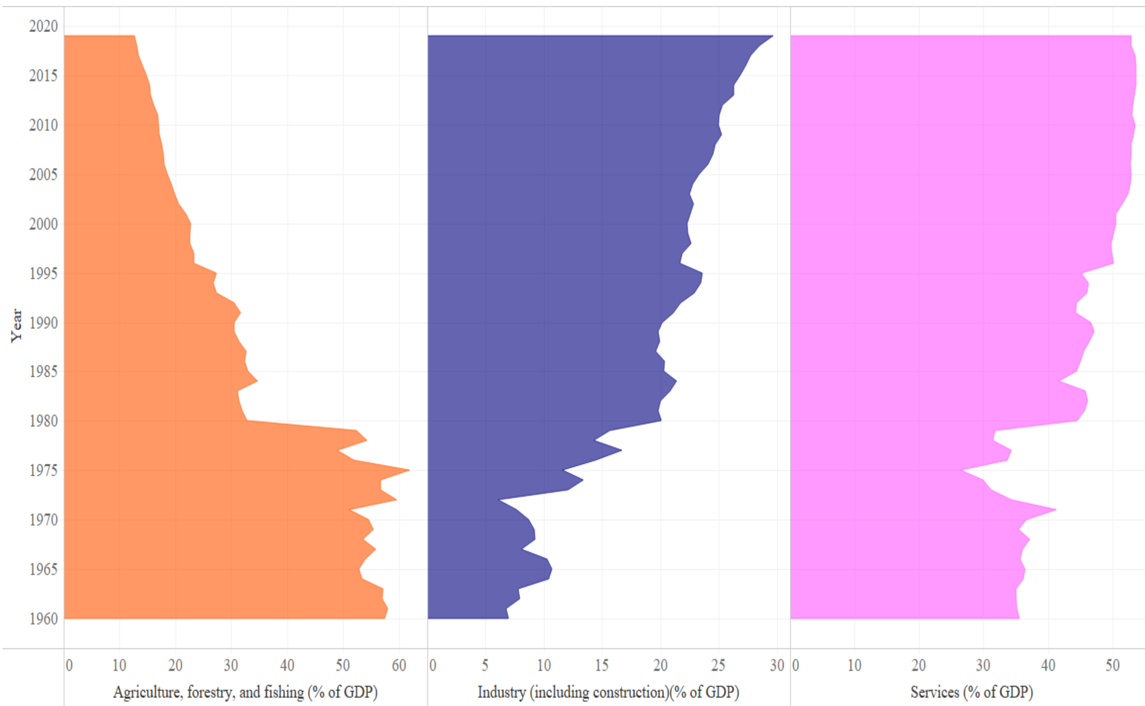
Figure 2. GDP, GDP Per Capita Growth, and Inflation of Bangladesh



Note. Source: World Bank (2021).

Over the years, the economy's structure has also changed in Bangladesh, along with macroeconomic transformation (Alam et al., 2020). The contributions of the non-farm sectors have increased significantly in the post-independence period (Osmani, 1990). Until the end of the 1970s, the contribution of agriculture, forestry, and fishing, from now on termed as agriculture, was much higher than the industrial or service sectors. The average share of value addition of agriculture in GDP was 55.13 from 1960 to 1979, while the average share of industry value addition was only 10.41 percent. During these two decades, the share of the service sector did not change significantly except a few years after the independence. There was a sharp decline in agricultural share and an increase in industrial share after 1980, while the share of the service sector was consistent. Figure 3 presents the share of agriculture, industry, and services in GDP over the years.

Figure 3. Share of Agriculture, Industry, and Services in GDP of Bangladesh



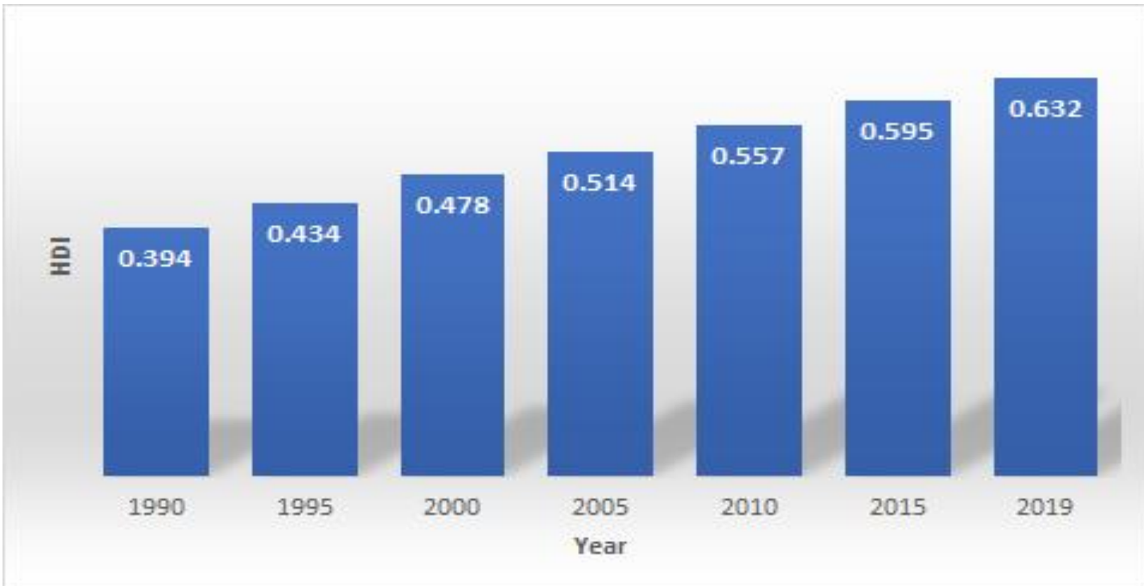
Note. Source: World Bank (2021).

Since its independence, Bangladesh has made remarkable progress in human development outcomes (Helal & Hossain, 2013). The human development index (HDI) value increased from 0.394 to 0.632 from 1990 to 2019, while the 2019 HDI value ranked Bangladesh 133 out of 189 countries.[9] In addition, from 1990 to 2019, life expectancy at birth increased by 14.4 years, mean schooling increased by 3.4 years, and GNI per capita increased from 870 to

[9] United Nations Development Programme (2020).

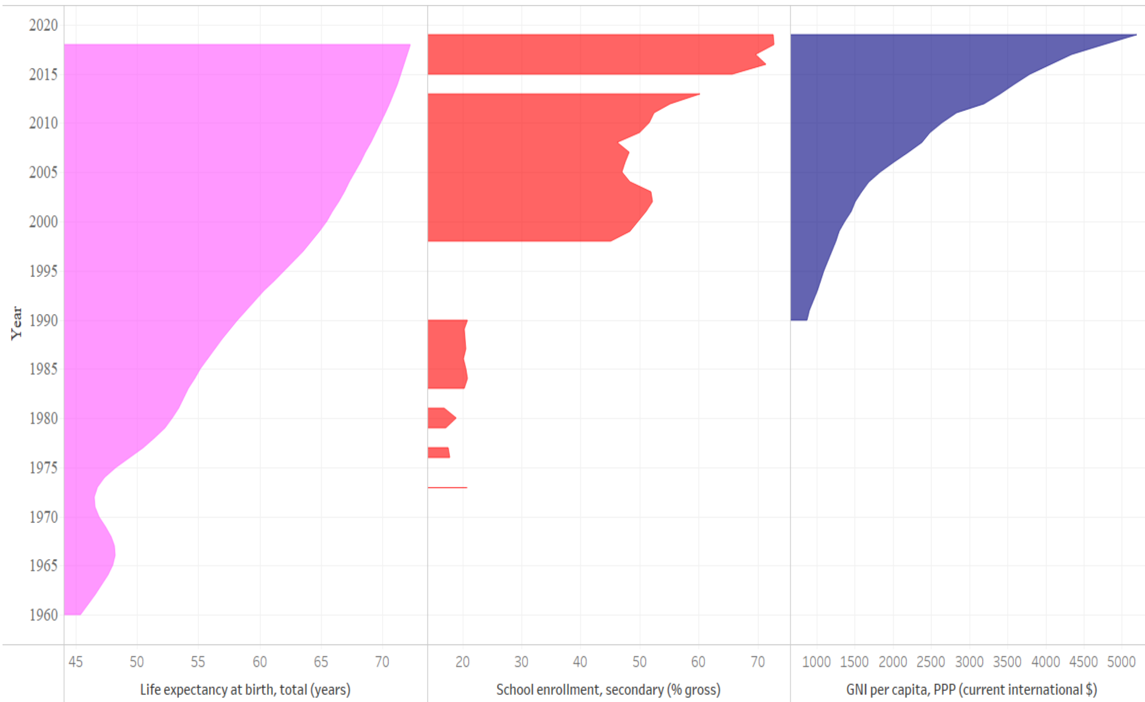
5,200 USD (World Bank, 2021). Figure 4 shows Bangladesh's overall human development index over the years. The life expectancy, school enrollment rate, and GNI per capita are also presented in Figure 5.

Figure 4. Human Development Index (HDI) of Bangladesh



Note. Source: United Nations Development Programme (2020).

Figure 5. Life Expectancy, School Enrollment, and GNI Per Capita of Bangladesh



Note. Source: WDI World Bank (2021)[10]

Industrialization of Bangladesh

During the regime of Pakistan from 1947 to 1971, the economic development differed significantly between West Pakistan and East Pakistan (Bangladesh). Bangladesh inherited a weak, neglected, and inequitable part of the economy from Pakistan (Jahan, 2019). After its independence in 1971, Bangladesh adopted economic management that facilitated socialism in the country. The first industrial investment policy in 1973 focused on tightening control over the economy and nationalizing all large-scale industries of the country, including most of the banks (Taher, 1994). Bangladesh emphasized more on the public sector with more regulation and maintaining a policy of import substitution, while the participation of the private sector was made restricted with some investment ceilings. The government used higher tariffs to increase

[10] Data on school enrollment and GNI per capita for few years are missing in the World Bank (2021) dataset.

revenue and protect domestic industries (Rahim, 1978; Salim, 2003). The new industrial policy in 1974 started encouraging private sector activities in the manufacturing sector on a minimal scale and tried to reduce the dominant role of the public sector through disinvestment (Park & Kim, 2020). Later, the revised investment policy of 1975 brought a significant breakthrough in private investment and savings.

New Industrial Policy (NIP), adopted in 1982, acted as a significant attempt toward liberalization and simplification of imports without severe reduction of product protection and rapid industrialization measures. Financial assistance was provided to the young private manufacturing sector through public policies. The newly privatized and divested nationalized industries were also supported with fiscal and financial support with a goal of industrial growth (Sahota, 1991). Then a Revised Industrial Policy (RIP) was introduced in 1986 to emphasize the private sector and strengthen the initiatives of NIP. This time, the government of Bangladesh adopted a science and technology policy, which aimed high, but little was achieved though few institutional arrangements could be made.

From the formulation of the first industrial policy until the early 1980s, there were several limitations in those policies. The most significant limitations were the absence of strategic vision, the prevalence of ideological predilection over pragmatic and empirical considerations, and the abortive attempt to promote private enterprises through public credit (Sobhan, 1991). However, multiple initiatives were undertaken as part of the liberalization process in the 1980s and 1990s (Salim, 2003).

Industrial policy in 1991 was based on the philosophy of a market-based competitive economy which made the requirement of permission for setting up industries unnecessary and removed the requirement of domestic equity participation for foreign investors. It promoted the market economy, which made the governmental role ‘promotional’ rather than ‘regulatory’ (Park & Kim, 2020). The industrial policy of 1999 was the most comprehensive policy to promote export-oriented industries and attract foreign direct investment (FDI) and specific objectives of balanced industrial development and equitable dispersions of industries in the regions. The liberalization of the industrial sector began in the 1980s through privatizations and a gradual cutting back on tariff protections. Additionally, the steps in the 1990s made the economy of Bangladesh more market-oriented through adopting a radically liberalized industrial policy (Khan & Blankeburg, 2009).

The Industrial Policy of 2005 planned to set up industries considering the real domestic demand and the prospect of exporting goods abroad. This policy also emphasized creating a solid capital market to increase investments in the industrial sector and provided infrastructural support to Cottage and Small and Medium Enterprises (SMEs). The Industrial Policy 2010 signals the private sector to lead industrialization. It also identified the need to enhance the industrial sector’s competitiveness and proposed formulating new laws and policies to encourage and expand intellectual property rights. It also targeted the establishment of special economic zones and industrial parks. Later, a supplementary policy paper, “Industrial Policy, 2016,” was framed to transform Bangladesh into a middle-income country by 2021 as per the statement of the Seventh Five-Year Plan (2016-2020) (Mamun, 2020; Park & Kim, 2020). Table 3 presents the main features of the industrial investment policies undertaken by different governments of Bangladesh.

Table 3. Major Industrial Investment Policies of Bangladesh

	Policy	Main features
1.	Industrial Investment Policy, January 1973	➢ The establishment of a socialist economy was facilitated. ➢ Reserved vital sectors, including trade and commerce, for the public sector. ➢ Investment for the private sector was limited to BDT 2.5 million. ➢ The moratorium on further nationalization for ten years was declared. ➢ The right to nationalize was reserved for unprofitable or underutilized enterprises.
2.	New Industrial Investment Policy, June 1974	➢ The revised policy was announced in mid-1974, given the rising prices at home and abroad. ➢ The private sector investment ceiling was raised to BDT 30 million.
3.	Revised Investment Policy, December 1975	➢ The ceiling on private investment was raised to 100 million. ➢ The moratorium on nationalization was deleted. ➢ The provision of equitable compensation was included for any nationalized industry. ➢ The stock exchange market was reactivated to generate private savings. ➢ Repatriation of foreign capital and profit was made permissible.
4.	New Industrial Policy, (NIP) June 1982	➢ Structural Adjustment Programs were introduced with the encouragement of private sector-led industrial growth. ➢ The role of the public sector was substantially downsized through a deregulation process. ➢ Emphasis was placed on import liberalization and tariff structure rationalization.
5.	Revised Industrial Policy (RIP), July 1986	➢ Major policy steps and Structural Adjustment Programs of NIP were followed with more emphasis. ➢ The liberalization of imports was encouraged by decompressing import bans and quantitative restrictions.

Policy	Main features
6. National Science and Technology Policy, 1986	➢ Attaining scientific and technological competence and self-reliance to accelerate production and employment in various sectors and sub-sectors of the economy. ➢ A guideline was made for institutional arrangements or rearrangements in the R&D structures, including education and training. ➢ An Engineering Research Council was proposed to establish in line with Medical Research Council.
7. Industrial Policy, July 1991	➢ The philosophy of a market-based economy was introduced after the change of government and re-democratization in 1991. ➢ Foreign trade was liberalized by rationalizing the tariff structure and non-tariff barriers.
8. Industrial Policy, 1999	➢ Private investment was prioritized by enabling a conducive environment where the role of government was as a facilitator. ➢ Goals were set to attract FDI in both export and domestic market-oriented industries. ➢ Developing indigenous technology and expanding raw materials production for import-substituting industries were encouraged.
9. Industrial Policy, 2005	➢ Planned industries were targeted to set up considering the real domestic demand and the prospect of exporting goods abroad. ➢ Schemes were taken to provide infrastructural support to Cottage and Small and Medium Enterprises (SMEs). ➢ Various institutions that worked on technological and technical efficiency enhancement and human development were provided incentives. ➢ Efforts were made to create a strong capital market to increase investments in the industrial sector.

	Policy	Main features
10	Industrial Policy, 2010	➢ Set targets to achieve industrial growth, generate huge employment growth, and increase livelihood through industrialization. ➢ Establishing private economic zones was encouraged by providing various forms of fiscal incentives. ➢ The issue of intellectual property (IP) rights was set to expand by formulating new laws and policies.
11.	Industrial Policy, 2016	➢ To increase the industrial sector's contribution to the national income from the existing 29 percent to 35 percent and the contribution of the labor force from 16 to 25 percent by 2021. ➢ To increase quality and income-generating employment through inclusive development. ➢ To establish diversified and export-oriented industries. ➢ Focusing on green technology and products in the context of preserving the environment.

Note. Source: Author's creation based on Park & Kim (2020), Rahim (1978), and other concerned policy papers.

Innovation Policies of Bangladesh

Though Bangladesh had modest growth in GDP throughout its independence, it suffered from a lack of innovation potential both in the public and private sectors, especially in R&D (Tahrima & Jaegal, 2012). The manufacturing sector is primarily labor-intensive, and firm-level profitability does not depend heavily on innovation (Waheed, 2017). Therefore, Bangladesh was approached with the concept of "Vision 2021-Digital Bangladesh," which aimed to fulfill citizens' hopes and aspirations and make an economically inclusive and politically accountable society with eight goals in 2007 (Center for Policy Dialogue[CPD], 2007). 'Digital Bangladesh' emerged not only as a vision but also started functioning to leverage ICT in service delivery systems primarily for the underserved.

In 2009, the newly formed government adopted a national ICT policy to achieve higher productivity across all the sectors of the economy and expand quality education to all parts of the country using ICT. Most importantly, Bangladesh adopted a perspective plan for digital Bangladesh in 2010 which set the target to transform the socioeconomic environment from a lower-income country to the first stages of a middle-income country. As per this perspective plan, the annual real GDP growth rate was planned to rise to 8.0 percent by 2015 and 10.0 percent by 2021 (General Economics Division [GED], 2012).

While Bangladesh has no formal innovation policy, it formulated a National Science and Technology Policy to encourage innovation and research in areas relevant to the economy and society in 2011. In addition, the government amended the ICT Act of 2006 in 2013 to use ICT-based applications for citizen-centric services. As a result, the country's education, health, agriculture, and economy can benefit from the ICT application (Park & Kim, 2020). Furthermore, the Industrial Policy 2016 set a target to increase the contribution of the industrial sector to the national income from the existing 29 percent to 35 percent and the contribution of the labor force from 16 to 25 percent by 2021. In 2018, the government of Bangladesh adopted the 'National Innovation and Intellectual Property Policy' to enhance innovation and creativity by establishing development-oriented pro-stakeholders and balanced intellectual property (IP) infrastructure in the country. This policy has attempted to make the IP an integral part of the national development plans and strategy. The government of Bangladesh has also declared 2018–2028 as Innovation Decade. Table 4 presents the major innovation policies adopted by the governments of Bangladesh to encourage economic development and innovation.

Table 4. Innovation-Related Policies of Bangladesh

Policy	Major Features
1. National ICT Policy, 2009	➢ To achieve higher productivity across all economic sectors, including agriculture and SMME (small, medium, and micro enterprises) using ICT. ➢ Govt. targeted to expand the reach and quality of education to all parts of the country using ICTs, ensuring computer literacy at all levels of education and public service, facilitating innovation, creating intellectual property, and adopting ICTs through appropriate R&D. ➢ A pool of world-class ICT professionals was created to cater to local and overseas employment opportunities. ➢ The issue of transparency, accountability, responsiveness, and higher efficiency was achieved in delivering citizen services.
2. Perspective Plan of Bangladesh 2010–2021	➢ Set the target to transform the socioeconomic environment from a low-income economy to the first stages of a middle-income country. ➢ Projected that the annual real GDP growth rate would rise to 8.0 percent by 2015 and 10.0 percent by 2021. ➢ Per capita annual income was projected to rise to about 2000 USD by 2021. ➢ The industrial sector should have a larger share of GDP, approaching 37% by 2021. ➢ Projected that share of export would rise to about 25% of GDP.
3. National Science and Technology Policy 2011	➢ Govt. aimed to ensure science and technology as an important and integral part of all development plans and activities. ➢ S&T was the basis for formulating the national development plan for economic and cultural development. ➢ Encouraged generation, adaptation, transfer, and assimilation of technology appropriate for basic, applied, and developmental research.

Policy	Major Features
	➢ Set the target to create an adequate infrastructure of R&D in science and technology areas of national need and encourage private sectors to set up R&D centers for quality products.
4. National Innovation and Intellectual Property Policy 2018	➢ The vision of this policy is to transform Bangladesh into a knowledge- and technology-based innovative country and use IP as a tool for Bangladesh's social, cultural, and economic development. ➢ Set the mission to establish development-oriented pro-stakeholders and balanced IP infrastructure in the country and make IP an integral part of the national development plans. ➢ Declaration of Innovation Decade from 2018 to 2028. ➢ A clear vision of promoting and protecting the IP issues, such as patent, design, trademark, copyrights, trade secret, geographical indications, layout design, utility model, plant varieties, etc., and integrating those issues in relevant policies and strategies were set. ➢ Reorganize and strengthen IP offices and institutions in public and private sectors regarding capacity building, transparency, and services for promoting, protecting, administering, and enforcing IPRs.

Note. Source: Author's creation based on relevant policy documents.

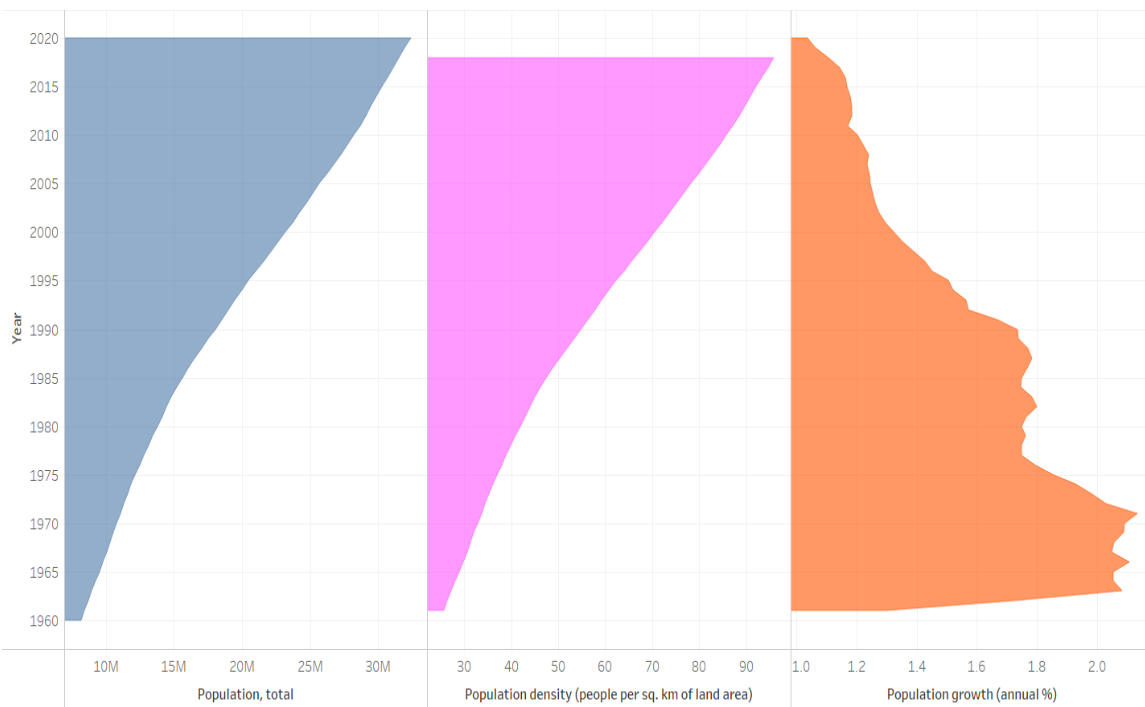
Malaysia

Overview of Malaysia

Malaysia is a Southeast Asian country and a member of the Association of Southeast Asian Nations (ASEAN). The Sultanate of Malacca governed the territories of Malaysia before 1511. However, those first fell into the Portuguese, beginning a colonial era in Malaya. Later, these territories became a colony of the Dutch and the British. British colonization started in 1824 and continued until the Second World War. Finally, Malaya became independent in 1957, and a state named Malaysia was formed in 1963, consisting of four colonies: Malaya, Sabah, Sarawak, and Singapore (Malaysia Information, n.d.). However, Singapore separated from Malaysia as an independent and sovereign state in 1965.

Malaysia is the 66th largest country globally in terms of total land area and the 45th largest country in total population. In 2020, the estimated population of Malaysia was about 32.36 million, and the population density is about 96 people per square kilometer of land area. The approximate annual population growth was 1.036 percent in 2020. The population growth in Malaysia was higher before 1972, when the population growth rate was more than 2 percent per annum; however, the population growth rate started decreasing during the 1990s. Figure 6 presents Malaysia's population, population density, and population growth over the years.

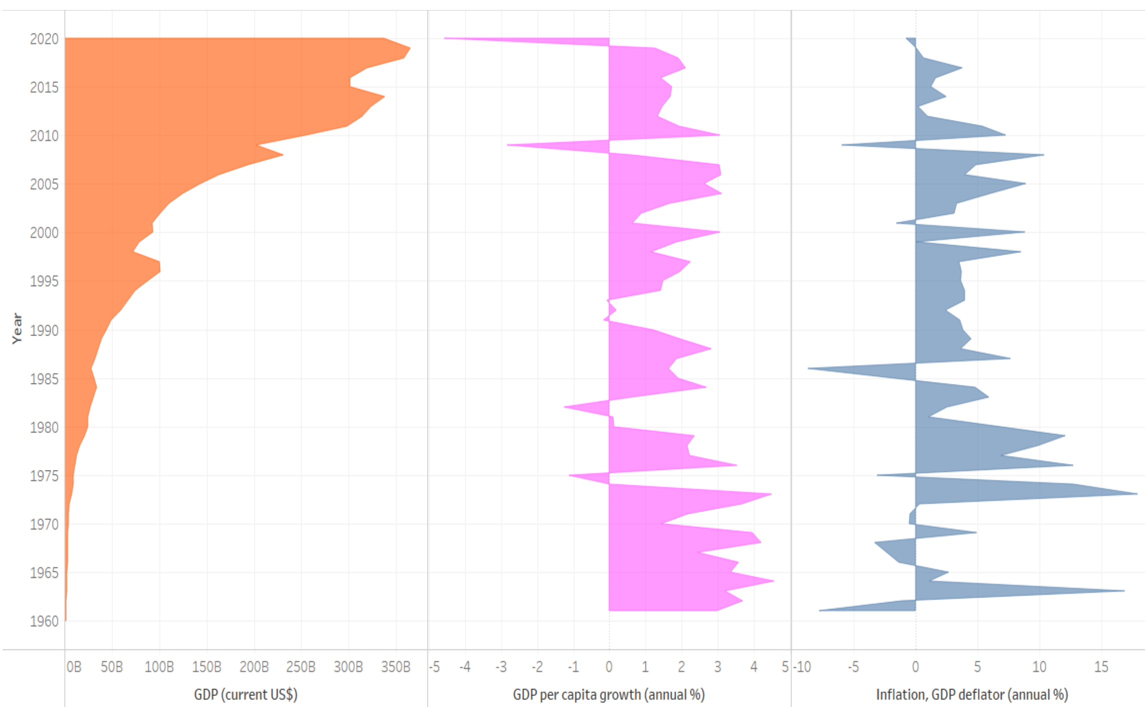
Figure 6. Total Population, Population Density, and Growth of Malaysia



Note. Source: World Bank (2021).

Malaysia is one of Asia's greatest success stories, with impressive economic and social development since its independence in 1957. It is characterized by an unpainful transition of power from colonial rulers, fewer conflicts, and well-developed institutions (Hill et al., 2012). It has shown robust growth and succeeded in developing into an upper-middle-income country. Now Malaysia is very close to passing the high-income threshold. Though Malaysia has been growing, the growth rate was not always smooth. During the 1990s, Malaysia was enjoying a period of higher growth interrupted by the Asian financial crisis of 1997. It was also hard hit by the global financial and economic crisis in 2009 (Organisation for Economic Cooperation and Development [OECD], 2016). However, from 2010 to 2019, there was moderate growth at the rate of 5.33 percent per annum. Figure 7 presents GDP, GDP per capita growth, and the inflation rate over the years.

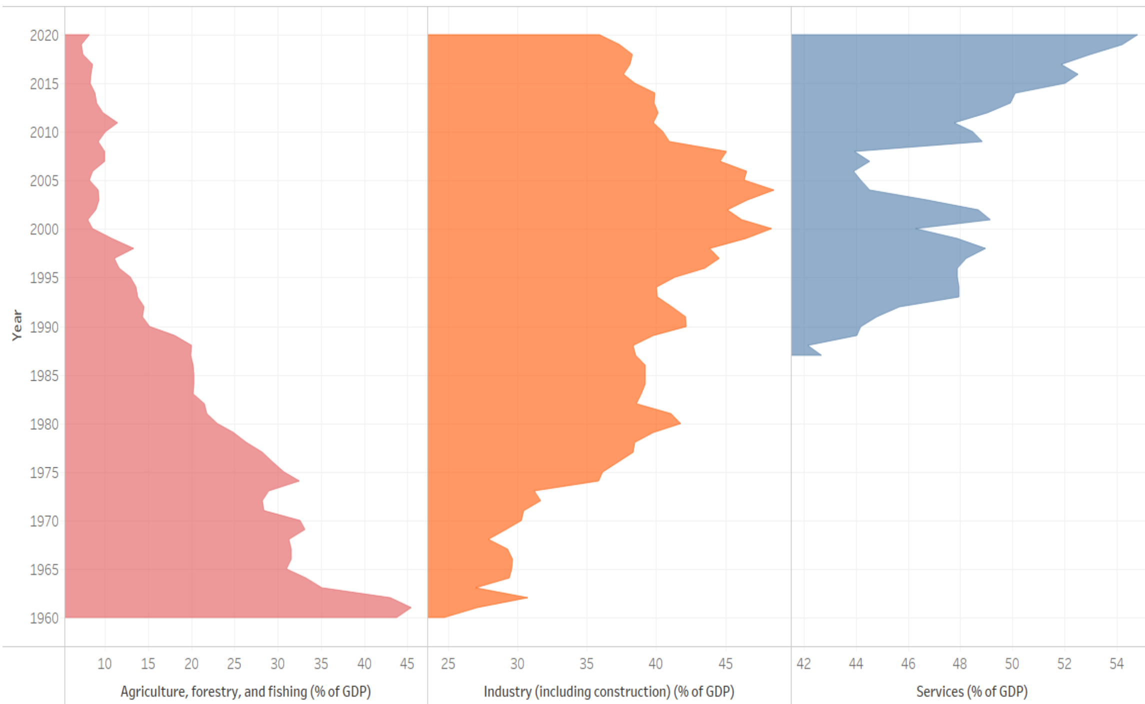
Figure 7. GDP, GDP Per Capita Growth, and Inflation in Malaysia



Note. Source: World Bank (2021).

Malaysia had a profound transformation and moved from an economy dependent on primary commodities to one driven by manufacturing. Recently, the Malaysian economy has experienced a large share of GDP from the services sector (OECD, 2016). In 1960, the agricultural sector had 43.72 percent, and the industrial sector had 24.71 percent. However, in 2000, the share of agriculture decreased to only 8.60 percent, while the industry share rose to 48.32 percent of GDP. After the 2000s, the value addition of the industrial sector also started decreasing while the service sector became vibrant. In 2019, the share of the service sector in GDP became 54.78 percent, and the industrial sector's share became approximately 36 percent. Figure 8 presents the share of agriculture, industry, and services in GDP over the years.

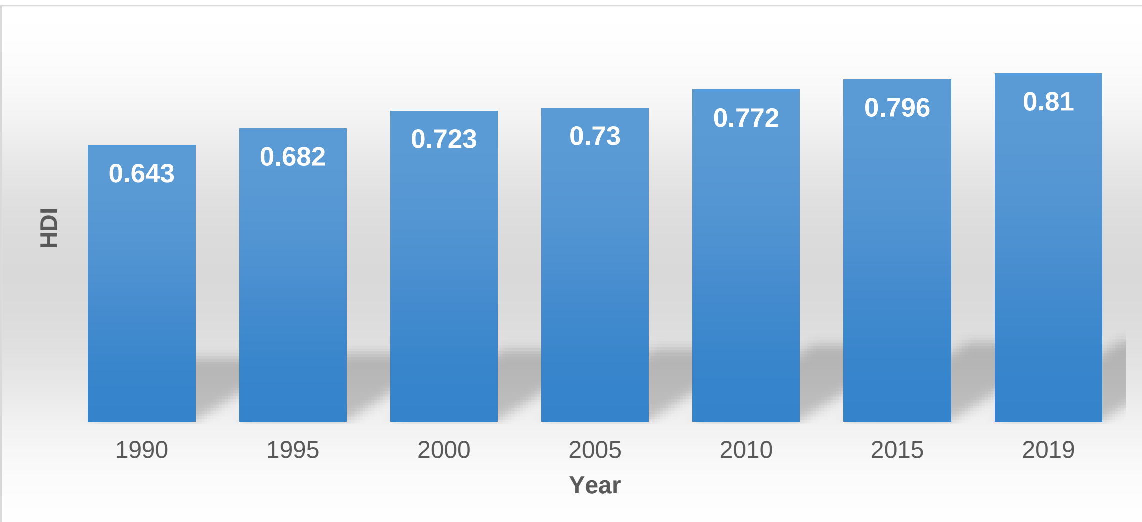
Figure 8. Share of Agriculture, Industry, and Services in GDP of Malaysia



Note. Source: World Bank (2021).

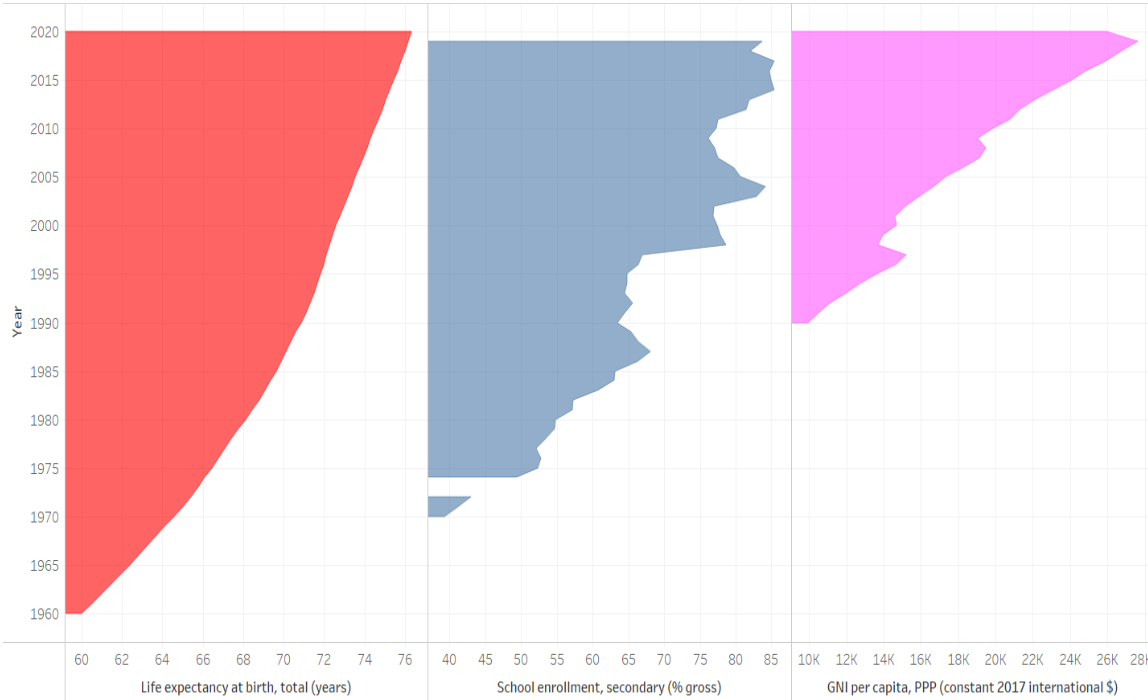
In 1990, Malaysia's human development index (HDI) value was 0.643, which ranked Malaysia 69th out of 144 countries. Nonetheless, the human development index (HDI) value increased from 0.643 to 0.810 from 1990 to 2019, and the HDI value of 0.810 in 2019 ranked Malaysia 62 out of 189 countries. However, Malaysia's life expectancy at birth was approximately 60 years in 1960, which rose to 70.87 years in 1990. Furthermore, from 1990 to 2019, the life expectancy at birth increased by 5.44 years, the mean years of schooling increased by 3.9 years, and the GNI per capita increased by approximately 177 percent (United Nations Development Programme [UNDP], 2020). Figure 9 presents Malaysia's overall human development index over the years. The life expectancy, school enrollment rate, and GNI per capita are also presented in Figure 10.

Figure 9. Human Development Index (HDI) of Malaysia



Note. Source: United Nations Development Programme (2020).

Figure 10. Life Expectancy, School Enrollment, and GNI Per Capita in Malaysia



Note. Source: World Bank (2021).

Industrialization of Malaysia

Malaysia inherited a liberal economic system, a tradition of stable macroeconomic policies, better infrastructure, and living standards when it became independent in 1957 from the British (Salleh & Meyanathan, 1993). Lall (1995) has shown three phases of Malaysian economic development. From 1957 to 1970, the first phase, the policy of import-substitution and the measures of attracting FDI were emphasized, which caused the introduction of protectionist measures and encouraged foreign firms to invest (see Table 5 for major policies toward Malaysian industrialization). The establishment of the Malaysian Industrial Development Authority (MIDA) in 1967 was essential to Malaysian industrialization. This authority assisted in building a dynamic and sustainable ecosystem in the industrial sector. It was also delegated to disburse fiscal incentives to ensure a favorable investment climate for high-tech export industries. From 1971 to 1985, the New Economic Policy (NEP) was introduced in the second phase to alleviate the underlying interethnic antagonisms over economic affairs. This policy resulted in an increased share in foreign-owned plantations and non-export industries and encouraged establishing state enterprises. This policy also introduced tax incentives to attract FDI in free trade zones and export processing zones.

In addition, the launching of the Heavy Industries Corporation of Malaysia (HICOM) in 1980 (Lall, 1995) focused on diversifying manufacturing activity and reducing heaving dependence on a small number of export-oriented activities. It promoted large projects in heavy industries such as steel production, machinery and equipment, petrochemical, cement, and automobile. HICOM also encouraged SMEs by promoting collaboration with foreign firms through technological development and more investment in R&D. The third phase, from 1985 onwards, the New Development Policy (NDP) was replaced with NEP to move towards the industrial interventions adopted by the East Asian Newly Industrialized Economies (NIEs).

The First Industrial Master Plan (IMP1), 1986–1995, emphasized a more selective strategy and provided distinct long-term indicative development roadmaps for targeted sectors and more targeted import protection. However, trade was liberalized by 1994 though support for the infant industry protection was retained. The Second Industrial Master Plan (IMP2), 1996, continued the strategies and steps of IMP1 and emphasized the functional, product, and value chain upgrade of the key manufacturing sector. Later, the Malaysian government introduced the Third Industrial Master Plan (IMP3) in 2006 in the context of significant manufacturing growth slow-down and a decrease in productivity and exports. This plan targeted to reach long-term global competitiveness and industrial growth through innovation in the manufacturing and services sector (Jomo et al., 2005; Lall, 1995; OECD, 2016). Table 5 presents major policies toward industrialization undertaken by different Malaysian governments.

Table 5. Major Policies toward Malaysian Industrialization

Major Policies/Plans	Significant Steps Toward Industrialization
1. Import Substitution Industrialization Strategy, 1958	➢ Introduction of protectionist measures, and at the same time, foreign firms are encouraged to invest. ➢ Domestic or foreign firms promoted the production of previously imported goods on Malaysian territories.
2. Establishing the Malaysian Industrial Development Authority (MIDA)	➢ MIDA was established under MIDA Act, 1967, which assisted in building a dynamic and sustainable investment ecosystem. ➢ Generous fiscal incentives were introduced to make a favorable investment climate for high-tech export industries.
3. New Economic Policy (NEP), 1970	➢ Steps were taken to alleviate the underlying interethnic antagonisms over economic matters. ➢ Domestic shares were increased in foreign-owned plantations and non-export enterprises. ➢ Tax incentives were introduced to attract FDI in free trade zones and export processing zones.
4. Launching Heavy Industries Corporation of Malaysia (HICOM), 1980	➢ Launched large projects in heavy industries such as steel production, machinery, petrochemical, cement, and automobile. ➢ Manufacturing activities were diversified and heavy dependence on a small number of export-oriented activities was also reduced. ➢ Promoted small and medium enterprises and led technological development by collaborating with foreign firms and investing more in local R&D.

Major Policies/Plans	Significant Steps Toward Industrialization
5. First Industrial Master Plan (IMP1), 1986	➢ The launch of IMP1 renewed and strengthened financial incentives to export-oriented firms and high value-added activities. ➢ Tax allowances on firms' training and R&D expenditures. ➢ Some targeted sectors were provided with long-term development roadmaps.
6. Action Plan for Industrial Technology Development (APIDT, 1990–2011)	➢ Strategic and integrated steering of innovation activities were introduced in specific sectors. ➢ Industrial R&D, matching grants, and soft loans toward industry-oriented and market-driven research were increased.
7. Second Industrial Master Plan (IMP2), 1996	➢ IMP2 emphasized the vital manufacturing sector's functional, product, and value chain upgrade. ➢ The industrial sector was targeted toward higher technology operations and developing the information technology and multimedia industry.
8. Third Industrial Master Plan (IMP3), 2006	➢ The introduction of this plan was in the context of significant manufacturing growth slow-down and a decrease in productivity and exports. ➢ The manufacturing and services sector was targeted to prepare for long-term global competitiveness and industrial growth through innovation in the manufacturing and services sector.

Note. Source: Author's creation based on Lall (1995) and OECD (2016).

Comparison of Country Characteristics

Table 6 presents a comparison of major country characteristics between Bangladesh and Malaysia based on the overview discussions of these countries in this chapter.

Table 6. Comparison of Country Characteristics

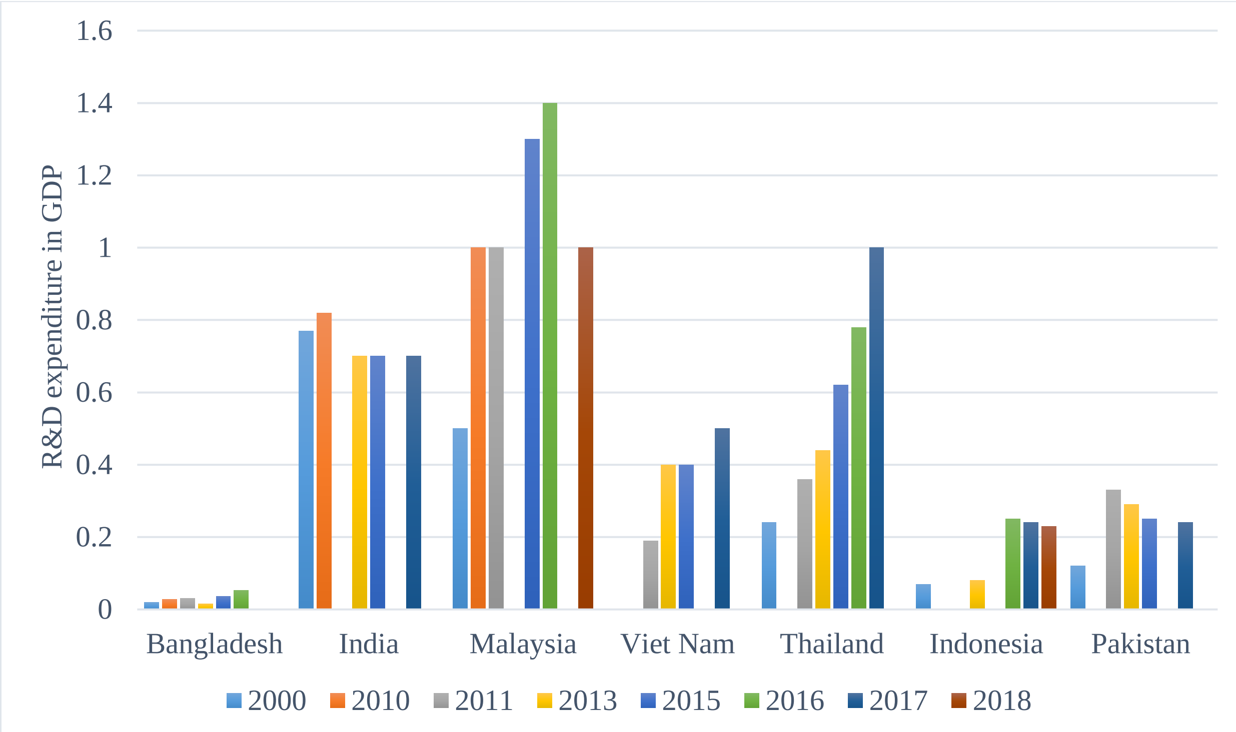
Characteristics	Bangladesh	Malaysia
Independence	Bangladesh first became independent from British colonial rule as a part of Pakistan in 1947. Later in 1971, Bangladesh became independent after a 9-month bloody war with Pakistan.	Malaysia became independent from the British rulers in 1957, consisting of four colonies: Malaya, Sabah, Sarawak, and Singapore. However, Singapore got separated from Malaysia in 1965 as an independent and sovereign state.
Country Size	Bangladesh has a relatively smaller area and land border with India and Myanmar. The total area of Bangladesh is 147,000 sq. km.	Malaysia is the 66th largest country in the world in terms of total land area. Currently, the total land area of Malaysia is 329,960 sq. km.
Population	Bangladesh has the highest population density in the world, and the estimated total population was 166.30 million in 2021.	The total estimated population of Malaysia in 2020 was 32.78 million in 2021, and the population density is about 96 persons per square kilometer.
Income Level	Bangladesh reached the Lower Middle-Income Country (LMIC) status in 2015 and is expected to graduate from the UN's LDC list in 2026.	Currently, Malaysia is an Upper Middle-Income Country (UMIC) and very close to passing the high-income threshold.
Share of Agriculture in GDP	The share of agriculture was more than half of GDP in the 1970s, which came down to 11.6% in 2021.	In the 1960s, the share of agriculture in GDP was more than 30%, which was reduced to 9.6% in 2021.
Share of Industry in GDP	Industry share in GDP was less than 15% in the early 1970s, which rose to 33.3% in 2021.	In the 1960s, the industry sector's share in GDP was around 30%, which rose to more than 40% in the 2000s. However, there was a decline in industry GDP later, and it became 37.7% in 2021.
Share of Service Sector in GDP	The service sector moved around 35% of GDP at the time of independence, which became 51.3% in 2021.	Recently there has been a sharp increase in the contribution of the service sector to GDP. In 2021, the share of the service sector was 51.5%.

Characteristics	Bangladesh	Malaysia
Per capita GDP	Bangladesh had a very low per capita at the time of independence in 1971, and that was 133.6 USD (current). However, per capita GDP rose to 2503 USD (current) in 2021.	Malaysia had a per capita GDP of 234.9 USD (current) in 1960, which rose to 799.9 USD (current) in 1974. However, in 2021, Malaysia’s per capita GDP has reached 11,371.1 USD (current).
HDI score	In 1990, Bangladesh had an HDI score of 0.394, which increased to 0.632 in 2019.	Malaysia has had a moderate HDI score since the inception of the HDI in 1990. The score was 0.643 in 1990, and that rose to 0.803 in 2021.
School Enrollment	School enrollment at the secondary level was 21% in 1971, while that became 74% in 2020.	In 1974, school enrollment at the secondary level was 49% and rose to 82% in 2020.
Life Expectancy	The life expectancy at birth was 47 years in 1971, which has gone up to 73 years in 2020.	In 1960, the life expectancy at birth was 60 years, which increased to 76.31in 2020.

Comparison of R&D Investment

The literature review in Chapter II reported that R&D investments are a critical element for innovation and competitiveness, and many studies of firms have measured R&D in numerous ways. Many studies have used the value of R&D investment as a covariate of innovation. The trend of gross R&D expenditure in GDP illustrates how the countries are promoting innovation through R&D. As stated earlier, this dissertation’s focal country is Bangladesh, and the comparative status of R&D expenditure as a percentage of GDP with other neighboring and comparator countries can reflect the R&D status of Bangladesh. Figure 11 presents below the Gross R&D Expenditure in GDP of different comparator countries of Asia.

Figure 11. Comparative R&D Expenditure as a Percentage of GDP[11]



Note. Source: Based on Ferdaous & Rahman (2017), Park & Kim (2020), UNESCO Institute of Statistics (2021), and World Bank (2021).

Comparison of Innovation Capabilities

Innovation capability is one of the measures of how well an economy is doing in terms of competitiveness. A higher level of competitiveness suggests increased economic well-being; more competitive economies are more likely to grow sustainably and inclusively, which eventually can help enjoy the benefits of economic growth (Cann, 2017). Schwab (2017) defines competitiveness “as the set of institutions, policies, and factors that determine the level of

[11] Data on gross R&D expenditure as percentage of GDP of the four countries are not available from a single data source rather than those data are collected from different sources. Bangladesh’s data have been collected from Ferdaous & Rahman (2017) and Park & Kim (2020), while Indian data mostly come from Park & Kim (2020). Furthermore, Malaysian and Vietnamese data have been collected from UNESCO Institute of Statistics (2021). The data for Thailand, Indonesia, and Pakistan are collected from World Bank (2021). However, some data are missing in some specific years.

productivity of an economy, which in turn, sets the level of prosperity that the economy can achieve" (p. 11).

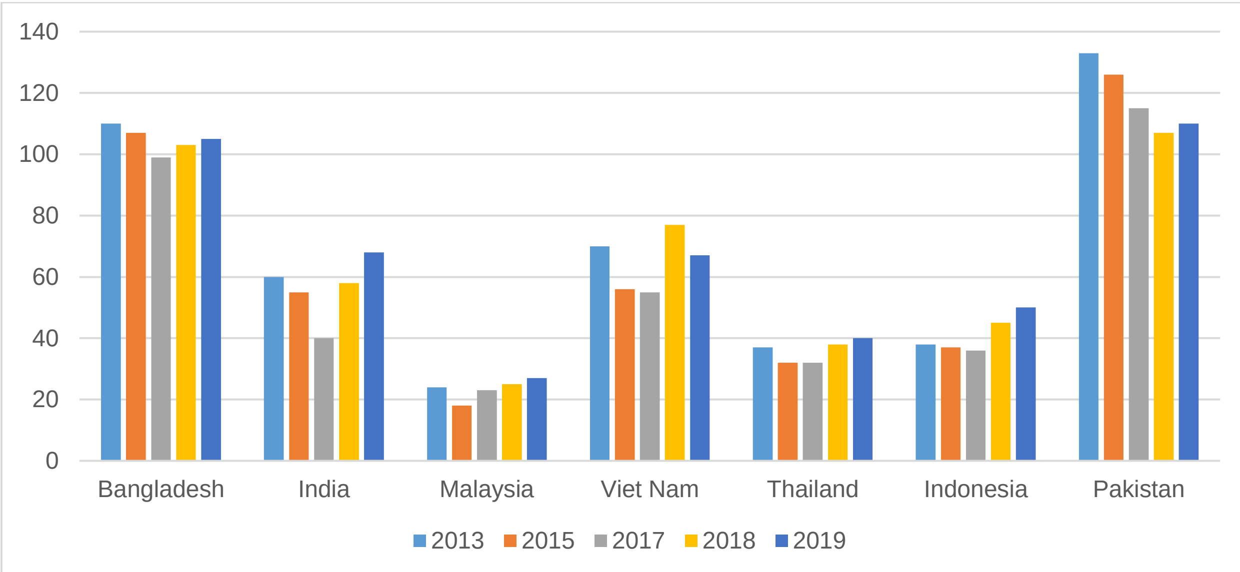
Perhaps the first initiative to measure global competitiveness was in 1979 by Professor Klaus Schwab, and the *Competitiveness of the European Industry* was a product of his efforts. The first report analyzed the competitiveness of 16 European countries to support policymakers and business leaders in formulating better economic policies and institutional reforms. However, since 2005, the Global Competitiveness Index (GCI) has provided a standardized assessment methodology used to assess the competitiveness of over 140 economies for producing the *Global Competitiveness Report*, though the methodology has undergone revisions (Schwab, 2014). The GCI currently uses 114 indicators to capture the matter for productivity and long-term prosperity. Those indicators are grouped into 12 pillars: institutions, infrastructure, macroeconomic environment, health and primary education, higher education and training, goods market efficiency, labor market efficiency, financial market development, technological readiness, market size, business sophistication, and innovation capability.

The pillar, 'Innovation Capability,' is one metric for identifying an innovation-driven economy. The ten indicators used for measuring the pillar 'Innovation Capability' are the diversity of the workforce, state of cluster development, international co-invention, multistakeholder collaboration, scientific publications, patent applications, R&D expenditures, research institute prominence, buyer sophistication, and trademark applications.

As stated earlier, this dissertation's focal country was Bangladesh. The other country studied for comparative purposes was Malaysia, which was chosen as an emulate based on its economic competitiveness ranking among the developing countries of Asia. Malaysia is one of the top-ranking Asian developing countries on the Global Competitiveness Index (GCI). Figure

12 shows the overall country ranking of Bangladesh and Malaysia (a lower ranking implies a more competitive country), including several other comparator countries of Asia based on Schwab (2019).

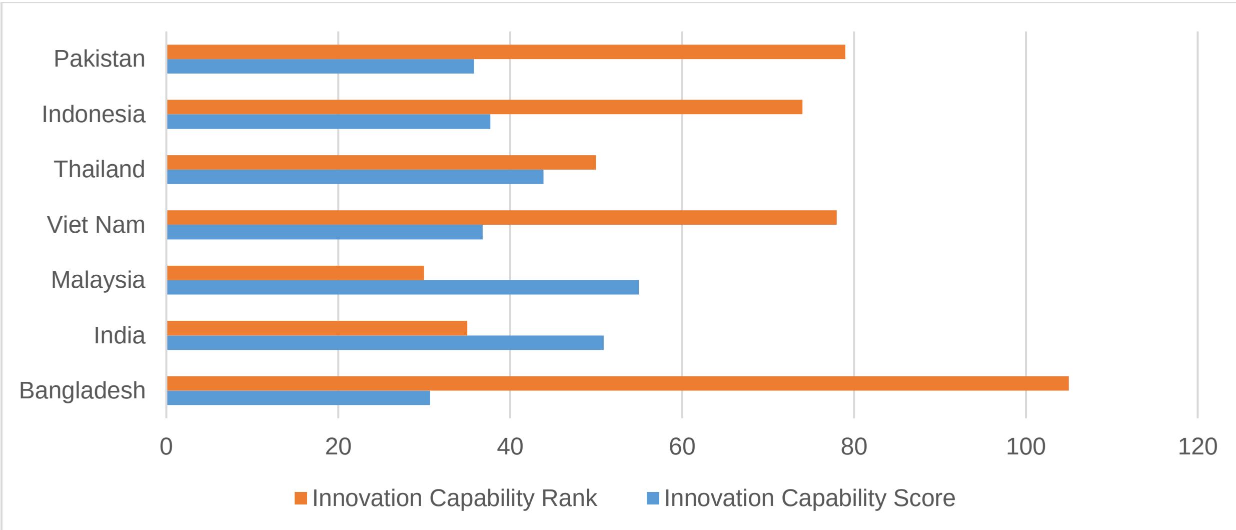
Figure 12. Comparative Country Ranking as Per GCI 4.0



Note. Source: The Global Competitiveness Report (2013-2019).

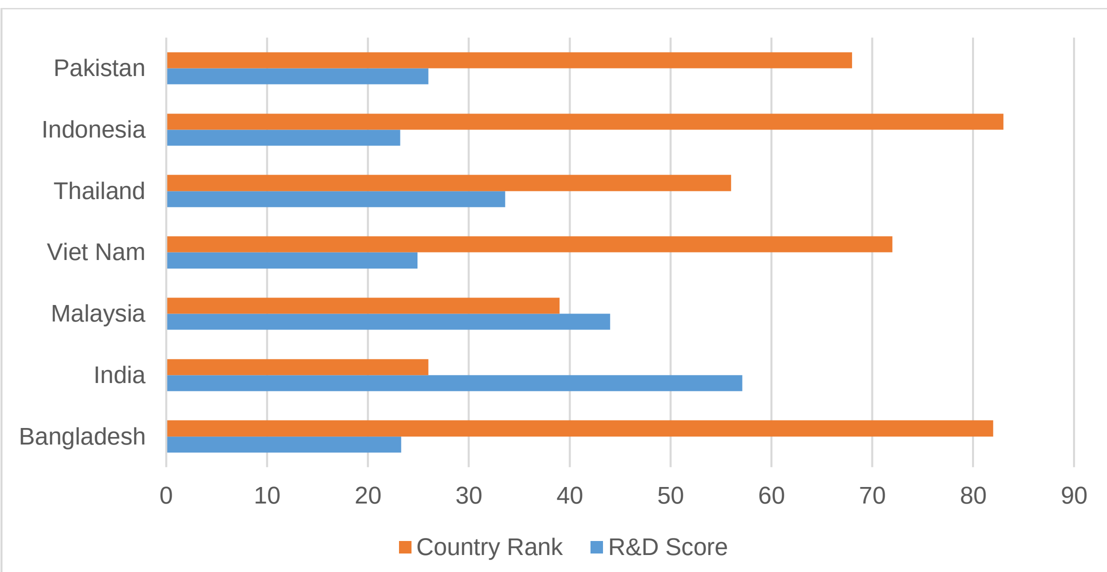
Figure 13 shows the comparative innovation capability country rank and the associated score ranging from 0 to 100. Also, Figure 14 presents the comparative country ranking based on R&D performance and the associated index. These rankings and scores are based on the Global Competitiveness Report 2019.

Figure 13. Comparative Innovation Capability Ranking and Score



Note. Source: Global Competitiveness Index 4.0, 2019

Figure 14. Comparative R&D Performance Ranking and Score



Note. Source: Global Competitiveness Index 4.0, 2019

It is evident that the country's ranking is inversely proportional to the score of the concerned pillar and sub-pillars. Bangladesh is the lowest-ranked R&D performer among the listed countries, and it has the lowest ranking in terms of R&D as a percentage of GDP shown in Figure 11.

CHAPTER IV: DATA AND DESCRIPTIVE STATISTICS

This chapter is divided into two parts. The first part presents a general description of the datasets used in the dissertation, and the second part provides descriptive statistics on those data. In the general description of the data, different sources of the data and the survey questions are described, and tables are presented with the survey questions that pertain to different forms of innovation and innovation activities. The primary objective of tabulating the survey questions is to document the choice of variables for the analysis in this study. The second part contains descriptive statistics and summarizes the quantitative features of the survey questions.

General Description of the Dataset

The datasets used in this study are taken from the World Bank Enterprise Survey[12] (WBES), which is based on firm-level surveys and covers a representative sample of an economy's private sector. The World Bank started conducting firm-level surveys in the 1990s. However, it emphasized the data collection efforts by setting a centralized and standardized format in 2005. These efforts of the World Bank establish comparability of firm-level data across countries. For this dissertation, this survey is termed the Standard Enterprise Survey (SES). The SES covers extensive information on a firm's experience in the private sector, focusing on the economy's business environment and investment climate encompassing corruption, competition, access to finance, and various performance measures.

Additionally, the World Bank launched the Innovation Follow-up Survey (IFS) in 2011, focusing on innovation and innovation-related activities within firms by revisiting the surveyed firms in the SES.

[12] The data source is Enterprise Surveys, the World Bank, http://www.enterprisesurvey.org

This dissertation focuses on two economies: Bangladesh and Malaysia. The WBES has conducted two kinds of surveys for Bangladesh; the first is the SES for Bangladesh, conducted between April 2013 and September 2013, and the second one, the IFS, was conducted from October to November 2013 to June 2014. However, the WBES has conducted only the SES for Malaysia, which continued from March 2015 to May 2016.

The SES for Malaysia provides more innovation-related information than the SES for Bangladesh. For example, the number of survey questions related to innovation in the SES questionnaire for Bangladesh is only nine; in contrast, the SES for Malaysia has more than nineteen survey questions related to innovation. The WBES has not administered any separate follow-up innovation survey for Malaysia. On the one hand, the survey questions in the SES for Malaysia about innovation are classified into five groups: product innovation, process innovation, organizational innovation, marketing innovation, and innovation activities. On the other hand, the SES in Bangladesh has nine survey questions related to innovation and innovation activities, while the IFS has six parts, of which five pertain to innovation questions. These five parts contain survey questions on product innovation, process innovation, organizational innovation, marketing innovation, and innovation activities. However, some survey questions in the IFS are different from the SES to some extent. Thus, only standard enterprise surveys of the two countries have been considered in this study to make a consistent analysis.

Descriptive Statistics

Six variables form the basis for the empirical analysis in this dissertation. The variables are based on the literature review in Chapter II and survey questions of enterprise surveys conducted in the two countries. Among those variables, one is the dependent variable, and five are independent variables. Among the independent variables, two are technical capital, and the other three are human capital.

The SES has different innovation questions related to product, process, organization, and marketing; however, this study has mainly focused on product innovation. There are two survey questions on product innovation. One is a new product innovation to the firm, and the other is a new product innovation to the market. If a firm has introduced new or significantly improved products or services, that is called product innovation new to the firm and termed *ProductInnov*. The related survey question is: “During the last three years [from the date of the interview between April 2013 and September 2013], has this establishment introduced new or significantly improved products or services?” The firms that have product innovation new to the firm have some that are also new to the market. The survey question related to new product innovation to the firm is: “Were any of the new or significantly improved products or services also new for the establishment’s main market?” As the innovations that are new to the firm might be imitative, thus this study has focused on only those firm innovations that are new to the market. From now on, *ProdInnovNMkt* is the innovation variable representing innovation outcomes.

Among the independent variables, R&D is the focal variable in this dissertation. This technical capital variable represents whether the firm does research and development activities in the firm. The survey question in the WBES of Bangladesh is: “During the last three years [from the date of the interview between April 2013 and September 2013], did this establishment spend on formal research and development activities, either in-house or contracted with other companies?” However, the survey question for R&D for Malaysia is slightly different from that of Bangladesh. The firms which conduct only market research surveys are excluded from the list of R&D firms in the case of Malaysia, while the issue of market research surveys is not mentioned precisely for the survey question in the SES of Bangladesh. And the survey question for Malaysia is, “During the last three years [from the date of the interview between March 2015 and May 2016], did this establishment spend on formal R&D activities, either in-house or contracted with other companies, excluding market research surveys?” The variable *RND* represents the R&D activities of the firms.

Foreign technology is another source of technical capital and one of the important inputs for innovation output, especially for developing countries. A firm with foreign technology means whether the firm uses a technology licensed by a foreign-owned company. The survey question in the WBES is: “Does this establishment at present [during the interview period between April 2013 and September 2013 for Bangladesh and between March 2015 and May 2016 for Malaysia] use technology licensed from a foreign-owned company, excluding office software?” The variable is named as *ForeignTech* in this study.

Three other human capital variables are the education level of the employees, the management experiences of the top-level managers, and the firm’s size based on the number of employees. The survey question for the education level of the employees is: “What is the average number of years of education [as of the date of interview] of a typical permanent full-time production worker employed in this establishment?” This variable is named as *AvgYrsEduc*. And the survey question for top managers’ managerial experience is: “How many years of experience working in this sector [as of the date of interview] does the Top Manager have?” This variable is named as *MgmtExp*.

Another human capital variable is related to the size of the firms, which is based on the number of employees. The survey question used for the firm’s sizes has three responses: whether the firm is small, medium, or large. If the firm has less than or equal to 19 employees, then the firm is small, and if the firm has less than or equal to 99 employees and greater than or equal to 20 employees, then the firm is medium-sized. Additionally, if the firm has more than or equal to 100 employees, then the firm is large. However, a binary variable, *Employment*, is created, which is equal to 1 if the firm has greater than or equal to 100 employees, and 0 otherwise. Table 7 presents the definitions of the dependent and the independent variables.

Table 7. Variable Definitions[13]

Dependent Variables	Definition
ProductInnov	If the firm has introduced new or significantly improved products or services in the last three years, then equal '1' and otherwise '0.'
ProdInnovNMkt	If the firm has introduced new or significantly improved products or services in the last three years and that is new to the firm, then equal '1' and otherwise '0.'
Independent Variables	
RND	If the firm has spent on formal R&D activities, either in-house or contracted with other companies in the last three years, then equal '1' and otherwise '0.'
ForeignTech	If the firm uses technology licensed from a foreign-owned company at present, excluding office software, then equal '1' and otherwise '0.'
AvgYrsEduc	Average years of education of a typical permanent full-time production worker (as of the interview period between April 2013 and September 2013 for Bangladesh and between March 2015 and May 2016 for Malaysia).
MgmtExp	Top manager's years of working experience in the sector.
Employment	If the firm has more than or equal to 100 employees, then equal '1' and otherwise '0.'

[13] As of the interview period between April 2013 and September 2013 for Bangladesh and between March 2015 and May 2016 for Malaysia. Thus, the last three years is dated from the time of the survey.

Most of the survey questions in the datasets have three answers "yes," "no," or "Don't know (spontaneous)," except in the cases of survey questions with discrete or continuous answers. For example, the survey questions related to variables *ProdInnovNMkt*, *RND*, and *ForeignTech* have these three answers. The variables *AvgYrsEduc* and *MgmtExp* are continuous, but those have another option of an answer "Don't Know." The other variable, *Employment*, consists of four answers to a survey question for Bangladesh—whether the firm is micro, small, medium, or large. In Malaysia, the survey question has three answers—small, medium, or large.

Table 8. Responses for Different Survey Questions[14]

Variable	Survey Question	Response	Country
ProductInnov	During the last three years, has this establishment introduced new or significantly improved products or services?	Yes – 491 No – 949 Don't Know – 2	Bangladesh
		Yes – 100 No – 883 Don't Know – 17	Malaysia
ProdInnovNMkt	Were any of the new or significantly improved products or services also new for the establishment's main market?	Yes – 278 No – 198 Don't Know – 15	Bangladesh
		Yes – 67 No – 33 Don't Know – 0	Malaysia
RND	During the last three years, did this establishment spend on formal research and development activities, either in-house or contracted with other companies?	Yes – 221 No – 1214 Don't Know – 7	Bangladesh

[14] The time period is based on the interview date between April 2013 and September 2013 for Bangladesh and between March 2015 and May 2016 for Malaysia]

Variable	Survey Question	Response	Country
	During the last three years, did this establishment spend on formal research and development activities, either in-house or contracted with other companies, excluding market research surveys?	Yes – 199 No – 785 Don’t Know – 16	Malaysia
ForeignTech	Does this establishment presently use technology licensed from a foreign-owned company, excluding office software?	Yes – 175 No – 1004 Don’t Know – 1	Bangladesh
		Yes – 115 No – 449 Don’t Know – 21	Malaysia
AvgYrsEduc	What is the average years of education of a typical permanent full-time production worker employed in this establishment?	Don’t Know – 16 Different number in years – 1164	Bangladesh
		Don’t Know – 72 Different number of years – 513	Malaysia
MgmtExp	How many years of experience working in this sector does the Top Manager have?	Don’t Know – 9 Different number in years – 1433	Bangladesh
		Don’t Know – 110 Different number in years – 890	Malaysia
Employment	Micro <5 Small >=5 and <=19 Medium >=20 and <=99 Large >=100	Small – 573 Medium – 492 Large – 377	Bangladesh
		Small – 383 Medium – 322 Large – 295	Malaysia

Note. Source: World Bank Enterprise Survey.

The responses to the survey questions with “Don’t know (spontaneous)” have been dropped from the datasets. A response of “yes” to a survey question is coded by a numerical value of “1,” and a response of “no” is coded by a numerical value of “0.”

The answer to the survey questions related *AvgYrsEduc* and *MgmtExp* are continuous. Answers are generally of two types. One type represents a continuous number, and the other is “Don’t Know (spontaneous).” Like the binary variables, the responses to the survey questions with “Don’t know (spontaneous)” have been dropped from the datasets for better analysis. In the case of the variable, *Employment*, answers to the survey questions with “Large” are given a numerical value of “1.” In contrast, the answer with “Micro,” “Small,” and “Medium” are given “0,” which also create a binary variable. Tables 9 and 10 present the number of different answers to different survey questions of the SES for Bangladesh and Malaysia, respectively.

Table 9. Descriptive Statistics for Bangladeshi Firms (*n* = 1,136)

Variables	Mean	SD	Min	Max
ProdInnov NMkt	.206	.405	0	1
RND	.165	.372	0	1
Foreign Tech	.149	.356	0	1
AvgYrs Educ	6.623	2.289	1	16
MgmtExp	19.826	10.57	1	60
Employment	.35	.477	0	1

Table 10. Descriptive Statistics for Malaysian Firms (*n* = 415)

Variables	Mean	SD	Min	Max
ProdInnov NMkt	.099	.299	0	1
RND	.299	.458	0	1
Foreign Tech	.222	.416	0	1
AvgYrs Educ	9.455	4.141	1	25
MgmtExp	11.865	7.757	1	50
Employment	.422	.494	0	1

Bangladeshi SES contains a sample size of 1,442 firms, but the sample size is reduced to 1,136 after deleting firms due to responses of "Don't know." As noted above, the survey year for Bangladesh was 2013. The mean value of *ProdInnovNMkt* for Bangladesh is .206, implying that 20.6 percent of Bangladeshi firms had product innovations new to the market in the last three years. The mean value of RND is .165, indicating that 16.5 percent of the firms did R&D in the last three years, while the mean value of *ForeignTech* is .149, suggesting that 14.9 percent of the firms used technology licensed from a foreign-owned company in the survey year. The mean values for *AvgYrsEduc* and *MgmtExp* are 6.623 and 19.826 years, respectively. It implies that, on average, the number of years of education of a typical permanent full-time production worker was 6.623 years in the survey year, while the top manager's experience, on average, was 19.826 years in the survey year. The mean value of *Employment* is .35, implying that 35 percent of the firms are large or had more than 100 employees in the survey year.

The sample size of the SES for Malaysia is 1000, which is reduced to 415 after deleting firms due to responses of "Don't know." As noted above, the survey years for Malaysia were 2015-2016. The summary statistics show that the mean value of *ProdInnovNMkt* for Malaysia is .099, implying that 9.9 percent of Malaysian firms had product innovations new to the market in the last three years. The mean value of *RND* is .299, suggesting 29.9 percent of the firms did R&D in the last three years, while the mean value of *ForeignTech* is .222, indicating 22.2 percent of the firms used foreign technology licensed from a foreign-owned company in the survey year. The mean values for *AvgYrsEduc* and *MgmtExp* are 9.445 and 11.865 years, respectively. Thus, on average, the number of years of education of a typical permanent full-time production worker was 9.445 years in the survey year, while the top manager's experience, on average, was 11.865 years in the survey year. The mean value of *Employment* was .422, implying that 42.2 percent of the firms were large or had more than 100 employees in the survey year.

On average, Bangladeshi firms are more innovative than Malaysian firms, as measured by the variable *ProdInnov NMkt*, while more Malaysian firms conduct R&D than Bangladeshi firms. Additionally, Malaysian firms use more foreign technology than Bangladeshi firms. It seems counter-intuitive that although fewer Bangladeshi firms are doing R&D and using less foreign technology, more Bangladeshi firms are innovative than their Malaysian counterparts. However, this tendency of a firm's innovation behavior may come from diminishing marginal returns to R&D investment and convergence theory, as discussed in Chapter V.

CHAPTER V: ECONOMETRIC MODEL

This study has used an analytical model following the framework of Link (2020) mentioned in Chapter II.

$$Innovation = f\,(R\&D, \mathbf{X})$$

where *Innovation* is measured in two ways: percent of firms that introduced a new-to-the-firm product/service (*PctInnovProdSer*), and percent of firms that introduced a new-to-the-market product/service (*PctInnovProdSerNewMkt*). *R&D* is measured by the percent of firms that spend on R&D (*PctR&D*), and vector **X** represents other explanatory variables that describe innovation activities.

However, for this dissertation, the innovation variable *ProdInnovNMkt* is binary, which measures whether the firm introduced new or significantly improved products or services that are new to the market. The empirical approach in this chapter is based on the following form:

$$\mathrm{P}(ProdInnovNMkt = 1 | RND, \mathbf{X}) = f(RND, \mathbf{X})$$

The focal explanatory variable, *RND,* is also binary and measures whether or not the firm spends on formal research and development activities. The other explanatory variables are *ForeignTech*, *AvgYrsEduc*, *MgmtExp,* and *Employment*. *ForeignTech* is a binary variable that measures whether the firm uses technology licensed from a foreign-owned company. *AvgYrsEduc* and *MgmtExp* are two continuous variables, which measure the average years of education of the permanent full-time production workers and the top manager's experience in years, respectively. The final binary variable, *Employment,* measures whether the firm is large or not, where a firm is considered as large if it has at least 100 employees.

Several studies, including Bhattacharya & Bloch (2004), Song and Oh (2015), Hadhri et al. (2016), and Ayalew (2019), used a probit model to analyze innovation activities. The binary response model and the latent regression form of this study are the following:

$$ProdInnovNMkt = 1\{ProdInnovNMkt^{*} > 0\}$$
$$ProdInnovNMkt^{*} = \beta_0 + RND\ \alpha + x\ \beta_1 + \varepsilon \qquad (5.1)$$

where *ProdInnovNMkt* = 1 if the firm innovates, and *ProdInnovNMkt* = 0 if otherwise; *RND* indicates whether or not the firm spends on formal research and development activities, and α denotes an unknown parameter associated with the variable *RND*. Furthermore, x is the vector that represents the variables with innovation activities conducted by firms and the characteristics of the firms. Definitions of these variables are given in Table 6. β_1 denotes the vector of unknown parameters associated with the vector x. Finally, ε is a continuously distributed variable independent of *RND* and x, and the distribution of ε is symmetric around zero. The characteristics of ε have been assumed, as per Woolridge (2013), consistent with the probit model.

$$P(ProdInnovNMkt = 1) = F(\beta_0 + RND\ \alpha + x\ \beta_1)$$
$$P(ProdInnovNMkt = 0) = 1 - F(\beta_0 + RND\ \alpha + x\ \beta_1) \qquad (5.2)$$

The probability of innovation, where *ProdInnovNMkt* = 1 means the firm is innovative, is a function of ($\beta_0 + RND\ \alpha + x\ \beta_1$). Equation (5.2) is a univariate probit model where $F(.)$ is the standard normal cumulative distribution function. $F(.)$ is also the cumulative distribution function (CDF) of ε.

However, for a linear model, ($\beta_0 + RND\ \alpha + x\ \beta_1$) represents the conditional mean where α and β_1 are the marginal effects of *RND* and x on the dependent variable, respectively. In the probit model, $F(\beta_0 + RND\ \alpha + x\ \beta_1)$ is the standard cumulative probability distribution function representing the conditional probability of innovation E(*ProdInnovNMkt*|*RND*, x). Therefore, α

and β_1 do not measure the magnitude of the marginal effect; instead, their signs show the direction, i.e., the positive or negative effect on the probability of innovation. While the probit model is used, the marginal effect can be measured by taking a derivative of the cumulative probability distribution function with respect to the independent variables. If x is continuous, I would calculate a partial derivative. However, the focal variable of this study, *RND*, is binary. Thus, the probability of innovation can be measured separately, while *RND* equals '1' and while *RND* equals '0', and the difference between these two gives the marginal effect of *RND* on innovation, conditional on *x*.

In the case of the univariate probit model, the error term in equation (5.2) might not be independent of the explanatory variables, and that can create an endogeneity issue. This endogeneity will likely create biased estimates. Thus, considering a probit model where a binary explanatory variable is endogenous, the simplest model can be the following, as stated in Woolridge (2010).

$$RND = 1[x\theta + u_1 > 0] \tag{5.3}$$

$$ProdInnovNMkt = 1[RND\gamma + x\delta + u_2 > 0] \tag{5.4}$$

where (u_1, u_2) is independent of *x* and distributed as bivariate normal with mean zero, unit variances, and correlation $\rho_1 = \text{Corr}(u_1, u_2)$. Suppose $\rho_1 = 0$, the errors u_1 and u_2 are independent. The coefficients of equations (5.3) and (5.4) can then be consistently estimated by estimating two separate probit models for *RND* and *ProdInnovNMkt*. However, if $\rho_1 \neq 0$, then u_2 and *RND* are correlated, which makes the probit estimation of equation (5.4) not consistent for γ and δ. Greene (2003, Section 21.6) and some other authors have suggested a joint maximum likelihood procedure for this case. A computational framework of the model in equations (5.3) and (5.4) by decomposing the joint distribution of (*RND*, *ProdInnovNMkt*) given *x* is the following:

$$f(\mathit{ProdInnovNMkt}, \mathit{RND}|\mathrm{x}) = f(\mathit{ProdInnovNMkt}|\mathit{RND}, \mathrm{x})\, f(\mathit{RND}|\mathrm{x}) \quad (5.5)$$

The bivariate probit model used in the above econometric framework is a way to model the endogeneity of *RND*, where the marginal effect is estimated in the following way:

$$\begin{aligned} \mathit{Marginal\ Effect} = {} & \mathrm{P}(\mathit{RND}=1, \mathit{ProdInnovNMkt}=1)/\mathrm{P}(\mathit{RND}=1) - \\ & \mathrm{P}(\mathit{RND}=0, \mathit{ProdInnovNMkt}=1)/\mathrm{P}(\mathit{RND}=0) \end{aligned} \quad (5.6)$$

To estimate from equations (5.3) and (5.4), respectively, an instrumental variable is not needed, but in this case, identification would only arise through the functional form (i.e., bivariate normality of the distribution). However, introducing an exclusion restriction can make the estimates more precise. Thus, I will also consider the use of an exclusion restriction based on a variable that predicts *RND* but that, conditional on *RND*, is not thought to predict innovation. Greene (1998) finds the estimation by applying an exclusion restriction is consistent though Woolridge (2010, p-596) mentions, based on Altonji et al. (2005), that even the introduction of exclusion restriction may ultimately have little impact on the estimated marginal effect.

Since I want to find the comparative likelihood of innovation output based on the presence of R&D (*RND*=1), on the absence of R&D (*RND*=0), and the associated average marginal effect of R&D, it is required to retrieve the standard errors of the mean to estimate the confidence intervals. As analytic expressions for the standard errors are not available, I use the bootstrap method to estimate the standard errors of the average probabilities and marginal effects. It is the distribution that is obtained by generating i.i.d. (independent and identical distribution) samples with replacement from the data set and calculating the required quantities in each bootstrap sample.

Efron (1979) first proposed the bootstrap method, a computer-based method for assigning accuracy measures to statistical estimates. It has subsequently been widely used as a convenient method for obtaining valid standard errors in many non-linear contexts. Efron & Tibshirani (1994) and some other textbooks provided elaborated methods of assessing complicated accuracy measures, like confidence intervals. To illustrate the bootstrap estimate of standard error, let us consider a data-analytic situation, where a random sample **x** = (x_1, x_2, …………, x_n) is available from an unknown probability distribution *F*. The parameter of interest is θ = *t(F)*, which we estimate as $\hat{\theta} = s(\boldsymbol{x})$, for some function s(.).

A bootstrap sample x*= (x_1^*, x_2^*, ……….., x_n^*) is a random sample of size *n* drawn from $\hat{F}$. The bootstrap datapoints x_1^*, x_2^*, ………., x_n^* are not the actual data set of **x** but rather a random sample size of *n*, drawn with replacement from the original sample of *n* objects **x** = (x_1, x_2, …………, x_n). Thus, the bootstrap data set consists of members of the original data set, but some may not appear at all, some may appear once, and some may appear multiple times. Hence, the estimate of a parameter of interest for the bootstrap dataset is: $\hat{\theta}^* = s(\boldsymbol{x}^*)$. If the standard error of a statistic $\hat{\theta}$ of an unknown distribution function, *F* is $se_F(\widehat{\theta})$. The bootstrap estimate of the empirical distribution function $\hat{F}$ is defined by $se_{\hat{F}}(\hat{\theta}^*)$.

For B independent bootstrap samples $x^{*1}, x^{*2} \ldots \ldots .., x^{*B}$, each of the samples consists of *n* data values drawn with replacement from the data set of **x**. Then the bootstrap replication finds the estimate of a parameter of interest as the following:

$$\hat{\theta}^*(b) = s(x^{*b}) \qquad b = 1,2, \ldots \ldots, B. \tag{5.7}$$

Then, the sample standard deviation of the B replications can help estimate the standard error $se_F(\hat{\theta})$, by the following equation:

$$\widehat{(se)}_B = \left\{ \sum_{b=1}^{B} \left[\hat{\theta}^*(b) - \hat{\theta}^*(.) \right]^2 / (B-1) \right\}^{\frac{1}{2}} \tag{5.8}$$

where $\hat{\theta}^*(.) = \sum_{b=1}^{B} \hat{\theta}^*(b)/B$

Then the normal-approximation bootstrap confidence interval is

$$C^{nb} = \left[\hat{\theta} - z_{1-\frac{\alpha}{2}} \widehat{(se)}_B, \qquad \hat{\theta} + z_{1-\frac{\alpha}{2}} \widehat{(se)}_B \right] \tag{5.9}$$

where $z_{(1-\alpha/2)}$ is the 1-α/2 quantile of the N (0,1) distribution.

In the context of the empirical model used in this study, I will apply the bootstrap procedure to calculate the standard errors of the following parameters:

θ_1 = P(*ProdInnovNMkt* = 1|X, *RND* = 1),

θ_0 = P(*ProdInnovNMkt* = 1|X, *RND* = 0),

and $\delta = \theta_1 - \theta_0$

While applying the bootstrap procedure, the number of bootstrap replications is an issue that should be selected. As per Hansen (2020), though there is no such exact number of replications, there is a trade-off between accuracy and computation cost. The computation cost is considered linear in *B*, while the accuracy (either standard error or p-values) is proportional to $B^{-1/2}$. For some final calculations, I have used *B=1000*.

CHAPTER VI: EMPIRICAL ANALYSIS

This chapter will discuss the potential correlations among the variables chosen in Chapter IV and the empirical findings using the econometric model in Chapter V. The correlations among the variables are presented on a country-by-country basis, and the empirical findings using the univariate probit model and the bivariate probit models with and without exclusion restriction are also presented. The variable *ForeignTech* comes from the survey question "Does this establishment at present use technology licensed from a foreign-owned company, excluding office software?" and is partially different in the time frame from other innovation and R&D variables. The innovation and R&D variables are based on the last three years, and in contrast, *ForeignTech* is based on the *present* use of technology licensed from a foreign-owned company. Thus, the estimated output from a univariate probit model without the independent variable *ForeignTech* is also shown. However, the pairwise correlations among the variables are discussed first, then the empirical findings from different sets of probit models are discussed.

Correlation Matrix

Two correlation matrices are created in separate tables to see the potential correlations among the variables for both Bangladesh and Malaysia. The *p*-values in the tables indicate the significance level and are measured under the null hypothesis that two variables have zero correlation. A lower p-value indicates that the two variables have a statistically significant correlation, meaning the probability of rejecting the null hypothesis is fixed and equal to the significance level. Tables 11 and 12 present below the correlation matrix for Bangladesh and Malaysia, respectively.

Table 11. Correlation Matrix for Bangladeshi Firms

Variables	(1)	(2)	(3)	(4)	(5)	(6)
(1) *ProdInnovNMkt*	1.00					
(2) *RND*	0.236***	1.000				
(3) *ForeignTech*	-0.011	0.107***	1.000			
(4) *AvgYrsEduc*	0.103***	0.026	0.181***	1.000		
(5) *MgmtExp*	0.024	-0.026	0.014	0.155***	1.000	
(6) *Employment*	0.105***	0.135***	0.305***	0.244***	0.125***	1.000

Note. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table 12. Correlation Matrix for Malaysian Firms

Variables	(1)	(2)	(3)	(4)	(5)	(6)
(1) *ProdInnovNMkt*	1.000					
(2) *RND*	0.207***	1.000				
(3) *ForeignTech*	0.309***	0.222***	1.000			
(4) *AvgYrsEduc*	0.063	0.185***	-0.104**	1.000		
(5) *MgmtExp*	-0.035	-0.159***	-0.044	-0.181***	1.000	
(6) *Employment*	0.273***	0.338***	0.273***	0.022	-0.069	1.000

Note. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

The correlation matrix for the firms of Bangladesh indicates that *ProdInnovNMkt* is positively correlated with *RND*, and the correlation is statistically significant at the 0.01 level. The magnitude of the correlation between the *ProdInnovNMkt* and *RND* is 0.236. In the case of *RND*, *ForeignTech* and *Employment* are positively associated with *RND*, and the magnitudes of correlations are 0.107 and 0.135, respectively, and statistically significant at the 0.01 level. Interestingly, *Employment* is positively associated with all other variables, and the correlation values are statistically significant, which implies that firms' size plays an important role in firms' innovation and R&D.

The correlation matrix for Malaysia shows that *RND*, *ForeignTech*, and *Employment* are positively associated with *ProdInnovNMkt* and statistically significant at a 0.01 level. Unlike Bangladeshi firms, *ForeignTech* is positively associated with *ProdInnovNMkt*, and the correlation magnitude is statistically significant. *ForeignTech*, *AvgYrsEduc*, and *Employment* are also positively associated with *RND.* Like the case of Bangladeshi firms, *MgmtExp* is also negatively associated with *RND*, and the correlation magnitude of *MgmtExp* with *RND* is statistically significant at 0.01 level.

Univariate Probit Regression

As stated, one of the major goals of this study is to find the marginal effect of R&D on the probability of innovation. Both the dependent variable, *ProdInnovNMkt,* and the focal explanatory variable, *RND*, are binary; thus, the univariate probit model is used. First, parameter estimates from the estimation of equation (5.2) for both Bangladesh and Malaysia are presented in Table 13. Then, the average predicted probabilities of innovation with (*RND* = 1) and without (*RND* = 0) R&D spending and the average marginal effect of *RND* on innovation are presented in Table 14.

Table 13. Univariate Probit Regression Results

Variables	Bangladesh (n = 1,136)		Malaysia (n = 415)	
	ProdInnovNMkt		*ProdInnovNMkt*	
	Coef.	*p*-value	Coef.	*p*-value
R&D	0.788*** (0.107)	<0.001	0.224 (0.212)	0.29
ForeignTech	-0.341** (0.133)	0.01	0.835*** (0.204)	<0.001
Log(AvgYrsEduc)	0.473*** (0.126)	<0.001	0.255* (0.152)	0.093
Log(MgmtExp)	-0.034 (0.064)	0.592	0.005 (0.173)	0.977
Employment	0.223** (0.095)	0.02	0.765*** (0.218)	<0.001
Intercept	-1.8*** (0.271)	<0.001	-2.668*** (0.552)	<0.001

Note. *** $p < .01$, ** $p < .05$, * $p < .1$ and standard errors in parentheses.

Table 14. Predicted Probabilities and Marginal Effects from the Univariate Probit Model

	Variable	Mean	Std.Err.	[95% Confidence Interval]
Bangladesh	Pr(*PInnovNMkt* =1|*RND*=1)	0.415	0.037	[0.342, 0.488]
	Pr(*PInnovNMkt* =1|*RND*=0)	0.163	0.012	[0.140, 0.187]
	Average Marginal Effect	0.252	0.039	[0.178, 0.328]
Malaysia	Pr(*PInnovNMkt* =1|*RND*=1)	0.117	0.024	[0.07, 0.164]
	Pr(*PInnovNMkt* =1|*RND*=0)	0.085	0.019	[0.048, 0.122]
	Average Marginal Effect	0.033	0.031	[-0.028, 0.094]

The univariate probit regression results for both Bangladesh and Malaysia show that the coefficient of *RND* is positive, and the magnitude of the coefficients are 0.788 and 0.224, respectively. Though the coefficient is statistically significant for Bangladesh, the coefficient for Malaysia is not. The coefficient for *ForeignTech* is negative for Bangladesh and positive for Malaysia; both are statistically significant. Furthermore, the coefficients for *Employment* for Bangladesh and Malaysia are 0.223 and 0.765, respectively, and statistically significant at 0.05 and 0.01 levels.

Table 14 shows the average predicted probability of innovation in the presence of R&D and in the absence of R&D and the associated average marginal effect of R&D on innovation for both Bangladesh and Malaysia. In the case of Bangladeshi firms, the average likelihood of innovation is 41.5 percent if the firm spends on R&D, while it is only 16.3 percent without R&D. The average marginal effect of R&D is 0.252, implying that R&D increases the likelihood of innovation on average by 25.2 percentage points. In the case of Malaysian firms, the likelihood of innovation that is new to the market in the presence of R&D is 11.7 percent, while that is 8.5 percent in the absence of R&D. The average marginal effect of R&D is 0.033 for Malaysian firms. So, it is evident that the marginal effect of R&D for Malaysian firms is much smaller than for Bangladeshi firms.

To determine whether the difference between the likelihood of innovation in the presence and absence of R&D in Bangladeshi and Malaysian firms is statistically significant, I compare the confidence intervals of the likelihood of innovation for these two groups of firms. Table 14 shows the 95% confidence interval of the means as well. The mean probabilities of innovation in the presence of R&D for Bangladesh and Malaysia are 0.415 and 0.117, respectively. The confidence interval for Bangladesh is [0.342, 0.488] whereas for Malaysia it is [0.07, 0.164].

Since these intervals do not overlap and are far apart, there is strong evidence that the probabilities of innovation in the presence of R&D between the two countries are significantly different.

Similarly, the mean probabilities of innovation in the absence of R&D for Bangladesh and Malaysia are 0.163 and 0.085, respectively. The confidence interval for Bangladesh is [0.140, 0.187] whereas for Malaysia, it is [0.048, 0.122]. Like the previous case (with *RND* = 1), these intervals do not overlap and are far apart. The confidence intervals found imply that the two countries' innovation probabilities in the absence of R&D are also significantly different.

Bivariate Probit Regression

As stated in Chapter V, I use the bivariate probit model as described by Woolridge (2010) to allow for the potential endogeneity of *RND*. The model has two equations. The first is the reduced form equation for the endogenous variable *RND*; the second is the equation for *ProdInnovNMkt*, which contains *RND* (and other controls) as explanatory variables. In this case, the set of control variables in both the equations for the endogenous variable *RND* and for *ProdInnovNMkt* are the same, which means that there is no exclusion restriction. Table 15 presents below the bivariate probit regression results of Bangladesh and Malaysia without exclusion restriction.

Table 15. Bivariate Probit Regression Results (No Exclusion Restriction)

Variables	Bangladesh (n = 1,136)		Malaysia (n = 415)	
	ProdInnovNMkt		*ProdInnovNMkt*	
	Coef.	*p*-value	Coef.	*p*-value
RND				
ForeignTech	0.268** (0.125)	0.032	0.56*** (0.168)	0.01
Log(AvgYrsEduc)	-0.045 (0.118)	0.705	0.469*** (0.11)	<0.001
Log(MgmtExp)	-0.098 (0.066)	0.136	-0.33*** (0.12)	0.06
Employment	0.377*** (0.1)	<0.001	0.833*** (0.145)	<0.001
Intercept	-0.813*** (0.271)	0.002	-1.319*** (0.385)	0.01
ProdInnovNMkt				
RND	0.561 (1.086)	.605	1.176** (0.517)	0.023
ForeignTech	-0.321* (0.169)	0.058	0.598** (0.246)	0.015
Log(AvgYrsEduc)	0.469*** (0.128)	<0.001	0.14 (0.15)	0.35
Log(MgmtExp)	-0.04 (0.069)	0.564	0.087 (0.166)	0.6
Employment	0.244* (0.139)	0.078	0.452* (0.273)	0.097
Intercept	-1.747*** (0.39)	<0.001	-2.601*** (0.53)	<0.001
Rho	0.125 (0.592)		-0.576 (0.285)	

Note. *** $p < .01$, ** $p < .05$, * $p < .1$ and Standard errors in parenthesis.

In the reduced form of the bivariate probit model where *RND* is a dependent variable, both *ForeignTech* and *Employment* have positive and statistically significant coefficients at 0.01 level for both Bangladesh and Malaysia. While Log*(AvgYrsEduc)* has a positive and statistically significant variable for Malaysia, *Log(MgmtExp)* has a negative but statistically significant coefficient at 0.01 level. However, the coefficients of both *Log(AvgYrsEduc)* and *Log(MgmtExp)* are not statistically significant in the case of Bangladeshi firms.

The second equation in the bivariate probit model determines the outcome of interest, where *ProdInnovNMkt* is the dependent variable and *RND* and other variables are explanatory. The model finds that *RND* has a positive coefficient for both Bangladesh and Malaysia, but the coefficient for Bangladesh is not statistically significant. The standard error for *RND* in the case of Bangladesh is larger in order of magnitude than for Malaysian *RND*. This suggests that perhaps there are some difficulties in identifying the coefficient. Hence, a model with an exclusion restriction can be used to check through. However, the coefficients for *Employment* for both Bangladeshi and Malaysian firms are positive and statistically significant at a 0.1 level. The coefficient of *ForeignTech* is negative and statistically significant at the 0.1 level for Bangladeshi firms, while the coefficient is positive and statistically significant at the 0.05 level for Malaysian firms. On the other hand, the coefficient of *Log(AvgYrsEduc)* is positive and statistically significant at a 0.01 level for Bangladeshi firms. In contrast, the coefficient is not statistically significant for Malaysian firms. Additionally, the top-level manager's experience does not significantly affect innovation.

The correlation coefficient ρ (rho) is the correlation between the unobserved heterogeneity (the regression "errors") in the two equations. When ρ equals zero, *RND* is exogenous in the second equation. Table 15 shows that ρ is only statistically significant and negative for Malaysia. Thus, there is little evidence that *RND* is an endogenous variable for Bangladeshi firms. At the same time, the estimates suggest that *RND* is endogenous for Malaysian firms. Thus, a univariate probit model may be more appropriate for the case of Bangladeshi firms. In contrast, the bivariate probit model is more appropriate for the case of Malaysian firms.

However, this dissertation is more interested in measuring the likelihood of innovation in the presence and in the absence of R&D and the average marginal effect of R&D on innovation. Thus, the point estimates from the bivariate probit model can be further scrutinized. Table 16 presents the effect of *RND* and without *RND* on the probabilities of *ProdInnovNMkt* and the associated marginal effect of *RND* on *ProdInnovNMkt*.

Table 16. Predicted Probabilities and Marginal Effects from Bivariate Probit Model (no Exclusion Restriction)

	Variable	Mean	Std.Err.	[95% Confidence Interval]
Bangladesh	Pr(*PInnovNMkt* =1|*RND*=1)	0.417	0.037	[0.344, 0.490]
	Pr(*PInnovNMkt* =1|*RND*=0)	0.163	0.012	[0.139, 0.187]
	Average Marginal Effect	0.253	0.039	[0.177, 0.329]
Malaysia	Pr(*PInnovNMkt* =1|*RND*=1)	0.11	0.023	[0.065, 0.155]
	Pr(*PInnovNMkt* =1|*RND*=0)	0.083	0.019	[0.046, 0.12]
	Average Marginal Effect	0.027	0.03	[-0.032, 0.086]

In the case of Bangladeshi firms, shown in the above table, the average predicted probability of innovation in the presence of R&D is 41.7 percent. Concurrently, that likelihood is only 16.3 percent if the firms do not do R&D. Consequently, the average marginal effect of R&D is 0.253, implying that R&D increases the likelihood of innovation by an average of 25.3 percentage points. In the case of Malaysian firms, the likelihood of product innovation in the presence of R&D along with other innovative activities is 11.0 percent, while it is 8.3 percent in the absence of R&D. Furthermore, the average marginal effect of R&D is 0.027. This marginal effect of R&D for Malaysian firms is much smaller than for Bangladeshi firms, similar to the marginal effect found in the univariate probit model.

While applying the bivariate probit model, the bootstrap method (as stated in Chapter V) is used to find the standard errors of the mean value. The standard errors are the simplest measures of statistical accuracy, while the bootstrap is a simulation-based method of statistical inferences. I have used 1,000 bootstrap replications to find the standard errors. Then these standard errors are used to measure the confidence interval as per equation (5.11) and presented in Table 15. The confidence interval in the presence of R&D for Bangladesh is [0.344, 0.490], whereas, for Malaysia, it is [0.065, 0.155]. A similar pattern also exists in the absence of R&D for both countries. The confidence interval for Bangladesh is [0.139, 0.187], whereas for Malaysia, it is [0.046, 0.12] in the absence of R&D. Like the univariate probit model, these intervals do not overlap or are far apart. This suggests there is strong evidence that the probabilities of innovation in the presence and in the absence of R&D between the two countries are significantly different.

Until this point, for the bivariate probit model, bootstrapped standard errors are calculated based on an individual country's firm data; however, I want to make sure that the bootstrapped standard error from the pooled data is consistently similar to that of an individual country's firm data. Using the pooled model, I can formally test for statistical differences between Bangladesh and Malaysia. Thus, a separate pooled bivariate probit model is applied, which combines both countries' data and creates a control "Bangladesh". Then again, a bootstrap method is used to find the standard errors based on the bivariate probit model with the pooled data. The pooled bivariate probit regression results are shown in the appendix, and the probabilities of innovation and the average marginal effects are presented below in Table 17. The mean probabilities of innovation in the presence of R&D and in the absence of R&D and the average marginal effects of R&D are very close to that of the output from an individual country's firm data.

Table 17. Predicted Probabilities and Marginal Effects from Bivariate Probit Model (with Pooled Data and No Exclusion Restriction)

	Variable	Mean	Std.Err.	[95% Confidence Interval]
Bangladesh	Pr(*PInnovNMkt* =1|*RND*=1)	0.414	0.037	[0.341, 0.487]
	Pr(*PInnovNMkt* =1|*RND*=0)	0.163	0.013	[0.138, 0.188]
	Average Marginal Effect	0.251	0.039	[0.175, 0.327]
Malaysia	Pr(*PInnovNMkt* =1|*RND*=1)	0.116	0.024	[0.067, 0.163]
	Pr(*PInnovNMkt* =1|*RND*=0)	0.085	0.019	[0.048, 0.122]
	Average Marginal Effect	0.032	0.031	[-0.029, 0.093]

Bivariate Probit Regression with Exclusion Restriction

As stated in Chapter V, I pursue the bivariate probit model to overcome the potential presence of endogeneity following Wooldrige (2010). *RND* is a potentially endogenous and dependent variable in the first equation, while *ForeignTech*, *Log(AvgYrsEduc)*, *Log(MgmtExp)*, and *Employment* are explanatory variables. Then *ProdInnovNMkt* is the dependent variable, whereas the other variables, including *RND*, are explanatory. Now we consider an exclusion restriction in the second equation, which produces the outcome of interest. The purpose of applying an exclusion restriction in this model is to explore the possible changes in the predicted probabilities of innovation and the marginal effects of R&D on innovation. In other words, we explore whether the estimates of the marginal effects are robust, even when the model is not purely identified through the functional form (i.e., the bivariate normality assumption).

To pursue this, the variable *Employment* is considered as an instrument, assuming that it indirectly affects *ProdInnovNMkt*. The assumption is that the variable *Employment* represents the number of employees in the firm, and the number of employees might not directly impact innovation. If the number of employees in the firm increases, the number of employees who are engaged in R&D might increase. Thus, the variable, *Employment*, is excluded from the second equation. Table 18 below shows Bangladesh and Malaysia's bivariate probit regression results with the exclusion restriction.

Table 18. Bivariate Probit Regression Results (With an Exclusion Restriction, *Employment*)

	Bangladesh (n=1,136)		Malaysia (n=415)	
Variables	*ProdInnovNMkt*		*ProdInnovNMkt*	
RND	Coef.	p-value	Coef.	p-value
ForeignTech	0.287**	0.032	0.548***	0.01
	(0.122)		(0.167)	
Log(AvgYrsEduc)	-0.067	0.705	0.476***	<0.001
	(0.116)		(0.11)	
Log(MgmtExp)	-0.113*	0.136	-0.322***	0.006
	(0.065)		(0.118)	
Employment	0.379***	<0.001	0.884***	<0.001
	(0.098)		(0.138)	
Intercept	-0.735***	0.002	-1.365***	0.01
	(0.254)		(0.383)	
ProdInnovNMkt				
RND	1.508***	0.605	1.59***	0.023
	(0.455)		(0.254)	
ForeignTech	-0.332**	0.058	0.537***	0.015
	(0.13)		(0.205)	
Log(AvgYrsEduc)	0.494***	<0.001	0.113	0.35
	(0.126)		(0.137)	
Log(MgmtExp)	-0.008	0.564	0.106	0.6
	(0.063)		(0.15)	
Intercept	-1.923***	<0.001	-2.366***	<0.001
	(0.264)		(0.477)	
Rho	-0.403		-0.767	
	(0.266)		(0.121)	

Note. *** $p < .01$, ** $p < .05$, * $p < 0.1$, *and standard errors in parentheses.*

The application of exclusion restriction makes the output of the bivariate probit model less reliant on the functional form. The reduced form of this equation produces coefficients of similar signs and statistical significance for *ForeignTech* and *Employment* compared to that of without exclusion restriction form of the bivariate probit model. The second equation for the outcome of interest shows the coefficients of *RND* for both Bangladeshi and Malaysian firms are positive and statistically significant at 0.01 level. In contrast, the coefficient of *RND* was not statistically significant for Bangladeshi firms when the exclusion restriction was not applied. However, interestingly, the statistical significance of ρ increases for the case of Bangladeshi firms compared to the case of no exclusion restriction. For example, when there is no exclusion restriction, the z-score magnitude of ρ for Bangladesh is 0.211 (the coefficient of ρ is 0.125 and the standard error is 0.592), and that increases to 1.51 (the coefficient of ρ is -0.403 and the standard error is 0.266) when an exclusion restriction is applied.

Table 19 below shows the probabilities of innovation and the average marginal effects from the bivariate probit model, while there is an exclusion restriction. The average predicted probabilities of innovation in the presence of R&D and in the absence of R&D for both Bangladeshi and Malaysian firms are very similar to the previous estimations in Table 16. This also validates the findings from Altonji et al. (2005) that even if a restriction is available, that might have little impact on the estimated marginal effect. Furthermore, the standard errors of the mean probabilities of innovation and the average marginal effects are also measured using the bootstrap method. Again, the confidence intervals found using the bootstrap method are similar to earlier estimates.

Table 19. Predicted Probabilities and Marginal Effects from Bivariate Probit Model (with an Exclusion Restriction)

	Variable	Mean	Std.Err.	[95% Confidence Interval]
Bangladesh	Pr(*PInnovNMkt* =1|*RND*=1)	0.417	0.036	[0.346, 0.488]
	Pr(*PInnovNMkt* =1|*RND*=0)	0.162	0.012	[0.138, 0.186]
	Average Marginal Effect	0.255	0.038	[0.181, 0.329]
Malaysia	Pr(*PInnovNMkt* =1|*RND*=1)	0.111	0.023	[0.066, 0.156]
	Pr(*PInnovNMkt* =1|*RND*=0)	0.076	0.018	[0.041, 0.111]
	Average Marginal Effect	0.034	0.029	[-0.023, 0.09]

Once again, with the case of exclusion restriction, a pooled bivariate probit model is used, which combines both countries' data and creates a control “Bangladesh”. Like the previous pooled model with no exclusion restriction, I want to ensure that the bootstrapped standard error from the pooled data is also consistently similar to that of an individual country's firm data, as that can test for statistical differences between Bangladesh and Malaysia. A bootstrap method is used to find the standard errors based on this pooled bivariate probit model. Pooled bivariate probit regression results are shown in the appendix, and the probability of innovation and the average marginal effects are presented below in Table 20. It also shows that the average predicted probabilities of innovation in the presence of R&D and in the absence of R&D and the average marginal effects of R&D are similar to before.

Table 20. Predicted Probabilities and Marginal Effects from Bivariate Probit Model (with Pooled Data and Exclusion Restriction)

	Variable	Mean	Std.Err.	[95% Confidence Interval]
Bangladesh	Pr(*PInnovNMkt* =1|*RND*=1)	0.412	0.037	[0.339, 0.485]
	Pr(*PInnovNMkt* =1|*RND*=0)	0.163	0.012	[0.139, 0.187]
	Average Marginal Effect	0.249	0.039	[0.173, 0.325]
Malaysia	Pr(*PInnovNMkt* =1|*RND*=1)	0.117	0.024	[0.07, 0.164]
	Pr(*PInnovNMkt* =1|*RND*=0)	0.076	0.018	[0.041, 0.111]
	Average Marginal Effect	0.041	0.028	[-0.014, 0.096]

Excluding *ForeignTech* from the Model

The variable *ForeignTech* comes from the survey question, "Does this establishment at present use technology licensed from a foreign-owned company, excluding office software?". This survey question asks about the use of technology licensed from a foreign-owned company *at the time when the question is asked*. But the survey questions related to variables on innovation and R&D are based on a different time frame. For example, the variable *ProdInnovNMkt* originates from two survey questions. The first one is: "During the last *three* [emphasis added] years, has this establishment introduced new or significantly improved products or services?" And the second one is: "Were any of the new or significantly improved products or services also new for the establishment's main market?". The other variable, *RND*, comes from a survey question "During the last *three* [emphasis added] years, did this establishment spend on formal research and development activities, either in-house or contracted with other companies?” So, these two variables consider the last three years from the interview date, while *ForeignTech* only considers the present case or the interview date. Because of this timing mismatch, a new model is explored where *ForeignTech* is dropped. I examine whether the predicted probabilities of innovation and the average marginal effects remain the same as before.

Table 21 below shows the results from the univariate probit model where *ForeignTech* is absent. It shows that the signs and statistical significance of the coefficients of explanatory variables are similar to the model where *ForeignTech* was not excluded.

Table 21. Univariate Probit Regression Results (Without *ForeignTech*)

	Bangladesh (n = 1136)		Malaysia (n = 415)	
Variables	*ProdInnovNMkt*		*ProdInnovNMkt*	
	Coef.	p-value	Coef.	p-value
R&D	0.758*** (0.106)	<0.001	0.402** (0.198)	0.042
Log(AvgYrsEduc)	0.434*** (0.124)	<0.001	0.182 (0.139)	0.19
Log(MgmtExp)	-0.03 (0.064)	0.633	0.06 (0.163)	0.716
Employment	0.16* (0.092)	0.083	0.92*** (0.207)	<0.001
Intercept	-1.757*** (0.269)	<0.001	-2.514*** (0.528)	<0.001

Note. *** $p < .01$, ** $p < .05$, * $p < 0.1$, and standard errors in parentheses.

Table 22 shows the average predicted probabilities of innovation and the average marginal effect of R&D from the univariate probit model, where the variable *ForeignTech* is no longer used as a control. The estimates found for the average probability of innovation for Bangladeshi firms with and without R&D are very similar to the model that contains the variable *ForeignTech*, as presented in Table 13. In contrast, the mean probability of innovation in the presence of *RND* and in the absence of *RND* for Malaysian firms reasonably differs from the mean where the model contains *ForeignTech*. This indicates that *ForeignTech* might significantly affect the mean probabilities of innovation for Malaysian firms, whereas *ForeignTech* is not as effective for Bangladeshi firms. However, the confidence interval in the presence of R&D for Bangladesh is [0.339, 0.478], whereas, for Malaysia, it is [0.083, 0.192]. A similar pattern of the probability of innovation is found in the absence of R&D for both countries, like the other models used before in this dissertation. The confidence interval for Bangladesh is [0.141, 0.188], whereas it is [0.040, 0.106] for Malaysia without R&D.

Table 22. Predicted Probabilities and Marginal Effects from the Univariate Probit Model (without *ForeignTech*)

	Variable	Mean	Std.Err.	[95% Confidence Interval]
Bangladesh	Pr(*PInnovNMkt* =1|*RND*=1)	0.408	0.036	[0.339, 0.478]
	Pr(*PInnovNMkt* =1|*RND*=0)	0.165	0.012	[0.141, 0.188]
	Average Marginal Effect	0.244	0.038	[0.170, 0.317]
Malaysia	Pr(*PInnovNMkt* =1|*RND*=1)	0.137	0.028	[0.083, 0.192]
	Pr(*PInnovNMkt* =1|*RND*=0)	0.073	0.017	[0.040, 0.106]
	Average Marginal Effect	0.064	0.034	[-0.002, 0.130]

CHAPTER VII: POLICY IMPLICATION FOR BANGLADESH

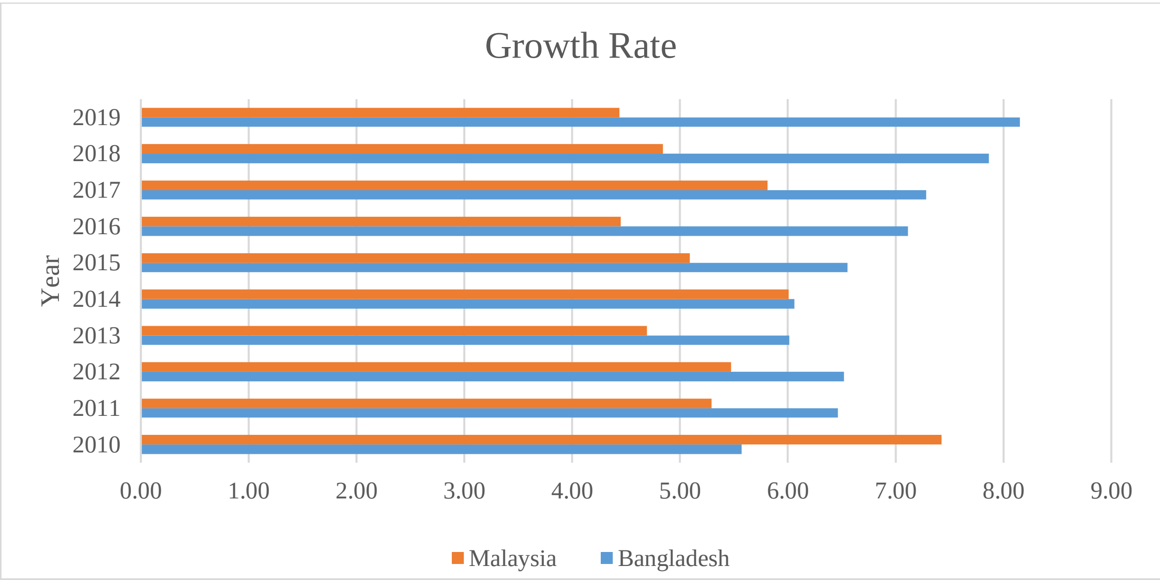
The discussions and empirical analyses in the previous chapters show that R&D activity is an important covariate with a firm's innovativeness. Furthermore, the analyses provide measurable comparisons of the relationship between R&D and a firm's innovation. Though the unit of observation in this dissertation was firm, the findings presented here are relevant for national policy interpretation.

This chapter discusses the statistics on innovative and R&D-performing firms of both countries and compares the relationship between R&D and innovative behavior. These comparisons are interpreted in terms of Bangladesh becoming more of an R&D-based innovative country and thus more competitive in world markets. At the same time, these comparisons complement the aspiration of the Government of Bangladesh stated in the Perspective Plan of Bangladesh 2021-2041.

> A harmonious public-private endeavor has to develop in Bangladesh in the following priority tasks to address future challenges and ensure competitiveness:
> - Ensuring infrastructure constraints;
> - Enhancing the quality of the workforce;
> - Investing in R&D to promote innovation at every stage of production (General Economic Division [GED], 2020-a, p- ix)

Statistics presented in this dissertation show that Bangladeshi firms are, on average, more innovative than Malaysian firms, while Bangladeshi firms do less R&D than Malaysian firms. The pairwise correlation coefficient of R&D and innovation is also larger for Bangladeshi firms than for Malaysian firms. The econometric analyses show that the likelihood of innovation in the presence of R&D is higher for Bangladeshi firms than Malaysian firms. This pattern of relationships is consistent with the law of diminishing marginal returns to R&D investments. After a certain level of innovation, the marginal rate of return to R&D diminishes, which is observed in Malaysia. The theory of convergence is also applicable in this case, as this theory postulates relatively poorer economies may experience more rapid growth than richer economies.

Figure 15. Growth Rate of Malaysia and Bangladesh



Note. Source: WDI World Bank (2020)

From the above figure and per capita GNI, it is evident that although Bangladesh and Malaysia are both developing economies, both countries are different regarding growth patterns and income status. Presumably, Malaysia has reached a certain optimal level of capacity; thus, additional input of R&D results in a smaller amount of innovation output, which follows the conventional law of diminishing marginal returns. Additionally, Malaysia has a consistently lower GDP growth rate than Bangladesh, which is similar to innovation performance in Bangladesh firms than in Malaysian firms. This similarity also conforms to the theory of economic convergence. Based on these validations, it can be presumed that Bangladeshi firms are at the initial innovation stage.

However, the Bangladesh government has set several targets to meet the development aspirations of achieving a high-income country status. Bangladesh wants to achieve the Upper

Middle-Income Country (UMIC) status by 2030 and the High-Income Country (HIC) status by 2041 (GED, 2021). These ambitions have been reported in several high-level policy papers like the 8th Five-Year Plan. However, it should be noted that five-year plans primarily guide Bangladesh's economic and development policies. The planning commission of Bangladesh serves as the Secretariat for producing the five-year plans, approved by the National Economic Council (NEC), which the Prime Minister of Bangladesh heads.

In 2020, Bangladesh adopted the 8th Five-Year Plan (July 2020–June 2025), keeping in mind the goal of achieving high-income country status by 2041. The 8FYP has projected a growth path that aims for a real GDP growth rate of 8.51 percent in FY 2025 and a rapid recovery from COVID-19. Regarding sectoral growth projection, the industry sector aims to have a growth rate of 11.90 percent in FY25, while the actual growth rate in FY20 was 6.48 percent. To achieve the projected growth in the industrial sector, Bangladesh needs to increase labor productivity and competitiveness in each economy sector, including the industrial sector. Therefore, Bangladesh continues to focus on upgrading the production technology to increase labor productivity, as noted in the following:

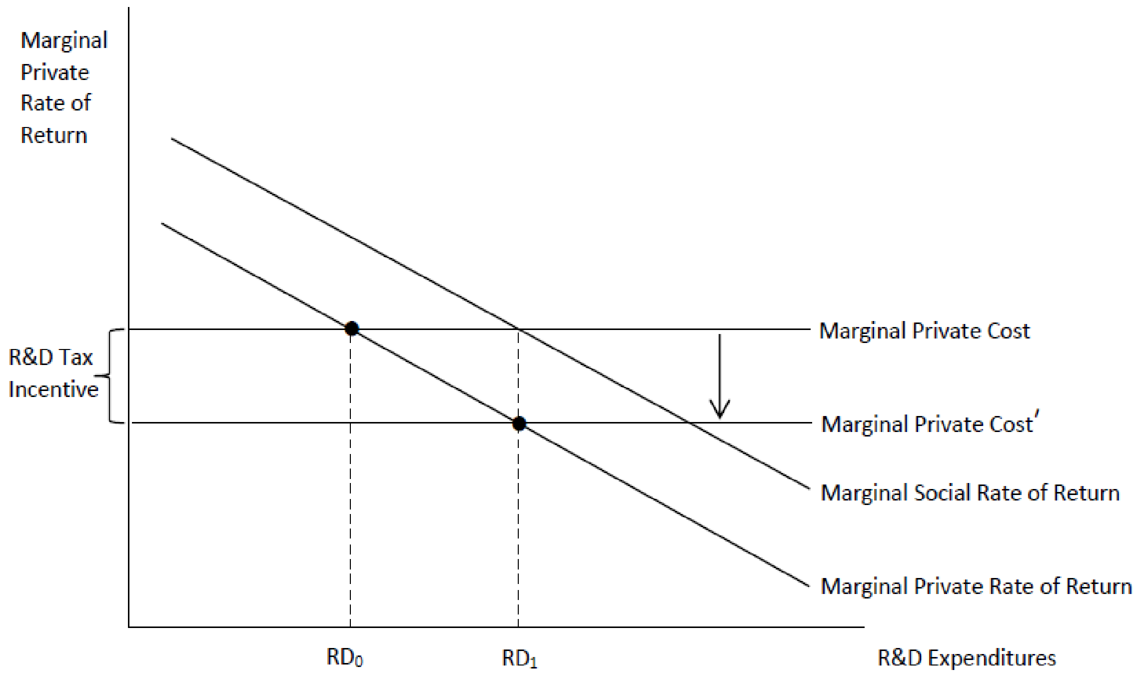
> Bangladesh production structure is undergoing growing capital intensity owing to the adoption of modern production technology. As Bangladesh continues to upgrade its production technology economy wide to increase labour productivity and competitiveness, capital intensity of production will go up requiring higher levels of investment to accelerate growth. This pattern is consistent with the experience of all UMICs like China, Malaysia and Thailand who saw substantial increases in the incremental capital output ratios, and therefore the investment rates, as they transited from lower middle income to higher middle income countries. (GED, 2020, p. 56)

Bangladesh is also underscoring the importance of achieving competitiveness in recent policy agendas. If the use of the word "competitiveness" is numbered in the last few FYPs, that can give a better idea. This word was used 84 times in the most recent 8th Five Years Plan, while that word was used in Seventh, Sixth, and Fifth FYPs 52 times, 30 times, and seven times, respectively. Nonetheless, for enhancing competitiveness, higher investment in R&D is very crucial. The literature also shows that increased R&D spending is associated with increased innovative activity. An increase in innovative activity is an element of increased productivity, which is associated with increased market competitiveness.

However, the gross investment in R&D in terms of GDP in Bangladesh is meager compared to the other comparable middle-income countries of Asia, as shown in Figure 11. Thus, a big push in the case of public investment in R&D and other public policy measures might be essential to achieving the goal of enhanced competitiveness per the 8th FYP.

The public policy measures include government supports to encourage private firms to invest in R&D. For example, Bozeman & Link (1984) found that tax incentives like tax credits stimulate private-sector R&D. Cappelen et al. (2012) found that tax credits can help develop new production processes. Leyden & Link (2015) showed how these incentives could leverage private-sector R&D, as illustrated in Figure 16. Le & Jaffe (2017) also found that R&D subsidy substantially affects innovation.

Figure 16. Economics of R&D Tax Incentives



Note. Source: Based on Leyden & Link (2015)

CHAPTER VIII: DISCUSSIONS AND FUTURE RESEARCH

Discussion

This dissertation analyzed innovation and other innovation activities, focusing on the R&D to innovation relationship at the firm level. Many studies of firms have explored the effect of R&D on innovation and whether that effect is positive or negative. These studies are mostly based on developed country data, while few studies are on developing country data. However, most innovation surveys, including the WBES, are cross-sectional, and many of the survey questions create binary variables. This study's innovation and R&D variables are also binary, which makes measuring the effect complex. To date, no study so far has measured the effect of R&D on innovation when the variables for innovation and R&D are both binaries, and there is a potential risk that the R&D variable is endogenous. From this perspective, measuring the effect of R&D on developing countries' innovation is one of this dissertation's major contributions.

Another major contribution of this dissertation is to compare the R&D effect of one country with another. This study has compared the effect of R&D on Bangladeshi firms with Malaysian firms. It finds that the likelihood of innovation for Bangladeshi firms is higher than that of Malaysian firms. Nonetheless, the findings from the empirical analyses seem counterintuitive as the descriptive statistics show that Bangladeshi firms, on average, do less R&D than Malaysian firms do.

However, this counter-intuitive finding is consistent with the law of diminishing marginal returns to R&D investments. As per the law, after reaching a certain optimal level of capacity, additional input of R&D should result in a smaller output of innovation. Presumably, Malaysia has reached a certain optimal level; thus, the increase of the probability of innovation decreases even though the investment in R&D is high. In contrast, Bangladeshi firms have not reached that optimal level; thus, the probability of innovation is higher than that of Malaysian firms. This finding is also consistent if these two countries' gross R&D expenditure in GDP is also compared. The national data on gross R&D expenditure in GDP for Bangladesh and Malaysia shows that Bangladesh has a meager investment in R&D than its Malaysian counterpart (see Figure 11).

Again, this econometric finding is also consistent with the theory of economic convergence, as the theory postulates that relatively poorer economies experience more rapid growth than richer economies. From the perspective of this study, Bangladesh is a lower-middle-income country with a per capita GNI of 2,030 USD in 2020, while Malaysia is an upper-middle-income country with about five times higher per capita GNI than Bangladesh. Similarly, the growth rate of Bangladesh in the last decade has been higher than the Malaysian growth rate (see Figure 15). Overall, the per capita GNI and the growth rate of these two countries imply that Malaysia is in a better position than Bangladesh, which is also consistent with the theory of economic convergence.

The discussion is mostly based on innovation and R&D relationships. However, technology licensed from a foreign-owned company, i.e., foreign technology, seems to affect Bangladeshi firms' innovation negatively, and Sharma (2019) also has similar findings on Bangladeshi firms. In contrast, foreign technology has a significant and positive role in Malaysian firms' innovation. However, employee education plays a positive and significant role in innovation in Bangladeshi firms, while employee education does not seem to be an important issue for Malaysian firms. At the same time, the top manager's experience does not seem important for both Bangladesh and Malaysian firms.

However, it is quite interesting that foreign technology negatively influences innovation in Bangladeshi firms, while employee education plays a significantly positive role. In contrast, foreign technology plays a significantly positive role in Malaysian firms' innovation, while the employee's education cannot pass on the significance, though it is positive. Perhaps, foreign technology does not affect innovation directly in Bangladeshi firms; rather, it comes through research and development. For that reason, in the reduced form of bivariate probit regressions, it is found that foreign technology has a positive and significant effect on R&D. Possibly, the employees are not educated enough to use foreign technology to innovate.

The perception mentioned above is consistent with the findings from the descriptive statistics that the average number of years of education of a typical permanent full-time production worker is about 6.6 years for Bangladeshi firms. In comparison, that is 9.45 years for Malaysian firms. Perhaps, the higher average years of employee education make the employees more equipped to use foreign technology for firms' innovation directly, which might happen to Malaysian firms. But, at the same time, Bangladeshi firms might need to use foreign technology through the research and development process for firms' innovation. Thus, in the reduced form of bivariate probit regression, foreign technology affects R&D positively and significantly. Therefore, the firm's employees' education base is a factor in making foreign technology adaptable to innovation. However, top managers' experience does not affect firms' innovation in both countries; in some cases, it affects them negatively.

Firm size, represented by the variable *Employment,* is found to have positive and statistically significant coefficients for both countries throughout the empirical analyses; this implies that large firms have a positive and significant influence over innovation. Nevertheless, both univariate and bivariate probit models find the coefficient of *Employment* is larger in magnitude for Malaysian firms. Furthermore, the descriptive statistics show that Malaysia has more large firms than Bangladesh. While 35 percent of Bangladeshi firms are large, Malaysia has 42.2 percent of large firms, which is coherent with the statistics of R&D firms in both countries. That is, Malaysia has more R&D firms compared to that Bangladesh. Though this study does not examine the role of larger firms in doing R&D, perhaps the findings imply that larger firms tend to do more R&D than smaller firms, which in turn plays a positive role in innovation. The innovativeness of the larger firms is also consistent with the conventional literature.

Limitations

Like other studies, this dissertation has several limitations. Data issue is one of the major limitations. This study lacks time series data. Thus, it was not possible to consider the lags between R&D activity and innovation due to the lack of time series data. Furthermore, the dataset used in this study contains self-reported data. Hence, a problem with self-reported data, especially self-reported R&D data, is that there is no control for how efficiently R&D is done across enterprises and the two countries.

The structure of the empirical models for both Bangladesh and Malaysia are the same, which implies that the underlying production function with innovation as output is the same between the two countries. Therefore, the data do not permit testing different production functions in the two countries.

This dissertation has compared the probability of innovations and the average marginal effect of innovations for two countries- Bangladesh and Malaysia. So, data for the two countries are extracted from the SES of the World Bank Enterprise Survey. Unfortunately, surveys for these two countries were conducted at two different times. For example, the SES for Bangladeshi firms was conducted from April 2013 to September 2013, while the SES for Malaysian firms in between March 2015 to May 2016. Thus, measuring innovation in this dissertation did not consider the time differences. At the same time, there are some differences in the content of a few survey questions.

For example, in the survey question for R&D, the SES for Bangladesh asked, “During the last three years, did this establishment spend on formal research and development activities, either in-house or contracted with other companies?" while the survey question for Malaysia was "During the last three years, did this establishment spend on formal research and development activities, either in-house or contracted with other companies, excluding market research surveys?" So, market research surveys are not included as R&D for Malaysian firms. In contrast, nothing is mentioned for Bangladeshi firms.

For the variable on the use of foreign technology, the SES for both Bangladesh and Malaysia asks, "Does this establishment at present use technology licensed from a foreign-owned company, excluding office software?" While the SES counts innovation and R&D for the last three years, the variable for foreign technology only considers the use of foreign technology at the survey time. Moreover, there was a follow-up innovation survey after the SES of Bangladesh, while no innovation survey was conducted for Malaysia. Additionally, the SES for Malaysia has more innovation-related questions, while the SES for Bangladesh has comparatively fewer questions on innovation.

While I performed the empirical analysis, the issue of potential endogeneity for the variable of R&D was not completely resolved. To overcome the presence of endogeneity, I pursued the bivariate probit models stated in Wooldridge (2010). The correlation coefficient ρ, from the bivariate probit model, is not equal to zero for both countries, but that is statistically significant only for Malaysia. Thus, there is little or no conclusive position that the variable for R&D is an endogenous variable for Bangladeshi firms.

Future Research

As analyzed in this study, the law of diminishing marginal returns works for the two-country case. However, this study can be extended to many other countries using two different groups of developed versus developing countries so that the law of diminishing marginal returns can also be validated for innovation purposes. Similarly, based on the country's per capita GNI and growth, future research can also explore whether the convergence theory applies from an innovation perspective.

As stated in the discussion part of this chapter, foreign technology does not affect innovation directly for Bangladeshi firms, while Malaysian firms do. At the same time, employees' education positively affects innovation in both Bangladeshi and Malaysian firms in the univariate probit regression. But, in the case of bivariate probit regression, education plays a positive and significant role for Bangladeshi firms, but the Malaysian firms cannot pass on the significance level though positive. So, is the lower level of employee education obstructing the employees from using foreign technology directly in innovation? That can be an issue of future exploration.

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APPENDIX A: BIVARIATE PROBIT REGRESSION

Bivariate probit regression (pooled data and combined with an interaction term)

RND	Coef.	*p*-value	[95% Conf Interval]
1. ForeignTech	0.538*** (0.17)	0.002	[0.206, 0.87]
1. Bangladesh	0.501 (0.467)	0.283	[-0.414, 1.417]
1. ForeignTech#1.Bangladesh	-.257 (0.208)	0.216	[-0.664, 0.15]
c.Log(AvgYrsEduc)	0.458*** (0.11)	<0.001	[0.243, 0.673]
c.Log(AvgYrsEduc)#1.Bangladesh	-0.51*** (0.162)	0.002	[-0.826, -0.193]
c.Log(MgmtExp)	-0.337*** (0.12)	0.005	[-0.571, -0.102]
c.Log(MgmtExp)#1.Bangladesh	0.232* (0.137)	0.089	[-0.035, 0.5]
1. Employment	0.844*** (0.145)	<0.001	[0.56, 1.128]
1. Employment#1. Bangladesh	-0.477*** (0.177)	0.007	[-0.823, -0.131]
Constant	-1.284*** (0.382)	0.001	[-2.033, -0.535]
ProdInnovNMkt			
1.RND	0.437 (0.919)	0.635	[-1.365, 2.238]
1.Bangladesh	0.837 (0.628)	0.182	[-0.393, 2.068]
1.RND#1.Bangladesh	0.582** (0.246)	0.018	[0.1, 1.063]
1.ForeignTech	0.793*** (0.278)	0.004	[0.248, 1.338]
1.ForeignTech#1.Bangladesh	-1.151*** (0.273)	<0.001	[-1.687, -0.616]
c.LogEduc	0.226 (0.192)	0.239	[-0.15, 0.603]
c.Log(AvgYrsEduc)#1.Bangladesh	0.246 (0.224)	0.272	[-0.194, 0.686]
c.Log(MgmtExp)	0.026 (0.193)	0.891	[-0.352, 0.404]
c.Log(MgmtExp)#1.Bangladesh	-0.054 (0.194)	0.779	[-0.434, 0.325]
1.Employment	0.701** (0.351)	0.046	[0.014, 1.388]
1.Employment#1.Bangladesh	-0.501* (0.297)	0.091	[-1.082, 0.08]
Constant	-2.678*** (0.55)	<0.001	[-3.757, -1.599]
Rho	-0.129 (0.544)		[-0.838, 0.742]

Note. *** $p < .01$, ** $p < .05$, * $p < .1$ *and Standard errors in parenthesis*

APPENDIX B: BIVARIATE PROBIT REGRESSION (with exclusion restriction)

Bivariate Probit (pooled data and combined with interaction term and an exclusion restriction)

RND	Coef.	*p*-value	[95% Conf Interval]
1. ForeignTech	0.541*** (0.167)	0.001	[0.213, 0.869]
1. Bangladesh	0.67 (0.459)	0.145	[-0.23, 1.571]
1. ForeignTech#1.Bangladesh	-0.233 (0.206)	0.257	[-0.636, 0.17]
c.Log(AvgYrsEduc)	0.472*** (0.11)	<0.001	[0.256, 0.687]
c.Log(AvgYrsEduc)#1.Bangladesh	-0.553*** (0.159)	<0.001	[-0.864, -0.243]
c.Log(MgmtExp)	-0.328*** (0.119)	0.006	[-0.562, -0.094]
c.Log(MgmtExp)#1.Bangladesh	0.21 (0.136)	0.122	[-0.056, 0.476]
1. Employment	0.901*** (0.14)	<0.001	[0.627, 1.175]
1. Employment#1. Bangladesh	-0.547*** (0.169)	0.001	[-0.878, -0.215]
Constant	-1.354*** (0.385)	<0.001	[-2.108, -0.6]
ProdInnovNMkt			
1.RND	1.388 (0.271)	<0.001	[0.858, 1.919]
1.Bangladesh	0.492 (0.553)	0.373	[-0.591, 1.576]
1.RND#1.Bangladesh	0.5** (0.201)	0.013	[0.107, 0.894]
1.ForeignTech	0.637*** (0.206)	0.002	[0.232, 1.041]
1.ForeignTech#1.Bangladesh	-0.99*** (0.236)	<0.001	[-1.687, -.616]
c.LogEduc	0.126 (0.14)	0.371	[-0.149, 0.401]
c.Log(AvgYrsEduc)#1.Bangladesh	0.331* (0.182)	0.069	[-0.026, 0.689]
c.Log(MgmtExp)	0.095 (0.156)	0.544	[-0.211, 0.4]
c.Log(MgmtExp)#1.Bangladesh	-0.095 (0.167)	0.567	[-0.423, 0.232]
Constant	-2.385*** (0.491)	<0.001	[-3.346, -1.423]
Rho	-0.635 (0.136)		[-0.833, -0.293]

Note. *** *p < .01,* ** *p < .05,* * *p < 0.1, standard errors in parentheses.*