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An Analytical Framework for Innovation Determinants and Their Impact on Business Performance

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Abstract: Innovation plays a pivotal role in the progress and goodwill of an organization, and its ability to thrive. Consequently, the impact analysis of innovation on the performance of an organization holds great importance. This paper presents a two-stage analytical framework to examine the impact of business innovation on a firm's performance, especially firms from the manufacturing sector. The prime objective is to identify the factors that have an impact on firm-level innovation, and to examine the impact of firm-level innovation on business performance. The framework and its analysis are based on the latest World Bank enterprise survey, with a sample size of 696 manufacturing firms. The first stage of the proposed framework establishes the analytical results through Bivariate Probit, which indicates that research and development (R&D) has a significantly positive impact on the product, process, marketing, and organizational innovations. It thus highlights the important role of the allocation of lump-sum amounts for R&D activities. The statistical analysis shows that innovation does not depend on the size of the firms. Moreover, the older firms are found to be wiser at conducting R&D than newer firms that are reluctant to take risks. The second stage of the proposed framework separately analyzes the impacts of the product and organizational innovation, and the process and marketing innovation on the firm performance, and finds them to be statistically significant and insignificant, respectively.

Keywords: innovation determinants; bivariate probit; data analysis; research and development

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1. Introduction

Innovation, the process of devising new ideas, methods, or products, is very necessary for the developing world to meet the requirements of a day-by-day increasing population. The circumstances are now changing rapidly for the launch of several surveys regarding innovation in developing and developed economies. These surveys have been proven to be a great help to understand the features of innovative firms, the role of effective investment in research and development (R&D), and firm-level innovation. These surveys help to distinguish the basic features of investment in R&D. In addition, investment-related resources in innovative activities are also identified regarding products, processes, marketing, or organizational innovations.

The Oslo Manual 2005 introduces four types of innovations, including product, process, marketing, and organizational innovation. Product innovation refers to the launch of a new or improved good or service. The improvements can originate from technical specifications, improved components or materials, incorporated software, etc. Process innovation involves a new or improved production process or delivery process. Marketing innovation may include a new marketing method where substantial changes are incorporated regarding packaging, product placement, or promotion. Lastly, organizational innovation is the introduction of a new or significantly improved organizational method for business practices, managing affairs, and business organization. Organizational innovations can reduce transaction costs and can provide a competitive niche for increasing a firm's performance.

International competition drove organizations to devise or to improve business strategies, especially those that are related to innovations for gaining increased market share. Current global competition has pushed individuals and organizations to evaluate current strategies and to design or to adopt novel strategies in order to gain a competitive edge. This also includes hiring or training persons for obtaining better entrepreneurial abilities. The innovation aims at devising new applications to launch intuitive solutions. It indicates the transformation of theoretical knowledge to physical or tangible applications. Innovation plays a crucial role in increasing the efficiency and profitability of firms. Firms focus on innovations to obtain a competitive edge over their rival firms by increasing business performance. Innovation provides a competitive niche as it increases firms' productivity or goodwill by providing more valuable goods/services than its competitors. Innovation plays a significant role to foster economic development by exploring new markets, as well as through the improvement of existing markets.

The literature has long emphasized that innovation creating technical progress is the vital element for sustainable and improved standards of living [1]. The arrangement of business innovation may be as ancient as humankind, as it signifies the systematic and dynamic improvement of processes, products, and the organizational work techniques of all types [2]. In the particular context of business innovation, the literature extensively recognizes that the research of Schumpeter in (1934) has a ground-breaking impact on the subject. As per Schumpeter, *innovation is expressed as the development of a new product, a new method of production, or a new source of supply, and the exploitation of new markets and new ways of organizing a business*. In the innovation process, a business organization may initially formulate conceptual models for new products and then convert them into commercialized propositions [3]. The purpose of the engagement of business organizations in innovation activities is to increase their market share, competitiveness, and productivity, which ultimately leads to increased profitability and performance.

Keeping in view the importance of innovation, this study proposes a framework to evaluate the impact of different factors on firm innovation. The framework also analyzes how firm-level innovation influences the performance of a business. The analysis is performed using the survey data from the World Bank enterprise that includes data from 696 manufacturing firms. The first stage involves using a Bivariate Probit model to analyze the impact of research and development (R&D) on the product, process, marketing, and organizational innovations. During the second phase of the framework, firm performance is evaluated within the context of product and organizational innovation, and process and marketing innovation. This is the first research of its nature in which we first identify the determinants of product innovation, process innovation, marketing innovation, and organizational innovation, and then we evaluate the impacts of these innovations on firm performance. There is a considerable body of literature available on different models of innovation that analyze a variety of aspects such as spatial analysis, market competition, political factors involvement, etc. However, no attempt has yet been made where firm characteristics, information sources, factors hindering innovation, and innovation efforts are incorporated under the same umbrella.

The rest of this study is divided into four parts. Section 2 describes important studies that are related to the current study. The research methodology is explained in Section 3. Section 4 presents the results, while the conclusion is given in Section 5.

2. Literature Review

The inquiry into the impact of business innovation on growth and productivity at a micro- and macro-level is not a novel area of research. A plethora of literature is available on this topic that investigates it from different perspectives [1,4]. The key problem relates to how to evaluate and estimate the impacts of technical changes on productivity. Different scholars have used different proxies for the technical change variables. For example, Solow in 1957 examined the technology–productivity relationship, where residual is used as a measure of technological progress. A large criticism of this approach led to a relatively easier and quantifiable measure of technical progress called R&D. Though several researchers have also questioned the use of R&D as a proxy of technological change to define productivity, it is widely used in the existing literature [3,5].

From an empirical analysis point of view, the literature on developed economies confirms a significantly positive impact of R&D on productivity levels [6–8]. The positive association can be found in Griliches in 1998 for the US [5], Harhoff in 1998 for German [9], Hall and Mairesse in 1995 for French [10], and Verspagen in 1995 for OECD republics [11]. As mentioned earlier, the use of R&D as innovation suffered several problems that do not detect the proper degree of innovative efforts. First, the spending on R&D activities is the dimension of input into the process of innovation rather than the output. Secondly, in developing countries such as Pakistan, business organizations produce technological developments that are exterior the prescribed R&D mechanism, which means that performing R&D might not be sufficient to produce innovative products [12].

The recent availability of innovation surveys makes it possible to define the innovation inputs and outputs. Innovation inputs can be defined as spending in innovation-related formal and non-formal R&D activities. For example, the training of employees, patent filing fees, and the purchase of software and hardware such as the acquisition of machinery are included in the firm's inputs. The majority of the literature used the production functions proposed by Pakes and Griliches [13], and Griliches [14], to analyze the connection between innovation determinants and their influence on business productivity. Both methodologies faced severe criticism due to their crucial assumptions. Crepon et al. [15] are regarded as pioneers in formulating a full structural model that connects business innovation to firm performance, which is approximated by productivity [15]. This model is recognized as the CDM model of innovation, and it consists of four equations and defines three relationships. First, the factors that influence the business organization's decision to engage in innovational activities; second, the knowledge production function connecting innovation to spend in the innovational activities and other factors; and third, the business performance equation relating firm performance to innovation output are considered. Another distinctive feature of this model is the introduction of the selection equation related to the 'decision to invest' in innovational activities to control the selection biases.

According to Zemplinerová and Hromádková, *innovation activity started to be analyzed as a process-starting decision on R&D investment, followed by innovation output and productivity growth* [16]. Based on the previous discussion, this research contends that R&D expenditures are not an innovation, but a key determinant of business innovation outputs. Other reported factors that can influence business innovation include the size of the business, organization age, the regular auditing of the business indicators, R&D subsidies, the economic situation of a country, the level of market competition, barriers to finance innovation, and strategic features such as involvement in foreign markets. The key factor that can impact the firm's decision to become involve in innovational actions is the size of the firm. Acs and Audretch describe that a bigger size firm is more likely to innovate in the industries that have barriers to entry, and that are highly concentrated in nature [17]. Several studies concluded that firms with larger sizes tend to have more of an ability to innovate [16]. As far as studies

based on CDM models are concerned, a positive association between firm size and the likelihood to be involved in innovation is found by [18,19]. Additionally, innovation subsidies from the government also play a dynamic part in the firm's choice to be involved in innovation.

After a keen evaluation of the literature on the determinants of innovation, this research concludes that every attempt at business innovation has been made from the viewpoint of developing republics such as Pakistan. These few studies are using different econometric models that are based on very crucial assumptions. As far as the two-stage innovation model is concerned, no serious attempt has been made in Pakistan. Similarly, no study incorporates a wide range of innovation determinates such as firm characteristics, information sources, factors hindering innovation, and innovation effort. This research is an attempt to incorporate these ignored areas with a novel dataset and estimation approach.

Extensive literature has been found in the recent past relating innovation with the business performances of firms [20–29]. The authors in [30] presented a mediation and a moderation model to investigate the effects of innovation capability on the links between radical and incremental innovations and business performance. They find that innovation capability fully mediates the relationship between radical innovation and business performance. Rosa et al. analyzed the market capitalization determinants of European innovative companies. The study identifies environmental measures that boost companies' share prices. Environment, restrictions, and the business climate are found to be key factors to innovative companies [31]. Another work by Vincenzo and his colleagues argues that the individual characteristics of business owners affect digital innovation, whereas gender diversity has a positive impact on digital innovation outputs. Furthermore, higher education levels of business owners improve digital innovation performance [32]. Viviana, on the other hand, verifies that green management positively impacts on labor productivity and overall sales, and that innovation and innovative businesses are more likely to make mixed-green and green investments [33]. Chun-Hsien Wang investigates the role of openness to innovation knowledge sources in driving firms' radical innovation by developing a theoretical model that predicts how political ties and business ties can be used by firms as a complementary mechanism to capitalize on their preferential resources [34].

Business model innovation is critical to firm survival and success. We find a study that segregates the business model innovation architecture into three elements of value proposition, value creation, and value capture innovation. It investigates how business model innovation contributes to digital start-up performance [35]. Another work [36] examines whether public procurement contracts, market orientations, public subsidies, intellectual property rights, and other firm characteristics shape small businesses' innovation outcomes. Mita et al. explores the firm-level drivers of innovation, and the interactions between companies and the local university in a moderate innovation EU region. The findings highlight that firms' size, sector, leadership's commitment to digitalization, and collaborations with the university explain companies' innovative performances [37]. Alfonso and colleagues in [38] investigate a sample of innovative SMEs following a multi-step procedure. Employing a composite indicator, they compute the SMEs' propensity to adopt ecological innovations. The study utilizes principal component analysis based on the SCoTLASS algorithm to identify the determinants that stimulate SMEs to invest in eco-innovation. Another related work studies how the fit between innovation capabilities and supply chain strategies affects business performance [39].

3. Research Methodolgoy

3.1. The Model

For the sake of simplicity, the research analysis is divided into two different but interlinked stages. The first stage deals with the identification of the determinants of firm-level innovation, while the second stage evaluates the impact of innovation on business performance in terms of productivity. Figure 1 shows the steps followed in the proposed research methodology.

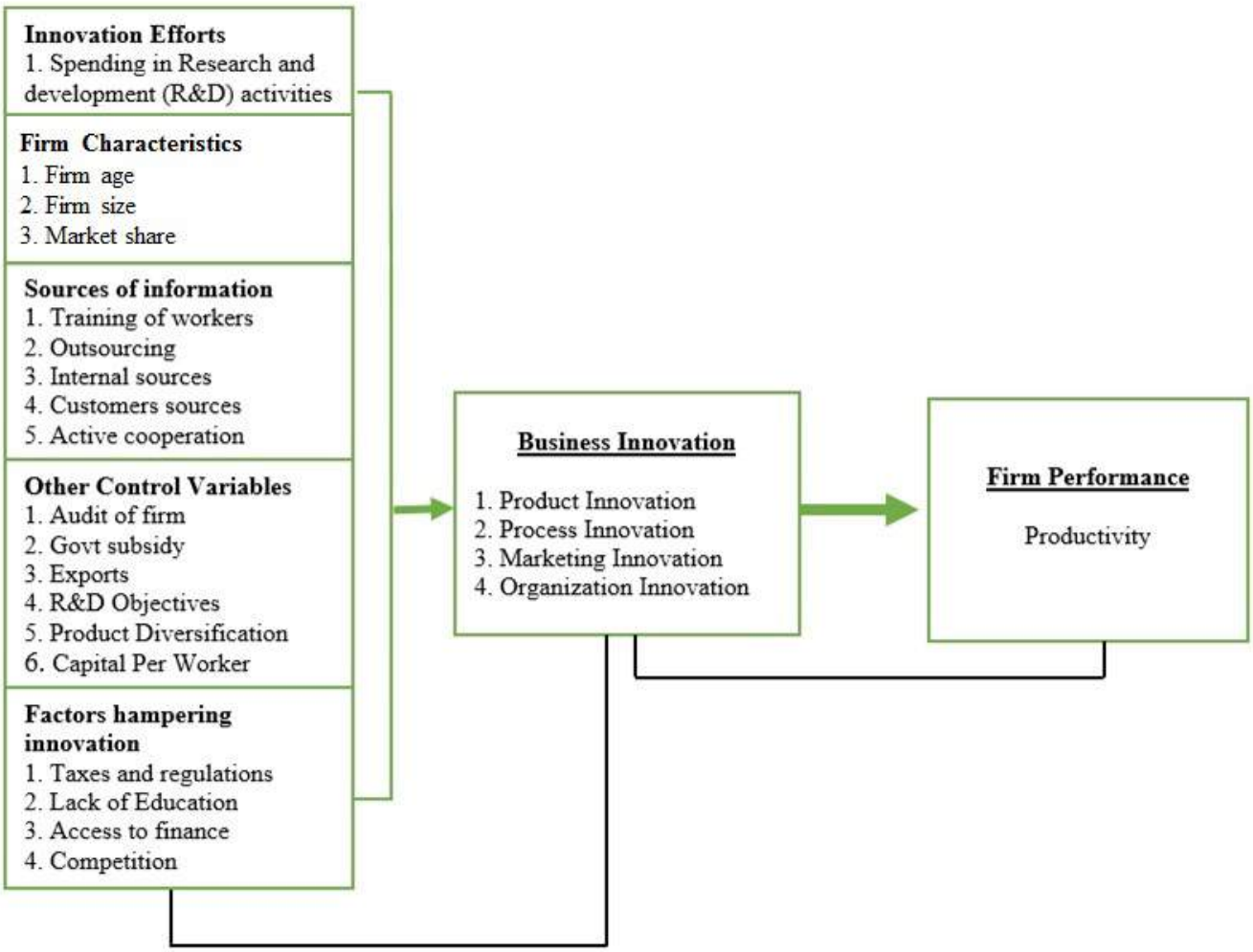

Figure 1. Research model adopted in this study.

The model consists of two stages. In the first stage, we analyze the impacts of different types of business-related variables such as firm characteristics, sources of information, factors hampering innovation, and variables related to innovation effort. The impact is analyzed for different kinds of business innovation such as product, process, organizational, and marketing innovation. In the second stage, we examine the impact of different types of business innovation on firm performance indicators such as sales, labor productivity, and profitability. Both stages of the models are interlinked. Initially, the first stage is carried out and the results are saved. Then, the second stage is estimated, where the saved results from the first stage are used as an instrument variable. In simple words, predicted product innovation, predicted process innovation, predicted marketing innovation, and predicted organizational innovation are used as the independent variables of the firm performance.

3.1.1. Stage 1 Model

The stage 1 model is given as *Business Innovation = f (firm characteristics, information sources, factors hindering innovation, and innovation effort)*

$$Innovation_i = \alpha_i + \beta FC_i + \gamma IS_i + \delta FHI_i + \vartheta IE_i + \rho X_i + \varepsilon_i \quad (1)$$

where $Innovation_i$ is the innovation type (i.e., product, process, organizational, and marketing), α_i is the intercept term, FC_i is the vector of firm characteristics, IS_i is the vector of information sources, FHI_i is the vector of factors hindering innovation, IE_i represents the

innovation efforts, X_i is a vector of other control variables, and ε_i is the disturbance term. Furthermore, β, γ, δ, and ϑ are the relevant coefficients of the variables.

3.1.2. Stage 2 Model

The stage 2 model is given as
Firm Performance = f (capital, labor, predicted business innovation)

$$Performance_i = \alpha_i + \beta K_i + \gamma L_i + \delta PredictedInnovation_i + \varepsilon \quad (2)$$

where $Performance_i$ represents the firm performance (labor productivity), K_i is the capital, L_i is the labor, $PredictedInnovation_i$ is the predicted values of business innovation from stage 1, and ε_i is the disturbance term. Furthermore, β, γ, and δ are the relevant coefficients of the variables.

3.2. Research Hypothesis

Based on the literature review, this study formulates the following five hypotheses.

Hypothesis 1. *Spending in innovation efforts i.e., investing in R&D activities, has a significantly positive effect on product innovation, process innovation, marketing innovation, and organizational innovation [19,40].*

Hypothesis 2. *Firm characteristics such as large-sized and old firms have a significantly positive impact on product innovation, process innovation, marketing innovation, and organizational innovation [14].*

Hypothesis 3. *Sources of information such as training, experience, and the education levels of employees have a significantly positive impact on product innovation, process innovation, marketing innovation, and organizational innovation [18].*

Hypothesis 4. *Factors hampering innovation such as corruption, higher tax rates, and access to finances have a significantly negative impact on product innovation, process innovation, marketing innovation, and organizational innovation [41].*

Hypothesis 5. *Business innovation, i.e., product innovation, process innovation, marketing innovation, and organizational innovation have significantly positive impacts on the firm performance (i.e., sales per worker or profitability) [42–44].*

In this research, the first four hypotheses are related to stage 1 while the fifth hypothesis is related to stage 2 of the model. In the literature review section, we identified that the spending on research and development (R&D) is the most important determinant of the firm's decision to engage in innovation activities [40,45]. The first hypothesis of this research is related to the innovation efforts made by the manufacturing sector of Pakistan to develop innovative products. The second hypothesis is related to the Schumpeterian hypothesis of innovation, which claims that older and bigger business organizations are more likely to produce innovative products and services [15,41]. There is a large body of literature available that claims that the sources of information such as the training of workers, average educational years, and top management experience also play a role in developing innovative products and services. For instance, managerial experience is the key determinant of business innovation [41]. Similarly, other research highlights that the training and education levels of workers shape business innovation [19]. Some researchers have also worked on identifying the factors that hamper business innovation. For instance, corruption has a direct and negative impact on firm innovation in Vietnam [46]. Similarly, a lack of access to finance has an adverse impact on innovation [42]. The last hypothesis is related to the second stage of the proposed research model. Different researchers have used different proxies for business innovations to find links with firm performance [43].

The majority of the researchers reported that a positive association exists between business innovation and firm performance [19,44,47,48]. However, there is no serious attempt that examines the impacts of a product, process, marketing, and organizational innovations on firm performance. This hypothesis will help to seal this gap.

3.3. Methods and Materials

3.3.1. Research Design and Unit of Analysis

The analysis of this research is established on the exploratory approach. The methodology used here is cross-sectional and quantitative, and the approach is a surveyed questionnaire research. The unit of analysis is the manufacturing business firms that are analyzed. The managerial position holders or the owners of the manufacturing firms are contacted by the World Bank during the data collection process.

3.3.2. Variables

The analysis of this research consists of two different stages, and so it has two kinds of dependent variables. The first stage deals with the identification of the determinants of firm-level innovation, while the second stage evaluates the impact of innovation on business performance in terms of profitability and productivity. The dependent variables of stage 1 include 'product innovation', 'process innovation', 'marketing innovation', and 'organizational innovation'. In the second stage, the impact of innovations on firm performance is evaluated. In the first stage, independent variables include 'firm characteristics', 'information sources', 'factors hindering innovation', and 'innovation effort', while in the second stage, independent variables include 'predicted product innovation', 'predicted process innovation', 'predicted marketing innovation', and 'predicted organizational innovation'. Table 1 shows the calculation of all variables.

3.3.3. Population and Sample Size

The population size is the manufacturing firms in Pakistan, and the sample size consists of 696 firms. This research is based on the World Bank Enterprise survey, which is publicly available on the World Bank website. The sample size is selected by the World Bank itself. The survey used a stratified random sampling technique and collected data from whole Pakistani manufacturing firms. We include all firms in this analysis.

3.3.4. Data Source

This research uses the Enterprise Survey, which was first-time conducted by the World Bank to record the innovational efforts in Pakistan. We use the data that are already available to the general public.

3.3.5. Data Analysis

This research performs regression analysis to analyze the relationship between innovation determinants on firms' performance. The multiple linear regression analysis is used to identify the determinants of innovation, and to examine the impact of business innovation on firm performance. In multiple regression analysis, it is mandatory to define the dependent variable(s) and the independent or explanatory variable(s) of the research which we already explained in the previous section.

Table 1. Study variables and their descriptions.

Variable Name	Description
Panel: A	Continuous variables
Firm Performance	Total output divided by the total number of employees of a firm
R&D Spending	Total spending on research and development in an attempt to produce innovative products
Market Share of Firm	The total sale of the firm is divided by the total sale of the whole sample firms
Firm Size	Total number of employees in the business organization or firm
Export Intensity	The total amount of product exported
Firm Age	Number of years since the organization was established
Capital Per Worker	Total capital of the firm divided by the total number of workers
Raw Material PerWorker	The total raw material of the firm used last year divided by the total number of workers
Raw Material PerWorker	The total raw material of the firm used last year divided by the total number of workers
Panel:B	Dummy Variables
Export to South Asia	Dummy variable = 1 if the firm exports its products to South Asian countries, otherwise zero
Export to US and EU	Dummy variable = 1 if the firm exports its products to the USA and European countries, otherwise zero
Internal Sources	Dummy variable = 1 if the firm uses internal sources to produce innovational goods, otherwise zero
Knowledge Obstacle	Dummy variable = 1 if the firm is facing difficulty in producing new and innovative products due to limited knowledge about the market or production process, otherwise zero
Spending Objective is Product Innovation	Dummy variable = 1 if the firm objective of spending on R&D activities is the production of innovative products, otherwise zero
Spending Objective is Process Innovation	Dummy variable = 1 if the firm objective of spending on R&D activities is the introduction of a new method of production of products, otherwise zero
Outsourcing	Dummy variable = 1 if the firm is taking help from foreign freelancers, otherwise zero
Customer as Information Source	Dummy variable = 1 if the firm uses customers' opinion as an information source to produce new products, otherwise zero
Active Cooperation	Dummy variable = 1 if the firm is engaged in cooperative activities with other business organizations, otherwise zero
Lack of Educated Employees	Dummy variable = 1 if lack of educated workers is the obstacle to producing innovative products, otherwise, zero
Product Innovation	Dummy variable = 1 if the firm introduced a new product last year, otherwise, zero
Government Subsidy	Dummy variable = 1 if the firm is receiving a subsidy from the government, otherwise zero
Process Innovation	Dummy variable = 1 if the firm introduced a new method of production last year, otherwise zero
Local Competition	Dummy variable = 1 if the firm is facing hard competition in local markets, otherwise zero
Foreign Competition	Dummy variable = 1 if the firm is facing hard competition in foreign markets, otherwise zero
Access to Finance	Dummy variable = 1 if access to finance is the problem for the firm, otherwise zero
Product Diversification	Dummy variable = 1 if the firm deals with more than 1 product, otherwise zero
Audit of the Firm	Dummy variable = 1 if the firm conducted an audit of the accounting indicators last year, otherwise zero
Taxation Obstacles	Dummy variable = 1 if the firm thinks taxation is an obstacle to innovation, otherwise zero
Marketing Innovation	Dummy variable = 1 if the firm introduced new packing or logo or ad of the product last year, otherwise zero
Organizational Innovation	Dummy variable = 1 if the firm introduced a new product last year, otherwise zero
Bonuses to Workers	Dummy variable = 1 if the firm gave bonuses to the workers last year, otherwise zero
Computer/Website Use	Dummy variable = 1 if firm uses computer or website to talk with customers or clients, otherwise zero
Human Capital	Dummy variable = 1 if the average schooling of the workers is greater than 12 years, otherwise zero.

4. Results

This section discusses empirical results based on the data, and provides conclusions that can help to formulate appropriate policy recommendations in the area of the determinants of firm-level innovation and firm performance. This section provides the estimated results, along with their interpretation.

4.1. Preliminary Data Analysis

Descriptive Statistics and Graphical Analysis

The Innovation Follow-up Survey defines the firm size in terms of employment, where the firm is recognized as a micro if the number of its employees is less than 5, small if it is between 5 and 19, medium if between 22 and 99, and large if more than 100. The province-wise breakdown of manufacturing units is given in Table 2. It shows that the majority of the innovation survey sample belongs to the Punjab province, with 385 firms, while KPK, Sindh, and Balochistan have 141, 94, and 76 firms, respectively.

Table 2. Province-wise surveyed firms.

Province	Firms	% of the Total Sample
Punjab	385	55.32
KPK	141	20.25
Sindh	94	13.51
Islamabad	76	10.92
Total	696	100.0

Figure 2 shows the ratio of samples for innovative firms from four provinces. It indicates that 55% of samples belong to the Punjab province, while KPK, Sindh, and Islamabad constitute 20%, 14%, and 11%, respectively.

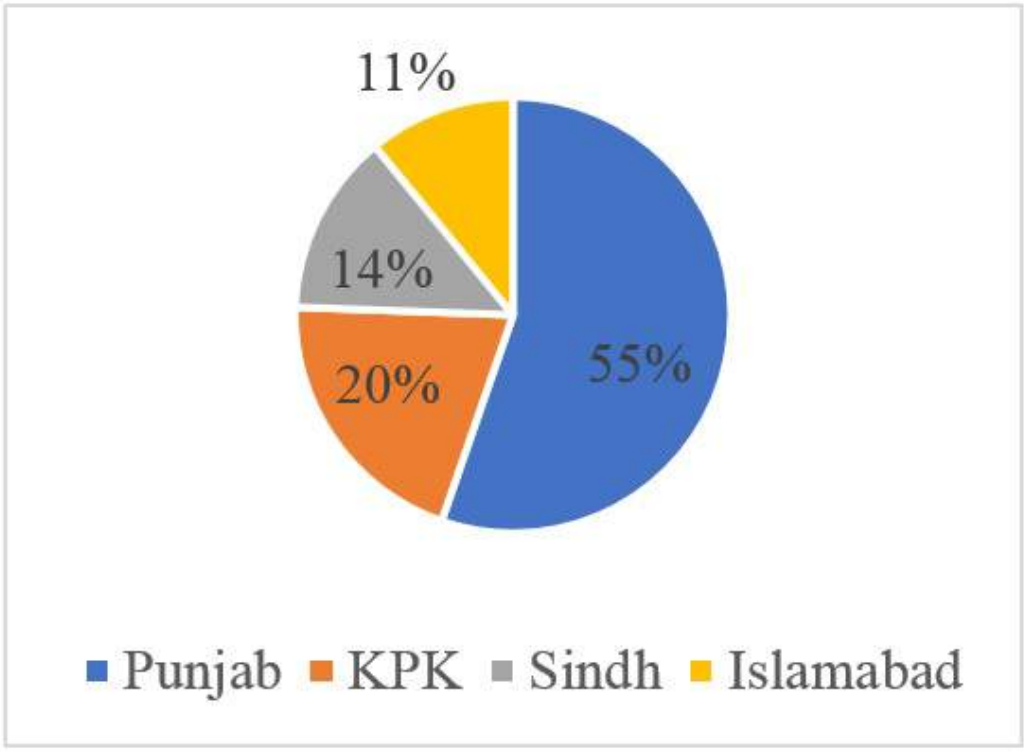

Figure 2. Province-wise distribution of firms.

The fundamental objective of this research is to present an analysis of the firm-level determinants of innovation, and their influences on firms' performance. We examine the innovative practices of Pakistani firms from several perspectives. Table 3 provides a comparative analysis of different innovative indicators of firms relative to South Asian and global business communities.

Table 3. Performances of Pakistani firms against South Asian and world firms.

Indicators	Pakistan	South Asia	World
% of firms using technology licensed from foreign companies	22.1	11.4	14.9
% of firms having their own website	46.9	31.4	45.5
% of firms using e-mail to interact with clients/suppliers	54.4	54.9	70.3
% of firms that introduced a new product/service	30.8	37.8	36.1
% of firms whose new product/service is also new to the main market	74.0	66.4	69.4
% of firms that introduced a process innovation	43.5	53.9	34.9
% of firms that spend on R&D	19.8	15.7	14.2

The innovation rate can be described as the implementation of a significantly improved or new product and/or service, process, marketing technique, or organizational method. Another exclusive feature of the innovation is that the product, process, marketing, or organizational approach must be new to the market, whether it is adopted from another firm or originally developed. The innovation behavior varies according to the type of firm or industry. Table 4 reports that garment manufacturer products are more innovative (36%) in product innovation among all other industries. On the other hand, the chemicals and chemical product business sector is leading in process innovation, at 47%. If the research and development spending of business sectors is considered, the food industry is spending the highest amount of annual turnover (23.4%) on research and development activities, followed by textile (17.4%) and garments (11.8%).

Table 4. Surveyed firms' involvement in innovational activities.

Business Sector	R&D Spending	Product Innovation	Process Innovation	New to Market
Food	23.4	26.2	25.4	71.9
Textiles	17.4	31.0	31.5	47.9
Garments	11.8	36.0	19.8	48.4
Chemicals and Chemical Product	37.0	29.0	47.1	60.3
Non-Metallic Mineral Product	6.1	13.6	21.2	73.4
Vehicles and Transport Equip	7.6	9.3	12.3	53.1
Other misc. Manufacturing	15.9	37.1	37.4	59.9

The firms are classified as small, medium, and large, depending on the employment size in the Innovation Survey. There are remarkable dissimilarities across firms of different sizes regarding the type of innovation and spending on R&D activities. A strand of literature based on the Schumpeterian hypothesis states that large firms have a greater propensity to engage in innovative practices. However, contrary to this finding, which is mainly grounded in developed economies, Table 5 points out that medium-sized Pakistani firms are leading in product innovation, process innovation, R&D spending, and the introduction of new products to the market.

Table 6 reports on the province-wise analysis of R&D spending and other innovation varieties. In total, 61.3% of Baluchistan firms are spending on R&D, followed by Islamabad (26.3%), KPK (23.5%), Sindh (20.6%), and Punjab (14.6%). The reason for the high rate of Balochistan and low rate of Punjab in R&D expenditures is the smaller number of firms from Balochistan and the larger from Punjab in the survey. It is mentioned in the description of the World Bank survey that this is performed in order to minimize the cost of the survey.

Sindh province is leading in product innovation, where 31.8% of firms have introduced innovative products during the understudied period, while Baluchistan firms are dominant in process innovation, with 62.1%.

Table 5. Size-wise involvement in innovational activities.

Firm Size	R&D Spending	Product Innovation	Process Innovation	New to Market
Small (5–19)	11.2	21.0	30.8	79.0
Medium (20–99)	27.1	39.4	57.2	76.5
Large (100+)	25.9	36.6	46.8	59.6

Table 6. Province-wise involvement in innovational activities.

Province	R&D Spending	Product Innovation	Process Innovation	New to Market
Punjab	14.6	42.0	39.5	74.4
Sindh	20.6	31.8	39.3	60.4
KPK	23.5	16.8	51.7	90.4
Islamabad	26.3	27.1	40.6	76.1
Baluchistan	61.3	28.5	62.1	78.3

The export status of surveyed firms is divided into two categories: direct exporters with more than 10% sales abroad, and non-exporters. Table 7 indicates that the firms spend more on R&D expenditures to introduce new products and processes to the market if they are trading across borders. A possible explanation for this report is that Pakistani firms are facing the pressure of a highly competitive foreign market with quality assurance requirements.

Table 7. Export-wise involvement in innovational activities.

Export Status	R&D Spending	Product Innovation	Process Innovation	New to Market
Direct exports $\geq$ 10.0%	28.6	47.5	48.7	74.2
Non-exporter	18.7	28.9	42.9	74.0

Table 8 presents R&D spending, along with different innovation types from the perspective of ownership status. It is more likely to be involved in R&D expenditures to introduce new products and services to the market if the firm has foreign ownership status.

Table 8. Ownership-wise involvement in innovational activities.

Ownership Status	R&D Spending	Product Innovation	Process Innovation	New to Market
Domestic	19.1	30.4	43.4	73.3
10% or more foreign ownership	70.2	37.1	75.1	91.7

As per the Oslo Manual 2005, there are plenty of components that hinder innovation activities at the firm level. The World Bank Innovation Survey asked the respondent Pakistani firms to rate the top business environment obstacle for innovative activities. Almost half (45.3%) of firms of the total sample state that electricity is the biggest obstacle in a firm-level innovation environment. This is followed by corruption, political instability, tax administration, crime, tax rates, poorly educated employees, access to finance, trade regulation, and transportation. Figure 3 shows the distribution of obstacles for innovational activities.

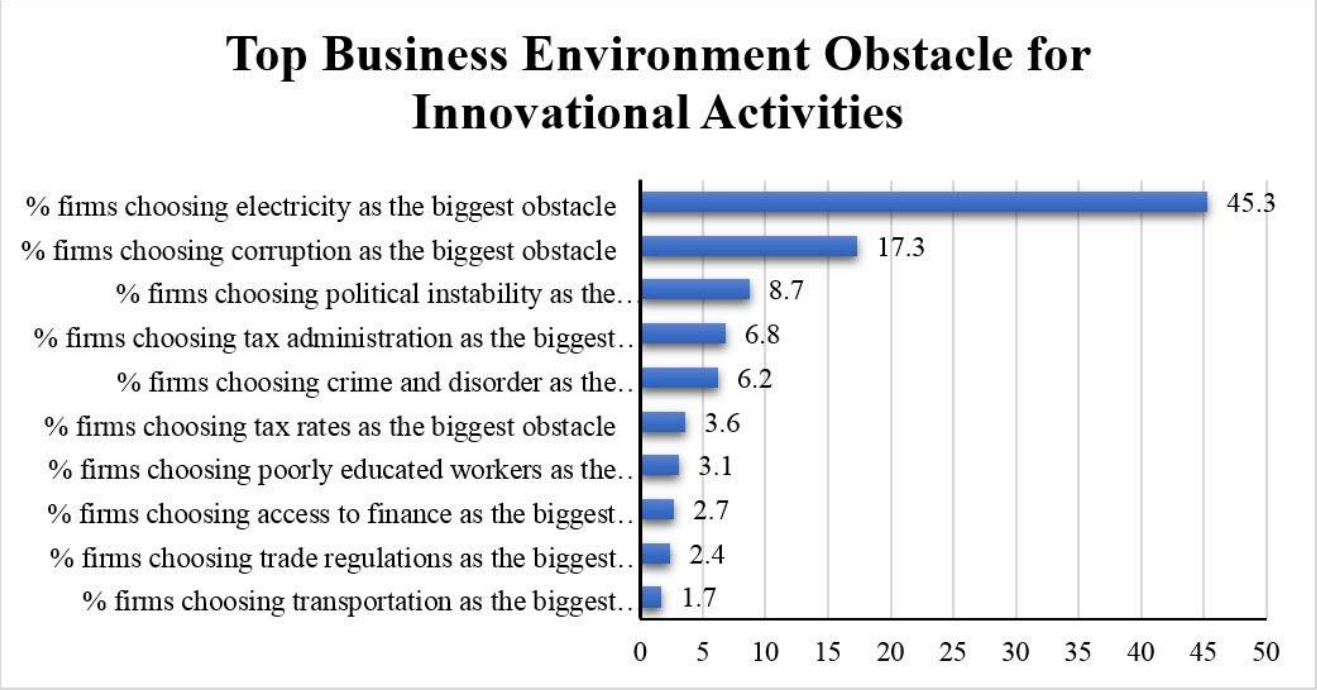

Figure 3. Innovational obstacles for surveyed firms.

4.2. Regression Analysis

According to the studies on innovation economics, R&D is the most important determinant of firm-level innovation [15,41].

$$R\&D_i = \alpha_i + \beta FC_i + \gamma IS_i + \delta FHI_i + \rho X_i + \varepsilon_i \quad (3)$$

R&D is a measure of innovation efforts. The predicted value of this variable is used in subsequent estimations. All other variables are defined previously. Table 9 reports the results of the R&D model, where spending in R&D activities is a dependent variable, while a series of variables are used as independent variables. Because the dependent variable is a continuous variable and the data are survey-based, the ordinary least squares (OSL) method is used to estimate the determinants of R&D spending. The results reveal that market share, export to the US and EU, internal sources, spending objectives in process innovation, outsourcing, customers as a source of income, and government subsidies variables have a statistically significant impact on the research and development spending of the firm.

The market share of the firm has a significantly positive impact on the innovation efforts of the firm, where innovation efforts are approximated by the R&D spending. It indicates that if the market share of the firm increases by 1 unit, then spending on R&D activities is increased by 0.02 units. Surprisingly, the employees' training for innovation and the size of the firm have no statistically significant impact on the R&D spending. As far as exports are concerned, the firms that export products to the US and European countries are more likely to spend on R&D activities. On the other hand, the firms that export products to South Asian countries are less likely to spend on R&D activities, which is also statistically insignificant. Moreover, internal sources have a significantly positive impact on R&D spending. It indicates that a 1 unit increase in the use of internal sources to produce innovational goods leads to a 0.79 unit increase in R&D spending. If the objective of R&D spending is the production of new products, then it has no significant impact on the R&D spending of the firm. However, if the objective is process innovation, then it has a significantly positive impact on the R&D spending of the firm. Similarly, the results further show that the firm involved in outsourcing is more likely to spend on R&D activities because the coefficient of outsourcing is 2.80, which is statistically significant at a 1% level

of significance. However, we have also identified many other variables that have no significant impact on research and development spending. These variables include active cooperation, a lack of educated employees, and exports. Lastly, the results indicate that government subsidies have a significantly positive impact on the firm's decision to spend on R&D and on development activities. These results are in line with some earlier studies.

Table 9. OLS estimation of research and development expenditures. Note: * 10%, ** 5%, and *** 1% levels of significance.

Explanatory Variables	Dependent Variable = R&D Spending by Firm			
	Coefficient	**SE**	**t-Value**	***p*-Value**
Market Share of Firm	0.0200 ***	0.0062	3.220	0.001
Employees Training for Innovation	−0.0371	0.5059	−0.070	0.942
Size of the Firm	−0.0971	0.0933	−1.040	0.298
Export to South Asia	−0.1577	0.6441	−0.240	0.807
Export to US & EU	0.8004 *	0.4844	1.652	0.099
Internal Sources	0.7963 *	0.4749	1.680	0.094
Knowledge Obstacle	−0.6099	0.7664	−0.800	0.426
Spending Objective is Product Innovation	0.0139	0.3635	0.040	0.969
Spending Objective is Process Innovation	1.3116 ***	0.3504	3.740	0.000
Outsourcing	2.8081 ***	0.8211	3.420	0.001
Customer as Information Source	−0.5863 **	0.2690	−2.180	0.030
Active Cooperation	−0.4369	0.4573	−0.960	0.340
Lack of Educated Employees	0.2597	0.3256	0.800	0.426
Export Intensity	0.0321	0.0375	0.860	0.392
Government Subsidy	3.7061 ***	0.9841	3.770	0.000
Constant	1.4618 ***	0.5579	2.620	0.009
Adjusted R-Squared				88.00
Total Observations				696

4.2.1. Estimation of a Stage 1 Model

The main model of this research consists of two stages. Stage 1 deals with the determinants of different types of firm-level innovations, while the second stage of the model examines the impact of different types of firm-level innovations. However, before estimating the first stage of the model, following the previous literature, we estimated the equation of research and development spending. According to [15], R&D plays a vital role in firm-level innovation. However, several factors define the behavior of R&D. That is why before using R&D as an independent variable or a possible determinant of firm-level innovation, we estimate the R&D equation. After estimating the equation, the predicted values of the dependent variable are saved. The predicted values in this case are research and development spending. In stage 1 of the model, we use this predicted value of R&D as an independent variable in the firm-level innovation model estimation. According to the OSLO manual, firm-level innovation can be divided into two categories: product and process innovations, and marketing and organizational innovations. We estimated stage 1 for both product and process innovation, and marketing and organizational innovation, separately. Table 10 provides the results of the product and process innovation modeling, where predicted research and development variables and a series of other variables are used as the explanatory set of variables. The reason for the inclusion of all these variables is to check which of them are the determinants of firm-level innovation.

Table 10 reports the estimated coefficients of product innovations and process innovation models. We used the Bivariate Probit technique to estimate the product and process innovation models. The reason for using this technique is based on the assumption that the firm decides product and process innovation simultaneously. In other words, following previous literature, we assumed that the manufacturing firms take both the decisions of product innovation and process innovation at the same time. To empirically check whether this assumption holds true or not, we find the ρ value of the bivariate probit model. The decision criteria are simple; if the ρ is other than zero, then we can say that both the decisions of product innovation and process innovation by firms are made at the same time.

In Table 10, the ρ value is 0.567, which verifies that the Pakistani manufacturing firms are making product innovation and process innovation decisions at the same time.

Table 10. Bivariate Probit estimation of product and process innovation. Note: * 10%, ** 5%, and *** 1% level of significance. Wald chi2 (1) = 189.85, Prob > chi2 = 0.0000.

Explanatory Variables	Dependent Variable = Product Innovation			Dependent Variable = Process Innovation		
	Product Innovation Model			Process Innovation Model		
	Coefficient	SE	ρ-Value	Coefficient	SE	ρ-Value
Predicted R&D	0.3227 ***	0.0586	0.0000	0.5109 ***	0.0655	0.0000
Size of Firm	0.0245	0.0444	0.5810	0.0316	0.0576	0.5830
Age of Firm	0.5668 ***	0.1301	0.0000	0.3274 *	0.1768	0.0640
Export to South Asia	−0.1562	0.3121	0.6170	−0.1394	0.4361	0.7490
Export to US & EU	−0.2837	0.2446	0.2460	−0.0057	0.3026	0.9850
Local Competition	0.5459 ***	0.1235	0.0000	0.4081**	0.1762	0.0210
Foreign Competition	0.3058 **	0.1333	0.0220	0.1698	0.1891	0.3690
Access to Finance	−0.1388	0.1936	0.4730	0.0943	0.2503	0.7060
Product Diversification	0.0577	0.1190	0.6280	−0.3281 *	0.1707	0.0550
Audit of Firm	0.3828 **	0.1558	0.0140	0.3848 *	0.2016	0.0560
Taxation Obstacle	0.1107	0.1445	0.4440	0.3984 **	0.1806	0.0270
Lack of Educated Workers	0.2912 *	0.1513	0.0540	−0.1298	0.2226	0.5600
Training of Employees	0.2795 **	0.1330	0.0360	0.3015 *	0.1745	0.0840
Constant	−3.772 ***	0.4409	0.0000	−3.784 ***	0.6161	0.0000
Athrho						0.641 ***
ρ						0.5653
Total Observations						696

Table 10 reports that the R&D has a significantly positive impact on both innovations, i.e., product and process innovation. It infers that the innovation efforts in terms of R&D activities play a significant role in the production of new products and processes. These results are in line with the strand of previous literature [10,16,41]. The results reveal that R&D spending is a key determinant of firm-level product and process innovations. Moreover, following Schumpeterian analysis, we hypothesized that bigger business organizations are more likely to produce innovative products and services. However, empirical analysis reveals that the size of the firm has no significant impact on the product and process innovations because the coefficients are statistically insignificant. Similarly, the second part of the Schumpeterian hypothesis of innovation, that *old-aged firms are more likely to produce innovative products and processes*, has been empirically verified by the data. Table 10 reports that the ages of firms play a significant role in the production of innovative products and processes. This finding is also in line with the previous literature on the same subject.

Next, we evaluate how the variables related to exports influence firm-level innovations. The variables used to define export market orientation include 'export to South Asia' and 'export to US & EU'. The results depict that market orientation does not play any role in product and process innovation. It confirms that export to South Asian economies or Western economies does not matter in terms of the production of innovative products and processes. Additionally, we examine how local and international competition influences product innovation and process innovation. The empirical findings report that local competition has a significantly positive impact on product innovation and process innovation, while foreign competition has a significantly positive impact on product innovation only, but not on process innovation. It infers that the competition, either local or foreign, plays a significant role in the production of innovative products in the Pakistani manufacturing sector. Among other variables, access to finance, product diversification, and taxation obstacle has no significant impact on product innovation. Furthermore, the audit of a firm, a lack of educated workers, and the training of employees have a significantly positive impact on product innovation. This infers that the variables related to human resources play an important role in the production of innovative products in the manufacturing sector of Pakistan. As far as process innovation is concerned, the auditing of the key performance indicators, the training of the employees, and taxation obstacles have statistically significant

and positive impacts on the process innovation, while other variables have no impact on the process innovation.

Table 11 shows the results of Bivariate Probit estimation for marketing innovation and organizational innovation. Similar to the previous analysis, we used the Bivariate Probit technique to estimate the marketing and organizational innovation models. The reason for the use of this technique is based on the assumption that firms decide on marketing and organizational innovation simultaneously. Following the previous literature, it is assumed that the manufacturing firms take both decisions on marketing innovation and organizational innovation at the same time. To empirically check whether this assumption holds true for our case, we find the ρ value of the Bivariate Probit model. The decision criteria are simple: if the ρ is other than zero, then we can say that both decisions of product innovation and process innovation by firms are made at the same time. In Table 11, the ρ value is 0.172, which verifies that the Pakistani manufacturing firms are making marketing and organizational innovation decisions at the same time.

Table 11. Bivariate Probit estimation of marketing and organization innovation. Note: * 10%, ** 5%, and *** 1% level of significance. Wald chi2 (1) = 242.17, Prob > chi2 = 0.0000.

Explanatory Variables	Dependent Variable = Marketing Innov.			Dependent Variable = Organizational Innov.		
	Marketing Innovation Model			Organizational Innovation Model		
	Coefficient	SE	ρ-Value	Coefficient	SE	ρ-Value
Predicted R&D	0.3507 ***	0.0755	0.0000	0.2298 ***	0.0673	0.0010
Size of Firm	0.0241	0.0429	0.5750	0.2466 ***	0.0444	0.0000
Age of Firm	−0.1977 *	0.1206	0.1000	0.3126 **	0.1268	0.0140
Export to South Asia	0.3457	0.3231	0.2850	−0.5345 *	0.3081	0.0830
Export to US and EU	−0.0342	0.2411	0.8870	0.4238 *	0.2330	0.0690
Local Competition	0.0884	0.1082	0.4140	0.3089 ***	0.1190	0.0090
Foreign Competition	0.4096 ***	0.1144	0.0000	0.0694	0.1278	0.5870
Access to Finance	0.2794 *	0.1711	0.1000	0.4137 **	0.1734	0.0170
Product Diversification	−0.1871 *	0.1051	0.0750	−0.2192 *	0.1152	0.0570
Audit of Firm	−0.0261	0.1560	0.8670	1.1495 ***	0.1601	0.0000
Taxation Obstacle	0.7978 ***	0.1480	0.0000	0.4640 ***	0.1369	0.0010
Lack of Educated Workers	0.1707	0.1526	0.2630	0.4240 ***	0.1532	0.0060
Training of Employees	0.4362 ***	0.1327	0.0010	0.0739	0.1308	0.5720
Constant	−0.0614	0.3846	0.8730	−3.130 ***	0.4287	0.0000
Log-Likelihood						−727.22
Athrho						0.1733 **
ρ						0.1716
Total Observations						696

Table 11 indicates that the R&D has a significantly positive impact on both marketing and organizational innovations, i.e., marketing innovation and organizational innovation, which infer that the innovation efforts in the form of allocating an amount for the R&D activities play a significant role in the marketing innovation and organizational innovation. Similar kinds of results are reported in the literature by several other scholars. The remaining variables show mixed kinds of impacts on marketing and organizational innovations. For instance, foreign competition, access to finances, taxation obstacles, and the training of employees have statistically significant and positive impacts on marketing innovation, while the age of the firm and product diversification also have a statistically significant but negative impact on marketing innovation. The remaining variables have no impact on the marketing innovations. On the other hand, the size of the firm, age of the firm, export to the US and EU, local competition, foreign competition, access to finance, audit of the firm, and taxation obstacle are identified as key determinants of the organizational innovations, with statistically significant and positive impacts. Only product diversification plays a negative impact on organizational innovation.

So far, we have examined what are the determinants of innovation efforts where innovation efforts are defined as the spending on research and development activities. Afterward, we analyze the impact of innovation efforts on product, process, marketing, and

organizational innovations. Additionally, we identified what are the key factors that play a role in the production of the product, process, marketing, and organizational innovations. In other words, this research highlights the key determinants of product, process, marketing, and organizational innovations. These findings can play a significant role in the firm-level decision-making process. It can help the firms to decide on which factor they need to pay attention to if the purpose is innovation.

4.2.2. Estimation of the Stage 2 Model

In the last stage of the estimation process, we examined how the product, process, marketing, and organizational innovations impact on the firm performance in Pakistan, where firm performance is defined as the labor productivity, i.e., the total output divided by the total number of employees. Because product, process, marketing, and organizational innovations have their determinant factors, we estimated them separately in the previous stage and use their predicted values in this stage. To deal with the endogeneity problem, first, we estimated the research and development model and use its predicted value as an explanatory variable in the product, process, marketing, and organizational innovation estimations. In this stage, the predicted values of the product, process, marketing, and organizational innovations from the previous stage are used as explanatory variables to deal with the endogeneity problem. Table 12 presents the results regarding the impacts of different types of innovations on firm performance in Pakistan.

Table 12. Impact of innovation on firm performance. Note: * 10%, ** 5%, and *** 1% level of significance.

Explanatory Variables	**Dependent Variable = Firm Performance**			
	Coefficient	**SE**	**t-Value**	***p*-Value**
Capital per Employee	0.5228 **	0.2543	2.0600	0.0430
Raw Material per Employee	−0.5685	0.3527	−1.6100	0.1110
Bonuses to Employees	−5.8259 ***	1.9105	−3.0500	0.0030
Computer and Website Use	3.4219 ***	1.2902	2.6500	0.0100
Human Capital	−0.9785	1.1847	−0.8300	0.4110
Predicted Product Innovation	5.7936 ***	1.9751	2.9300	0.0040
Predicted Process Innovation	−0.7458	1.9099	−0.3900	0.6970
Predicted Marketing Innovation	0.8469	1.3762	0.6200	0.5400
Predicted Organizational Innovation	6.5208 ***	1.3754	4.7400	0.0000
Constant	0.5226	5.1502	0.1000	0.9190
Adjusted R-Squared				50.0
Total Observations				696

Table 12 suggests that the coefficients of the factors that may or may not have had an impact on the performances of Pakistani firms, using the regression technique. As mentioned earlier, this research aims at examining the impacts of different kinds of firm-level innovation on firm performance after controlling for several other variables, including the capital per employee, raw material per employee, bonuses to employees, computer and website uses, and human capital. The results reveal that product innovation and organizational innovation have a significantly positive impact on firm performance in Pakistan. However, the results further indicate that process innovation and marketing innovation have no statistically significant impact on firm performance in Pakistan. Similar kinds of results are reported by different scholars [6,10,18,19]. It indicates that product innovation and organizational innovation are the key factors that can play a role in boosting the productivity of Pakistani firms. If the business objective is to boost firm productivity, Pakistani firms should allocate a substantial amount for research and development activities that can increase firm-level innovation and that lead to a higher firm performance in terms of labor productivity. Quantitatively speaking, if product innovation increases by one unit, the firm performance will be increased by 5.79 units in terms of firm productivity. Similarly,

if organizational innovation increases by one unit, the firm performance will be increased by 6.52 units in terms of firm productivity. The results further highlight that organizational innovation has the largest impact on firm performance among all of the innovational types. Moreover, the results indicate that process innovation and marketing innovation play no significant role in boosting the firm performance in terms of productivity.

As far as the control variables are concerned, the capital per employee has a significantly positive impact on the firm performance. If the capital per employee increases by one unit, the labor productivity is increased by 0.523 units. The results further highlight that bonuses to employees negatively affect the firm performance. It shows that these kinds of perks do not play any significant role in the encouragement of employees to boost the firm performance. Furthermore, other variables such as raw material per employee, computer and website use, and human capital play no significant role in the firm performance. The insignificance of these variables implies that in the case of a developing economy such as Pakistan, they do not contribute to the labor productivity of the firms. To sum up, the capital per employee, product innovation, and organizational innovation are the key determinants of firm productivity in Pakistan.

4.3. Discussion

Firm-level innovation is recognized as a key source of profitability and firm performance. However, during the last decade, the innovation and productivity ranking of the Pakistani manufacturing sector has been rapidly deteriorating. There is an acute need to identify the factors that play a role in weakening or polishing the innovation rates of Pakistani firms. The fundamental objective of this research is to examine the impact of firm-level innovation on firm performance in the manufacturing sector of Pakistan. Business innovation is based on the definition provided by Oslo Manual 2005. This research objective can be divided into two broad sub-objectives: (1) to identify the factors that have an impact on firm-level innovation, and (2) to examine the impact of firm-level innovation on business performance.

The estimation technique of this research consists of two stages. In the first stage, we analyzed the impact of different types of business-related variables (i.e., firm characteristics, sources of information, factors hampering innovation, and innovation effort-related variables) on different kinds of business innovation (i.e., product, process, organizational, and marketing innovation). In the second stage, the impact of different types of business innovation on firm performance is investigated in terms of labor productivity. Both stages of the models are interlinked. R&D is used as an input in the innovation equation, but several other factors define the R&D variable [10,15], so, before finding the determinants of innovation, we need to estimate the R&D equation first. After estimating the R&D equation, we used the predicted value of the R&D variable as a regressor in the innovation equation, i.e., during stage 1 of the model. Then, the predicted dependent variables of stage 1 are used as explanatory variables in stage 2.

Both product and process innovation infer that the innovation efforts through the allocation of a lump-sum amount for the R&D activities play a significant role in the production of new products and processes. It further revealed that the size of the firm has no significant impact on the product and process, because the coefficients are statistically insignificant at the conventional levels of significance. Similarly, the second part of the Schumpeterian hypothesis of innovation, *old-aged firms are more likely to produce innovative products and processes*, has been empirically verified by data. As far as marketing and organization are concerned, R&D has a significantly positive impact on both marketing innovation and organizational innovation, which infers that the innovation efforts through the allocation of lump-sum amount for the R&D activities play a significant role in marketing innovation and organizational innovation. Similar kinds of results are reported in the literature by several scholars. Stage 2 results uncovered that product innovation and organizational innovation have a significantly positive impact on firm performance in Pakistan. However,

the results further reported that process innovation and marketing innovation have no statistically significant impact on firm performance in Pakistan.

5. Conclusions and Recommendations

This study examines the impact of firm-level innovation on firm performance in the manufacturing sector of Pakistan. A two-stage framework is implemented to achieve the objectives of this research. The first stage analyzes the impact of different business-related variables such as firm characteristics, sources of information, factors hampering innovation, etc., on business innovation, including product, process, organizational, and marketing innovation. For the second stage, the impact of business innovation on firm performance is investigated. For both stages, R&D is used as an input in the innovation equation. The predicted variables of stage 1 are used as explanatory variables for stage 2. The results indicate that R&D has a significantly positive influence on product and process innovation. Furthermore, the size of the firm does not influence the product and process for Pakistani firms. For marketing and organizational innovation, R&D has a significantly positive impact on both. These results are in line with several existing works. The stage 2 results reveal that product innovation and organizational innovation show a significantly positive impact on the firm performance. However, process innovation and marketing innovation do not show a statistically significant impact on the firm performance. In addition, the findings report that job-related perks such as employee bonuses have a negative impact on the firm's performance.

The findings of this study have various policy recommendations for researchers and practitioners. Empirical estimation identified several determinants of innovation efforts that can help the firm-level decision-makers optimally utilize limited resources. These findings can play a significant role in the firm-level decision-making process. It can help the firms to decide on which factor they need to pay attention to if the purpose is innovation. To sum up, an understanding the findings proposed in this study on the relationship between firm-level innovation and firm productivity can better equip policymakers to devise fruitful interventions. For instance, research and development play a vital role in the firm-level innovation process. Additionally, Pakistani firms should focus on product innovations and organizational innovations if they want to increase firm-level labor productivity.

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