TECHNOLOGY ADOPTION AND PRODUCTIVITY ANALYSIS IN THE SIALKOT SPORT GLOVES INDUSTRY: A COMPARISON AMONG SMALL, MEDIUM AND LARGE ENTERPRISES

By

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Introduction

Following the end of World War II many economists conducted comparative studies to identify the determinants of long term economic growth. Some of them believed industrial policies and economic infrastructure were the drivers of long term economic growth in contrast to economists who emphasized the role of capital intensive firms and more automated production techniques. It was not until 1956 when Robert Solow presented an economic framework in which the impact of technology on growth was explained in terms of the Solow residual which was later referred to total factor productivity (Solow, 1956). This theory led to a strategic focus on investment in technology for economic growth and development. This idea was further presented by Romer (1989) in the form of new growth theory. This theory deviates from the neoclassical treatment of technology as exogenous and modeled technology as endogenous.

The contribution of technology in macroeconomic performance and development is explained through growth accounting which looks at the amount of investment in technology at the firm level. It is generally the microeconomic impact of investment in technology which leads to growth in the aggregate economy. There is rich literature that provides both empirical and theoretical evidence (especially for the East Asian economies) of how investment in technology by firms is a major reason behind economic growth miracles (Amsden and Chu, 2003; Lall and Urata,2003; Mathews and Chu, 2007). These authors discuss how technology adoption is extremely relevant for export oriented manufactures since they are the ones who not only face competition at the domestic and international levels but also has to maintain competitive by adopting the latest products and process technologies to meet ever changing global requirements. Technology is considered an important driver of not only economic diversification but also for sustainable economic growth along with poverty alleviation.

In this thesis, the sports gloves manufacturing sector of Pakistan is analyzed. This is an important export sector in the economy and Figure 1 shows the export destinations of Pakistani made gloves. The figure shows that the major destination of these gloves is Europe, North America and South America. The figure also shows that there is a significant market for high and medium quality gloves. Moreover, Pakistan exports of gloves only constitute 0.15% of total world exports (International Trade Statistics, 2014). At the same time, China's exports have increased by over six times in their share of exports of gloves since 2000. Similarly, India's exports of gloves have also increased by fivefold since 2000. At the same time, Pakistan exports have only increased by 2.7 times since 2000 which reflects how the country has fallen behind (Pakistan Bureau of Statistics, 2013-14).

Figure 1: Export Destinations of Pakistani Gloves with respect to Quality of Goods

Key: ○ High Quality Gloves Export Destinations

□ Medium Quality Gloves Export Destinations

△ Low Quality Gloves Export Destinations

Source: Authors own drawing from data collected.

Pakistan has a limited number for globally competitive exporters out of which a significant number are clustered around the city of Sialkot which has a population of less than one million people and is located in north-eastern Punjab. It has the distinction of exporting diverse range of world class sport goods. The city exported approximately USD $2 billion worth of goods in 2015 and its exports constitute 9% of the country's total exports of USD $22 billion.[1] After extensive data collection and interviews were conducted with the main decision makers of the firm it was revealed that the businessmen of Sialkot are trying to resolve their respective problems independently by devising corrective measures instead of relying on either government or politicians. Local businessmen have developed the local infrastructure like a new airport, establishment of a technology university, launching a local airline, and improving local roads Moreover, the local Chamber of Commerce has privately financed a dry port in Sialkot which facilitates the clearing of goods from customs before it reaches to the conventional port.

The primary focus of this thesis is technology adoption in the Sialkot gloves sector. Technology adoption is a complex phenomenon which is dependent upon different firm characteristics and environment under which firms are operating. In contrast, technology mapping determines the current technological state and competitive position of a firm to clearly identify the viable and profitable areas for future investment. This study is an attempt to explore multiple determinants of technology adoption and map the current and past state of technology in the Pakistan sport gloves industry of Sialkot which has not yet been focused upon in the literature. Pakistan has experienced a 10% increase in sporting good exports over the last five years. (Pakistan Trade Authority, 2013-2014). According to most recent international trade statistics on total exports of gloves manufacturing, sports gloves contribute 29% to world exports in contrast to non-sports gloves

[1] The Economist, "How a small Pakistani city became a world-class manufacturer", Asia (October 29, 2016)

which contribute 71% (International Trade Statistics, 2013-14). In Pakistan exports of sports gloves contributes 43% to total glove exports while 57% of gloves exported are non-sports gloves (Trade development authority of Pakistan, 2013-2014). Interestingly, in the category of sports goods exports in Pakistan, glove exports have experienced the highest increase of $25.06 million in 2013 in contrast to the exports of other sports goods which have experienced a decline 29.64% (Pakistan Bureau of Statistics, 2013-14). Thus, it is useful to focus on the gloves sector which is a success story in the context of Pakistan.

Our particular analysis will look at firm level productivity using different measures of total factor productivity in the gloves sector and the relationship between total factor productivity and technology levels across firms in the sector. In this analysis, the growth in output will be decomposed into growth in inputs and growth in total factor productivity and we will also relax the usual assumption that inputs are used efficiently.

The main research questions for this study focus on whether firm size, management practices, financial constraints, research and development and export destinations affect firm level technology adoption and revenue, labor and total factor productivity. The main research questions and research hypotheses for the proposed study is as follows:

Research Questions

1) Is total factor productivity affected by technology adoption in the Sialkot gloves industry?

2) Is total revenue productivity affected by technology adoption in the Sialkot gloves industry?

3) Is labor productivity affected by technology adoption in the Sialkot gloves industry?

4) Does firm size affect firm level technology adoption?

5) Does the age of a firm affect firm level technology adoption?

6) Do firm profitability and the percentage of retained earnings affect technology adoption?

7) Do financial constraints affect technology adoption?

8) Does R& D affect technology adoption?

9) Are export destinations having a major effect on technology adoption?

Research Hypothesis

H1: Total factor productivity is positively and significantly affected by technology adoption in the Sialkot gloves industry.

H2: Total revenue productivity is positively and significantly affected by technology adoption in the Sialkot gloves industry.

H3: Labor productivity is positively and significantly affected by technology adoption in the Sialkot gloves industry.

H4: Firm size positively and significantly affects firm level technology adoption.

H5: Age of a firm positively and significantly affect firm level technology adoption.

H6: Firm profitability and the percentage of retained earnings positively and significantly affect technology adoption.

H7: R& D positively and significantly affect level of technology adoption?

The study will contribute in the existing literature as so far there is no empirical evidence related to Pakistan sports gloves industry and technology adoption and mapping. In comparison to past theoretical and empirical research on different cottage industries this study will contribute by providing insight into level of technology adoption at each stage of the production process involved in the manufacturing of sport gloves. Furthermore, it will provide a cost benefit analysis of technology adoption and technology mapping for different sized firms.

The layout of the thesis is as follows: It begins by providing a detailed review of the literature on technology adoption and productivity and their respective correlates. This is followed by a discussion of the data sources and the methodology used in the analysis. Then the thesis presents models to empirically test the research hypotheses. The results and findings are followed by conclusions.

Literature Review

Historically, international trade and industrial production were two different concepts and were largely separate from each other up until the conventional theory of comparative trade advantage was introduced into the world economy. It was the era when merchant organizations production was completely independent from actual producers. During that time primary commodities and semi manufactured goods constitute major chunk of goods traded and international specialization reflects the countries abundant resources and factors endowed. Moreover, the structure of international economy was designed in a way that even just using the relative factor cost to international trade sustained the sufficient degree of explanatory power (Soedersten and Reed, 1994; Szirmai, 1998).

However, since the second half of last century some of the developing countries especially East Asian economies experienced rapid growth in productivity and economic performance by not only changing the structure of international trade but also incorporating new variables into factors that affect global competition. Porter (1990) further provided his insight with regard to the new variables in his accounts on treatise competitive advantage of nations. In these, he highlighted that establishment of large scale organizations connected with foreign direct investment in multiple ranges of products and projects, creative destructions and technological breakthroughs with improved infrastructure, communication networks and transportation, mechanization of production process and adoption of new technologies in manufacturing processes as the key variables for competitive edge. Furthermore, he also explained that these variables translated into improved international trade both in terms of value and size. So many developing and developed economies realizing the importance of trade and the idea of gains from trade from increased competition, specialization, economies of scale and scope, variety of goods, lower prices and high profit margins. Moreover, he concluded the main channel for firms to realize the maximum gains from trade is through exports. The transformation acted as major instrument to bring about structural changes in the newly established industrialized economies. These economies experienced higher productivity and profits by developing considerable potential in exports.

Technology Adoption (High Tech, Medium Tech and Low Tech Firms)

Since the thesis is focused on technology adoption, it is useful to look at the literature in this area. Nelson and Phelps (1966) have presented a technology adoption model which explains that rate at which technological laggards adopt technological enhancements in leader countries is positively dependent on educational attainment and proportionate to the technology gap between the leader and themselves. Their results showed that if new technology is adopted, it will then combined with human capital and have a positive impact on level of output produced. Moreover, if technology advancement is sustained only then it will aid in skill accumulation.

Besides this, Benhabib and Spiegel (1994) further extended the model of Nelson and Phelps (1996) by incorporating endogenous growth elements in it representing how the level of human capital stimulates countries to adopt technology and develop their own technological innovations. Adoption of technology from abroad can also be related and expressed as technology transfers; for instance, Coe et al., (1997) related it with total factor productivity. In their study total factor productivity is a function of research and development stock in importing country trading partner, stock of imported machines and equipment, research and development expenditure in domestic GDP and country specific parameters. The empirical findings shows that technology is transferred from leader to followers and its rate of technology adoption is further dependent on the level of education of the recipient country.

Benhabib and Spigel (2002) extended and refined their previous model (Benhabib and Spiegel, 1994) by allowing for different functional forms of the technology adoption process. One of the forms is relevant and converges to a balanced growth in which followers are growing at the same pace as leaders. In the second form it allows for divergence in total factor productivity growth rates between the leaders and followers especially if there is major difference in level of human capital. They further conducted an empirical panel study on 84 countries for the years 1960 and 1995 and their results reveal a positive role of human capital as main driver for technology adoption and facilitating growth.

Comin and Hobijn (2004) used the historical cross country technology adoption database which follows the data of adoption of many technologies for 215 years from 23 world’s leading industrial economies. The main objective of study was to determine and study factors that can lead to cross-country differences in technology. They found evidence of trickle down adoption which is considerably robust across technologies specifications. Moreover, well-to-do technology leaders are first to adopt latest technologies and are more likely to innovate. Secondly, once the leaders adopt technology, laggards also start adopting new technologies in order to catch up or at least get align with the leaders. Now there are host of positive and negative factors associated with trickle down technology adoption. The positive factors include income per capita; human capital and trade openness in contrast negative factors include military or either government. Moreover, another limiting factor to technology adoption is a legislation that is rarely cooperative and effective.

Apart from this Coleman (2004) expressed two limitations in the Comin and Hobijn (2004) work. Firstly, in his view the initial finding that countries with low human capital are less likely to adopt technologies or will either be slow in adopting technologies directly implies that rate of technology adoption is an efficient response to insufficient resources. For instance Caselli and Coleman (2002) empirically suggest human capital as not the most important factor in determining the level of technology adoption. Secondly, it was not clear whether new technologies adopted are also the most efficient ones. It could be the case that most rapid adopters of advanced technologies are having inefficient outcomes as they might have adopted it too early. Moreover, data is restricted to developed economies therefore inference about the rate of technology adoption could be biased towards an efficiency based results.

Besides the role of human capital on technology adoption research and development also has varied impacts as research and development investments is essential to understand and operationalize technologies. This notion is further supported by Griffith, Redding and Van Reenen (2000), they have used data of 12 OECD countries covering the time frame from (1974-1990). Their results reveal technology adoption and research and development as positive correlates and similarly positive effect of investment in research and development on total factor productivity growth.

On the other hand, Acemoglu and Zilibotti (1999) argued that even if all economies have access to same level of technologies there will be still significant differences in productivity outcomes. The paper primarily focused on certain aspect of technology transfer which includes technology imported from North to South excluding South-South trade. Technology in the North is superior to that of the South but the condition of the economy plays an important role in determining whether technology adoption will be appropriate or not.

Even if there are no barriers to technology adoption the theoretical models still explain how a mismatch in skill-difference induced technology further translates into productivity differences. For instance, if the South has unskilled labor then even adopting new technology will result in low productivity levels. Moreover, Basu and Weil (1988) are of view that technology is “appropriate” only for countries which are capital intensive in nature. It means they have similar capital-labor ratio.

Besides this, Lall (2001) further discussed the connection between the export performance and the adoption of technology by firms. He emphasized that technology plays a key role in international competitiveness whereas the empirical findings provided the mixed reviews. Moreover, some of the empirical studies found no link between the export performance and investment in technology (Cotsomitis et al. (1991) and Kumar (2002). Furthermore, in recent studies technology adoption in terms of research and development expenditure also showed positive impact on export performance (Kumar and Siddharthan, 1994; Basile 2001). Additionally, in early studies technology adoptions were being measured in terms of technology stock and research and development intensity (Kumar 1990; Cotsomitis et al., 1991). On the other hand, Lall (2002) had conducted empirical study on India and reported that adoption of e-business technologies also impact the export performance of Indian small and medium-sized industries (SMIs).

It thus appears both from theoretical and empirical studies that adoption of technology plays a major role in export performance of manufacturing firms. Therefore, in this study we have hypothesized that firm level technology adoption and its key determinants provide potential explanation for the export prospective for Sialkot sports gloves industry of Pakistan. It will further help in explaining the causes for innovations process while designing a conceptual framework of technology mapping in Sialkot gloves industry. Following specific hypotheses are proposed for this study to capture the link of major determinants of technology adoption in sport gloves industry with supporting evidences from previous theoretical and empirical studies.

Productivity and Firm Performance of Small, Medium and Large Manufacturing Firms

Since the thesis relates technology adoption to firm performance and productivity, it is useful to look at these concepts and the accompanying literature more closely. Productivity is defined as ratio of volume measure of output to volume measure of input used. The literature provides evidence there is no single measure of productivity nor it has certain unique purpose. The main objective of productivity measurement includes technology, efficiency, real cost savings, benchmarking production processes and living standards.

Productivity calculations are considered to be main ingredient in determining technical change and technology adoption. Griliches (1987) described technology as “the currently known ways of converting resources into outputs desired by the economy”. Furthermore, it can comes in multi forms such as new blue prints, new organizational tools and techniques, advances in new products, adoption of latest machines and equipment etc.

The pursuit for identifying changes in efficiency is different from technical change. Diewert and Lawrence (1999) define full efficiency with respect to engineering when the production process achieves the maximum amount of output physically available with current technology and given fixed set of inputs. Harberger (1998) further restates that there are numerous factors behind productivity growth and pointed out real cost savings as one of the most important factors.

Productivity calculations provide society an opportunity to evaluate the growth of firms and industry. There are multiple factors which can cause improvement as well as deterioration in productivity. From the outset, technology adoption is considered to be the main determinants of total factor productivity and policies are driven both by the government and firm to promote and encourage investment in this regard to have positive impact on firm growth and output produced.

Besides this, technology is adopted and invented by small number of leader firms as most of the countries do not produce state of the art technologies themselves indeed acquire it from somewhere else. There are different ways to acquire technology such as through trade and Foreign Direct Investment (FDI). Both are considered to be affected by way of adopting technology and indirectly effecting total factor productivity. FDI is considered as transfer of technology from developed economy with high organizational forms to developing and emerging economies. FDI has an advantage and there are positive externalities from it. Griffith, Reading and Simpson (2003) found a positive relationship between FDI and productivity growth in manufacturing firms.

Apart from this, Mayer (2001) combines two aspects of literature relevant to productivity growth. Firstly, import is one of the channels to incorporate foreign advanced technology into domestic production which has positive impact on productivity. Import is referred to machines and equipment domestic firms acquire for better performance and outcomes through research and development. Secondly, human capital is another aspect which plays major role in technology adoption and indeed creation of domestic technology.

Hasan (2002) has studied Indian manufacturing firms for the two periods between 1976/1977 and 1986/1987. He examined how technology is impacted through both embodied and disembodied technology inputs. Results of the embodied technology inputs revealed a positive and significant effect of imported new capital goods and new domestic capital goods on productivity levels. In contrast, terms of the latter, disembodied capital positively affects productivity with a limitation of foreign origin.

On the other hand, research and development investment also has positive impact on productivity growth levels. Lichtenberg and Siegel (1991) provides evidence of above statement from empirical estimation on 2000 US firms, Hall and Mairesse (1995) validates the statement by conducting research on 197 French firms on the data from 1980 to 1987. Ahan (2001) is of view that in reality it is not innovation input referred as research and development investments main component of productivity growth it is indeed use of advanced technology. This argument is logical as empirical studies uses only input data which is by and large available.

Similarly, Geroski (1991) provides other interesting findings that innovation such as adoptions of advanced technologies have much greater impact on its user's productivity growth in contrast to its producers. Baldwin and Diverty (1995) conducted a study on Canada Survey of Manufacturing technology 1989 and empirical findings suggest that both plant size and plant growth are closely linked to technology. McGuckin, Streitwieser and Doms (1998) conducted research on US firms and found that plants using advanced technologies are having relatively much higher productivity growth in comparison to firms who have not adopted technologies and even controlling for the factors such as plant size, age and capital intensity. Moreover, (Crepon, Duguet and Mairesse, 1998) also found positive correlation between higher productivity and new and advanced technologies by conducting research on 4000 French manufacturing firms between 1986 and 1990.

In contrast, Bartelsmann, van Leeuwen and Nieuwehuijsen (1996) provide contradictory results about the relationship between advanced technologies and productivity growth levels in a study of firms conducted in Netherlands. The main findings were that capital deepening was behind labor productivity growth. Moreover, Comin (2002) also questions the impact of research and development on total factor productivity. Author finds that less than 3-5 tenths of one percentage point of total factor productivity can be attributed to research and development. The results are opposing to the view that research and development is the main driver of long term growth and productivity. Similar evidence was also found in panel data estimates while incorporating fixed effects that research and development has minimal effect on productivity (Jones and Williams, 1998).

Firm Size (Small, Medium and Large Firms)

One of the factors related to technology adoption may be firm's size. There is significant amount of evidence that size of firm has important linkage with adoption of technology. However, there is ambiguous theoretical linkage between the size of firm and adoption of technology. There are many reasons to expect positive relationship between firm size and technology adoption as larger the size of firms more they experience economies of scale in production. Moreover, they possess higher capacity for bearing risks and above all have if not strong then at least better financial position that attaches higher probability of investment in technology (Krugman, 1979). Empirical studies provided mixed results on firm size and adoption of technology. Some studies found to have positive relation between firm size and technology adoption (Bartoloni and Baussola, 2001; Tariq et al., 2009; Suri, 2011) in contrast to studies who have reported that small firms have higher level of technology adoption (Oster 1982). For this study, we therefore hypothesize that the size of the firm will have a positive impact on a firm's investment in technology.

Age of firm

Another factor affecting technology adoption may be the age of the firm. Age of firm can also affect the decision to invest in technology in many ways. Firstly, the old firms are more experienced and well aware of the market conditions thus try to maintain and sustain competitive edge both in domestic and international markets for a longer period of time therefore will be more inclined to adopt latest technologies. Secondly, older firms have to invest in new technologies as with passage of time equipment's and machinery used in firms becomes obsolete. Therefore, for consistency and future benefits they need to adopt new technologies. For this study, we therefore hypothesize that the age of the firm and technology adoption has a positive relationship.

Firms Production Size (Amount of Output Produced by the firms) and Capacity

A third factor in technology adoption is the firm production size and capacity. The firm production size and capacity have a positive impact on technology adoption. Firms with larger production sizes have higher capacity along with more motivation to adopt new technologies to sustain their competitive edge in the market. Thus, they are always inclined to adopt improved process and product technologies. The empirical evidence also provides a positive link between production size and capacity (Tariq et al., 2009). In this study we therefore hypothesize firm production size and capacity will have a positive relationship with technology adoption.

Research and Development by firms to adopt latest technology

Another obvious factor in technology adoption is firm level research and development. It is generally believed that firm spending on research and development has a strong connection with technological adoption. Moreover, with increase cost associated with technological adoption there is less probability of firms spending on research and development. On the other hand, under certain scenarios higher spending on research and development by firms provide higher incentive for technology adoption (Lee, 1983). Similarly, Albert et al.,(2005) in recent study suggested a positive connection between the amount of research and development and the level of investment in technology. Therefore in this study we hypothesize firms spending more on research and development will lead to greater technological adoption.

Profitability and Revenue generated by firms

Also, some authors have pointed out that firm level profitability may impact technology adoption. The firm's probability is the key measure to determine whether they will adopt technology or not. Generally, firms with higher profits margins are inclined to adopt more advanced technologies as they have finances to bear the cost of adopting technology along with urge to sustain competitive edge position by producing best quality products at lower costs and capturing the highest market share (Stoneman and Kwon, 1996; Suri, 2011).

Export Destinations of Small, Medium and Large Enterprises

The amount of technological adoption may be closely related to export destinations. Generally, firms with more advanced technologies usage in production process and process innovation leads to maximization of revenues by exporting in the developed economies (Barriors et al., 2003). Similarly, empirical evidence has been found in Argentinean firms that by upgrading current state of technology and installing new advanced equipment's in production process translated into exports into developed economies (Bustos and Paula, 2011). Therefore, this study hypothesizes that technology adoption and higher income export destinations have a positive relationship.

Data

This study is based on field survey conducted on 20 registered sports small and medium and large gloves industries of Sialkot Pakistan. The number of workers employed is considered to be an important criteria in defining the size of firm for this thesis. Small firms refer to those who have a maximum of fifty (50) workers employed, medium sized firms have greater than fifty but less than equal to two hundred and fifty (250) workers and large sized firms employ more than two hundred and fifty (250) workers. There are 500 registered gloves firms in Sialkot but this study have restricted the sample only to sport gloves producing firms. There are total 35 registered sport gloves firm in Sialkot. In this study twenty firms are selected on random basis from the population size. A quantitative technique of questionnaire was used to collect data for this study. The respondent of the questionnaire is primarily the main decision maker of each firm in sample. The data was gathered by meeting in person the decision maker of each firm with bilingual mode of communication according to the requirement of time. Moreover, each factory survey is also accompanied by having complete overview of the production process followed in each organization to further make analysis and comparison across firms. The questionnaire was divided into five major sections which include size of firm, production process, management, finance, research and development and export destinations. Size of firm section provides information with regard to types of gloves produced their production size at peak, normal and lowest level during the past twelve months and past two years. Furthermore, this section also provides information with regard to age of firm and total number of employees. The second section provides insight about technology adoption, costs and number of employees at five major production steps which include procurement of raw materials, cutting, printing, stitching and quality check and packing and logistics. The management section determines the levels of management, number of direct and indirect employees, span of control and workers time shift. Finance sections highlight the net assets of firms, firm's profit margins and net worth of the firm. The research and development and export destination section state the amount of spending by firms in research and development along with major export destinations.

Table 1 show the descriptive statistics of the output, material, labor, capital and energy cost of the firms with respect to classification according to levels of technology adoption. On average the output produced by high tech firms is significantly higher than medium tech and low tech firms for both year 2015 and 2013. Moreover, material, labor, capital and energy costs have also increased for all types of firms over the span of two years. But, once again high tech firms are experiencing the higher total cost than medium to low tech firms.

Besides this, output produced on average by high tech firms is approximately four times that of medium tech firms whereas on average output produced by medium tech firms is approximately five times that of low tech firms in year 2015. In contrast, on average output produced by high tech firms was five times approximately of medium tech firms whereas output produced by medium tech firms was approximately five times that of low tech firms in year 2013. So, it explains high tech firm level on average output has slightly decreased over the period of two years in comparison medium to low tech firm output level remained constant.

Intermediate goods cost of high tech firms are three times that of medium tech firms whereas medium tech firm costs are approximately four times that of low tech firms for the year 2015 and 2013. Moreover, labor costs for high tech firms are three times that of medium tech firms whereas medium tech firms cost are two times that of low tech firms for the year 2015 and 2013.

The major cost differences across firm technology specifications are of capital expenditure. On average high tech firms capital cost are forty six times that of medium and low tech firms for the year 2015 and 2013. It implies it is costly to climb the technology ladder from medium to high tech firms. Moreover, there are no major gaps in output produced if comparison is made from medium to high tech firms. But, over here it is important to mention high tech firms produced finest quality of gloves and have significant price differences which act as added component for market sustainability and competitive edge.

Figure 4 shows the average trend of firm total factor productivities. In both years 2013 and 2015 significant number of firms was clustered around the mean total factor productivity and only one firm was experiencing above average productivity. It is interesting to mention that in 2013 none of the firm was having below average total factor productivity where as in 2015 one of the firms experienced this trend. Furthermore, as shown in Figure 5 there are fifteen firms in 2015 which were clustered around the average total revenue productivity indeed one firm is experiencing higher total revenue productivity from firm average whereas in 2013 more firms were clustered around the average total factor productivity, only two firms were behind the average total factor productivity and one was experiencing accelerating trend. Figure 6 shows on average labor productivity trends. In year 2015 the labor productivity of firms had improved from average to above in comparison to year 2013.

Table 1: Descriptive Statistics of Inputs and Outputs by Level of Technology

	Output	Material Cost	Labor Cost	Capital Cost	Energy Cost
Average High-Tech 15	3,384,000	1,276,767,450	193,999,650	31,735,779	52,852,500
Standard Deviation High-Tech 15	3,829,523	1,386,218,298	227,422,172	56,640,351	55,501,760
Average Medium-Tech 15	768,000	436,902,600	66,573,000	679,834	13,203,000
Standard Deviation Medium Tech 15	650,938	358,268,042	41,065,338	545,816	8,351,676
Average Low -Tech 15	140,571	123,373,371	27,307,063	794,262	6,079,200
Standard Deviation Low-Tech 15	109,666	124,557,440	32,528,779	678,600	8,027,153
Average High-Tech 13	3,677,143	1,039,784,714	183,462,321	39,780,515	49,029,857
Standard Deviation High-Tech 13	3,663,230	1,175,298,253	187,543,863	65,630,377	42,219,687
Average Medium-Tech 13	688,800	335,551,800	56,563,920	747,816	10,202,400
Standard Deviation Medium-Tech 13	547,537	242,763,836	35,549,384	600,398	5,820,435
Average Low-Tech 13	138,000	106,778,700	24,102,750	865,883	5,243,250

Mapping the Gloves Production Process

The production process of sports gloves of various forms is relatively simple. The process starts with the ***procurement of the raw materials***. Raw material could be procured both from the local and international market dependent upon the need of the firm. If the raw material is procured from within Sialkot or its nearby cities it will take at maximum one day to get the material delivered at desired destination. Moreover, some raw material are procured from the local market including fabric, PVC foam, Letix foam, elastic, velcro, thread, spandex lycra and new prim. These materials are imported majorly from China by local vendors who further supply it in local firms. The major raw material in sport gloves production is leather which is either synthetic (fake leather rexine) or in pure form. It depends on the quality of output and likewise demand and nature of gloves to determine which form of leather to use. Generally, all firms irrespective of the size are using both in production. Leather is procured from international market directly by the firms according to their production capacity. Some gloves firms have leather tanneries operational as well which produces leather through in house production. If leather is procured from international market it will take on average of 30 days again dependent on import destination.

After the raw material is procured then next stage is the ***inspection of leather***. It is done in chemical laboratories. The sample of different types of leather are send for testing on random basis and its result determines the quality of leather and whether it is feasible for production or not. Besides the, chemical testing of leather inspection is also made by firm leather experts in warehouse before it is moved into next production process. If the chemical test report is negative there are very minimal chances of defect. The testing time varies by firm size and different categories of firms. Pure leather chemical testing takes on average 1.5 days by large enterprises, 2.5 days by medium enterprises and 3.5 days by small firms. In contrast, fake leather testing takes on average 2.5 days for large enterprises, 3.5 days for medium sized enterprises and 4.5 days for small enterprises.

The next process after the inspection of leather is of ***pattern making and cutting of leather***. This process is performed both manually by human labor and also by machines dependent upon the size of firm and level of technology adoption. Generally, small size firms with significantly less cost of capital and production capacity prefers manual patter making and cutting of leather. Card paper and pencils are used for pattern making and scissors are the main tool of leather cutting on designed pattern. It is time consuming in nature, have less accuracy and generation of scrap. It takes on average 8.5 minutes by one worker to make pattern and cut the pair of gloves. In contrast, medium to large scale firms have adopted the technology and using machines at this stage of production to reduce time and cost and for improved quality. Most of the medium sized firms have adopted hydraulic cutting press machine, pattern cutting machine and post bed machines at this stage of production which takes on average 30 seconds by one worker to make pattern and cutting of leather. Moreover, with aid of these machines 10-15 pairs of gloves can be cut simultaneously. In addition, from our data sets there is only one large scale enterprise which has adopted Spreader table technology machine and its main function is to first design the pattern on software with target of zero percent scrap or wastage and then cutting of computer aided pattern through sharp cutter. It amounts to high capital cost but it produces ten times higher defect free output without any waste and only require four workers to operate it and do the tasks which generally requires on average of 40-50 workers. It takes on average 5 seconds to cut one pair of gloves through this machine.

After the leather pattern and design is cut then comes the stage of ***printing and dyeing***. Printing and dyeing again can be done both manually and through machine dependent upon the level of technology adopted and firm size. Generally, manual printing through dye is done in most of the small to medium enterprises. Only few medium and almost all large enterprises have adopted the heat transfer sublimation machine. It takes 7 minutes on average by one worker to print one pair of gloves through manual dye but time could vary with increase in number of colors and design to be printed. In contrast, heat transfer sublimation machine is advanced and computerized and entails the capacity to print complete sheet of leather of regular size at once. It takes on average 1 minute to print one pair of gloves through machine.

After the printing and dyeing process, the ***stitching*** process starts. Stitching is done through machines for all kinds of sports gloves irrespective of firm size. But, the type of machine used for stitching varies across firms. For instance, medium to large firms have employed advanced technology by using computerized jockey machines, embossing machine, binding and safety over-lock machines. Generally, single needle and double needle machines are used for stitching. It takes on average 20 minutes to stitch one pair of boxing gloves by one worker, 12 minutes on average to stitch one pair of goal keeping and safety gloves by one worker and 15 minutes on average to stitch one pair of fancy bike and other sport gloves by one worker in small size firms. Moreover, it takes on average 15 minutes to stitch one pair of boxing gloves by one worker, 7 minutes on average to stitch one pair of goal keeping and safety gloves by one worker and 10 minutes on average to stitch one pair of fancy bike and other sport gloves by one worker in medium size firms. In contrast, it takes on average 12 minutes to stitch one pair of boxing gloves by one worker, 6 minutes on average to stitch one pair of goal keeping and safety gloves by one worker and 5 minutes on average to stitch one pair of fancy bike and other sport gloves by one worker in small size firms. Average time for stitching varies across firms due to quality of machines. Local machines or either imported second hand machines are not as productive as brand new machines.

Once the pair of gloves got stitched, then it is transferred to ***quality assurance department*** where each pair of gloves is checked completely either through human experts or machine before it goes for final ***finishing and packing***. Small to medium sized firms and even some large firms are still using human experts for quality checks, final finishes and packing. The only machine used by some of the large enterprises is scanning machine for metal detections. It takes on average 3 minutes to check, finish and packs one pair of gloves per worker in all firm size. There is variation of 1-2 minutes on average if scanning machine is used.

The final stage of production process involves ***transportation and logistics*** of the gloves produced. Time varies from export destination to destination such as if goods have to be transported in local market it will be delivered with one day irrespective of the firm size. Medium to large scale firms have their own means of transports for intercity delivery or even transportation of final goods to dry port. In contrast, for international market it will take on average one month to deliver goods at export destinations.

Figure 2: Gloves Production Process Flow

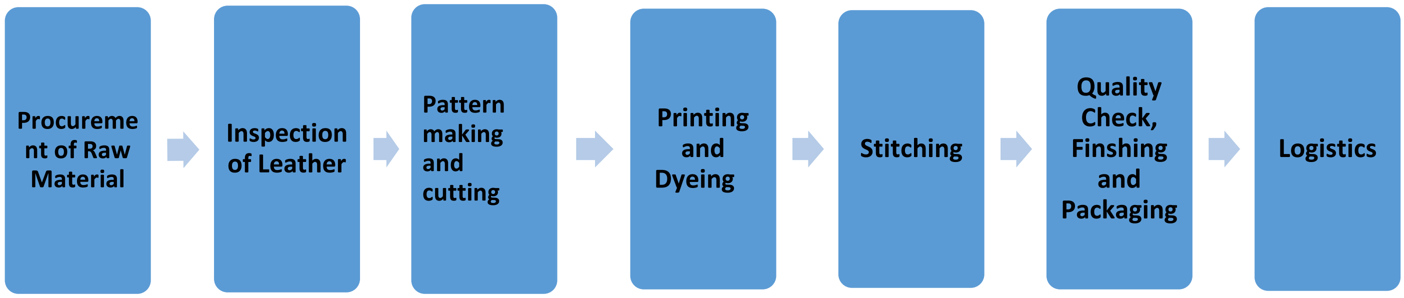


Table 2: Gloves Production Process Table

Sr #	Gloves Production Steps	Machines Used	Average Time per worker in Small Enterprises	Average Time per worker in Medium Enterprises	Average Time per worker in Large Enterprises
1	**PROCUREMENT OF LEATHER**				
	Local Market (Sialkot & Near By Cities)	Animal Carts, Cars, Trucks and Loaders	1 Day (Dependent upon Quantity of Material)	2 Day (Dependent upon Quantity of Material)	3 Day (Dependent upon Quantity of Material)
	National Market (All over Pakistan)	Cars, Rails, Buses, Trucks and Loaders	1 day to 2 weeks (Dependent upon import destination and quantity of material)	2 day to 1 week (Dependent upon import destination and quantity of material)	3 day to 1 week (Dependent upon import destination and quantity of material)
	International Market	Shipping, Loaders, Trucks	30-40 days (Dependent upon import destination and quantity of material)	20-30 days (Dependent upon import destination and quantity of material)	20-30 days (Dependent upon import destination and quantity of material)
2	**INSPECTION OF LEATHER**				
	Synthetic Leather	Chemical Labs	5-4 days	3-4 days	2-3 days
	Pure leather	Chemical Labs	3-4 days	2-3 days	1-2 days
3	**PATTERN MAKING AND CUTTING**				
	Manual	Scissors	8-10 mints/pair of gloves/worker	-	-

	Machine	Hydraulic Cutting Press Machine, Pattern Cutting Machine, Travel head, Post bed machines, spreader Table Technology (Only in few large enterprises)		30 seconds to 1 min/pair of gloves/worker	10 sec-30 sec/pair of gloves/worker
4	**PRINTING AND DYEING**				
	Manual	Handmade dye	7-8 mints/ worker/pair of gloves	6-7 mints/ worker/pair of gloves	
	Machine	Heat transfer sublimation machine		1-2 mints/ worker/pair of gloves	30 seconds/ worker/pair of gloves
5	**STITCHING**				
	Machine	Jockey Single Needle, Double Needle, Jockey Computerized Machines, Zigzag Machine Embossing, Binding and Over lock machines	20-25 mints one pair of boxing gloves/ worker 12-15 mints one pair of goal keeping gloves/worker 10-12 mints one pair of safety gloves/worker 15-20 mints one pair of other sports fancy gloves/worker	15-20 mints one pair of boxing gloves/ worker 10-12 mints one pair of goal keeping gloves/worker 7-10 mints one pair of safety gloves/worker 10-15 mints one pair of other sports fancy gloves/worker	12-15 mints one pair of boxing gloves/ worker 8-10 mints one pair of goal keeping gloves/worker 6-8 mints one pair of safety gloves/worker 5-10 mints one pair of other sports fancy gloves/worker
6	**QUALITY ASSURANCE, FINISHING AND PACKING**				

	Manual		2-4 mints/pair of gloves/worker	2-4 min/pair of gloves/worker	
	Machine	Scanner for metal detectors		1-2min/pair of gloves/worker	1-2 min/pair of gloves/worker
7	**LOGISTICS**				
	Local Market (Sialkot & Near By Cities)	Animal Carts, Cars, Trucks and Loaders	1 Day (Dependent upon Quantity of Material)	1 Day (Dependent upon Quantity of Material)	1 Day (Dependent upon Quantity of Material)
	National Market (All over Pakistan)	Cars, Rails, Buses, Trucks and Loaders	1 day to 2 weeks (Dependent upon export destination and quantity of material)	2 day to 1 week (Dependent upon export destination and quantity of material)	3 day to 1 week (Dependent upon export destination and quantity of material)
	International Market	By Air, Shipping, Loaders, Trucks	30-40 days (Dependent upon export destination and quantity of material)	20-30 days (Dependent upon export destination and quantity of material)	20-30 days (Dependent upon export destination and quantity of material)
Authors own calculations.					

Measuring Technology in the Production Process

One of the main questions in this research is to determine how the level of technology changes across firms. In order to examine technology levels, this study has given firms technology rankings based on the sophistication of the technologies involved at each production step. A firm is categorized as low technology firms if it is using machinery only in the stitching process, medium technology firms of machinery is used in both cutting and stitching of the gloves and high technology firms if machinery is involved in the cutting, stitching and printing process of gloves. The empirical estimations shown in Table 3 and 4 depicts that there has been a movement in technology ladder from low-tech firms to medium-tech firms over the span of two years but there is no movement up to high tech firms. Similarly, medium tech firms output and revenue produced is four times that of small firms whereas high tech firms output and revenue produced is four times that of medium tech firms. Upon key observation there are no major differences between low-tech to medium-tech firms cost of capital. But, there is significant difference between high tech to medium tech cost of capital. This provides evidence why there is movement along low-tech firms climbing up the ladder of medium tech firms and there is no shifting from medium to high tech firms. Figure 3 further shows over the span of two years there are seven firms ranked as high-tech. In contrast, three firms have shifted from low-tech to medium-tech firms.

Figure 3: Technology Levels of Glove Manufactures

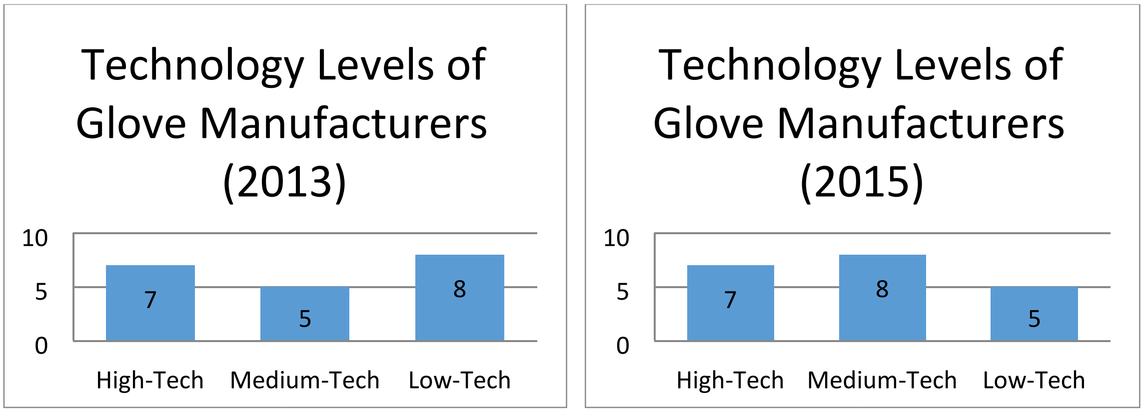


Table 3: Differences between firms based on Technology Levels

Technology	Average Annual Production	Average Total Annual Revenue	Average Total Annual Cost	Average Annual Profit	Average Mark Up	Average Current Year Cost of Capital
High-Tech	3,384,000	2,694,735,000	1555355379	1,139,379,621	73.82	31,735,779
Medium Tech	768,000	925,560,000	517358434	408,201,566	66.77	794,262
Low-Tech	140,571	23,786,0571	157553896	80,306,675	55	679,834

Average Annual Production: Total number of high, medium and low quality gloves produced on average in a year by a firm.
Average Total Revenue: Total revenue generated from selling high, medium and low quality of gloves on average at their respective prices in a year
Average Total Cost: It is the sum of material, labor, energy and capital cost of firm for the year.
Average Annual Profit: It is the difference between total revenue and total cost including the overhead cost of the firm in a year
Average Mark-up: It is the annual profit divided by the total cost.
Average Current Year Cost of Capital: It is the yearly cost of machinery used in the production process of each firm.

Table 4: Differences between firms based on Technology Levels

Technology	Average Annual Production Differences	Average Total Annual Revenue Differences	Average Total Annual Cost Differences	Average Annual Profit Differences	Average Mark Up Differences	Average Current Year Cost of Capital Differences
% age difference from Low to Medium	446.34	289.12	228.37	408.30	20.84	16.83
% age difference from Medium to High	340.63	191.15	200.63	179.12	10.56	3895.63
% age difference from Low to High	2307	1033	887	1319	34	4568

Production: Total number of high, medium and low quality gloves produced on average in a year by a firm. Average Total Revenue: Total revenue generated from selling high, medium and low quality of gloves on average at their respective prices in a year

Average Total Cost: It is the sum of material, labor, energy and capital cost of firm for the year.

Average Annual Profit: It is the difference between total revenue and total cost including the overhead cost of the firm in a year

Average Mark-up: It is the annual profit divided by the total cost.

Average Current Year Cost of Capital: It is the yearly cost of machinery used in the production process of each firm. The value is net of depreciation.

Source: Authors own calculations

Research Methodology

Measuring Productivity

This paper aims to determine the link between technology and productivity. Thus, from the given data set we looked at three different measures of firm's level productivity which includes (1) Total Factor Productivity, (2) Total Revenue Productivity and (3) Labor Productivity.

A Cobb-Douglas production function with four factors of production—capital, labor, energy and intermediate goods—is used to estimate Total Factor Productivity (TFP) and Total Revenue Productivity (TRP) (Solow, 1957;Hulten, Charles R., 1996,2001 ; Schreyer and Pilat, 2001) .The Cobb-Douglas production function specification used in the estimation is

$$\mathbf{Y_{ij} = A_{ij}\, K^{\alpha}{}_{ij} L^{\beta}{}_{ij} M^{\lambda}{}_{ij} E^{\mu}{}_{ij}}$$

where

Y_{ij} = Output (Firm Sales)

K_{ij} = The replacement value of machinery for the particular year

L_{ij} = Labor cost

M_{ij} = Material cost

E_{ij} = Energy cost

And

$$\alpha_{ij} = \frac{Capital\ Cost_{\ ij}}{Total\ Cost_{ij}}$$

$$\beta_{ij} = \frac{Labor\ Cost_{\ ij}}{Total\ Cost_{ij}}$$

$$\lambda_{ij} = \frac{Material\ Cost_{\ ij}}{Total\ Cost_{ij}}$$

$$\mu_{ij} = \frac{Energy\ Cost_{\ ij}}{Total\ Cost_{ij}}$$

Productivity was measured by:

$$Aij = Y_{ij} / K^{\alpha}{}_{ij}L^{\beta}{}_{ij}M^{\lambda}{}_{ij}E^{\mu}{}_{ij}$$

Aij= Total Factor Productivity

Aij= Total Revenue Productivity when output is determined in terms of money

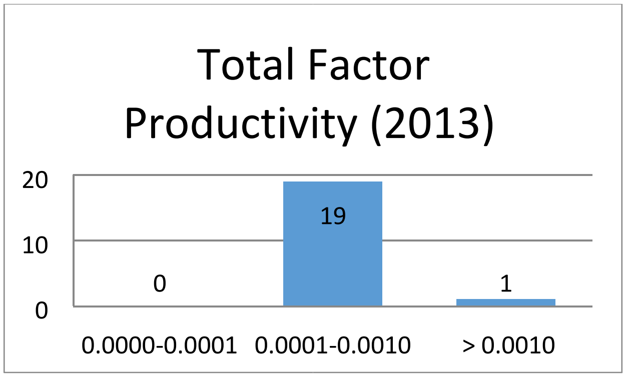
TFP is estimated as the residual term of the production function. The TFP values used in this study have further applied the non-parametric Solow residual method, in which output elasticity of each input factor is calculated as the cost share of that input in total cost. TFP is estimated as the residual of the production function, making use of the calculated elasticities. Moreover, firm sales in terms of number of pair of gloves sold are used to measure output in case of TFP. It includes the value of all high, medium and low quality gloves sold on average during the particular year. Firm sales in terms of rupees (price times the quantity) are used to measure output in case of TRP. Furthermore, to calculate output in terms of revenue the price of high quality goods were multiplied by the number of high quality gloves and likewise for the medium and low quality goods before the total summation. To determine the capital cost for current year the data was gathered of all types of machinery used in the production process, year in which they were operational, the expected life of the machine and most importantly there depreciation methodology. In general, most firms have adopted the straight line accounting method of deprecation.[2] The replacement value of machinery and equipment (net of depreciation) is used to measure capital. Besides this, labor cost is summation of the total compensation given to workers directly involved in the production process. And intermediate goods are determined by summing up per unit cost of raw materials and intermediate materials and multiplying with respective number of gloves produced. Labor Productivity is measured by total output divided by number of workers.

[2] Straight line method of depreciation for the year= Cost of machine- scrap value/ No. of estimated useful life

$$\textbf{LP} = Y_{ij} \,/\, \textbf{Number of Workers}$$

Moreover, the Figures 4, 5 and 6 shows the clustering of total factor productivity and total revenue productivity around mean productivity levels. In 2015, total factor lower productivity tail became thicker which indicates a large number of low productivity firms. The similar trend is represented in labor productivity numbers which shows a fat lower tail indicating clustering of firms around low labor productivity. In addition, figure 7 shows productivity levels by technology level of firms and which is align with our hypothesis that high and medium tech firms are more productive in contrast to low tech firms.

Figure 4: Total Factor Productivity 2013 and 2015



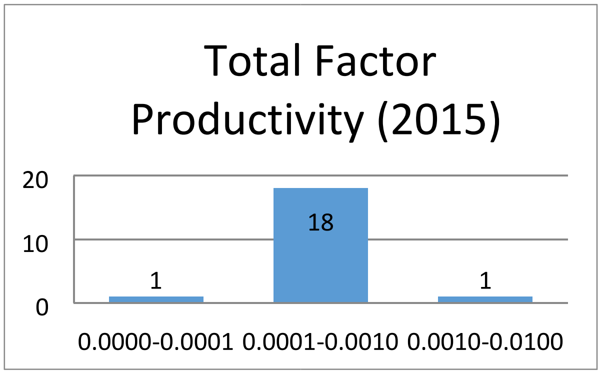
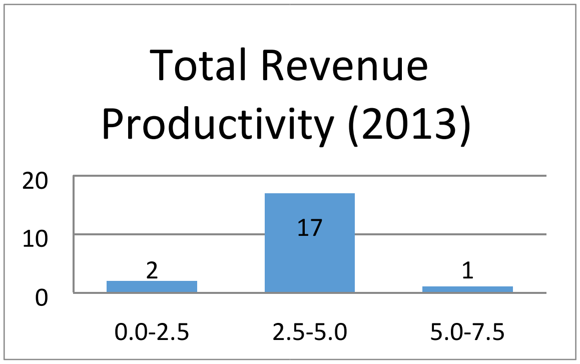


Figure 5: Total Revenue Productivity 2013 and 2015



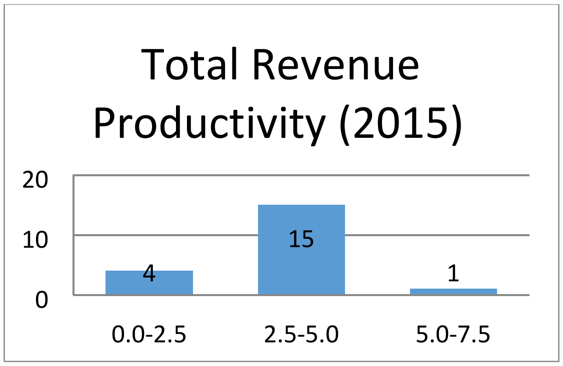


Figure 6: Labor Productivity 2013 and 2015

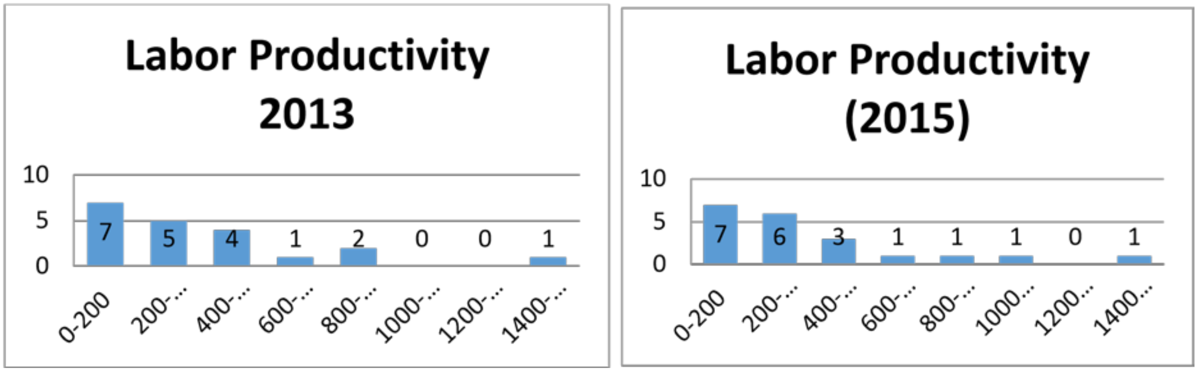
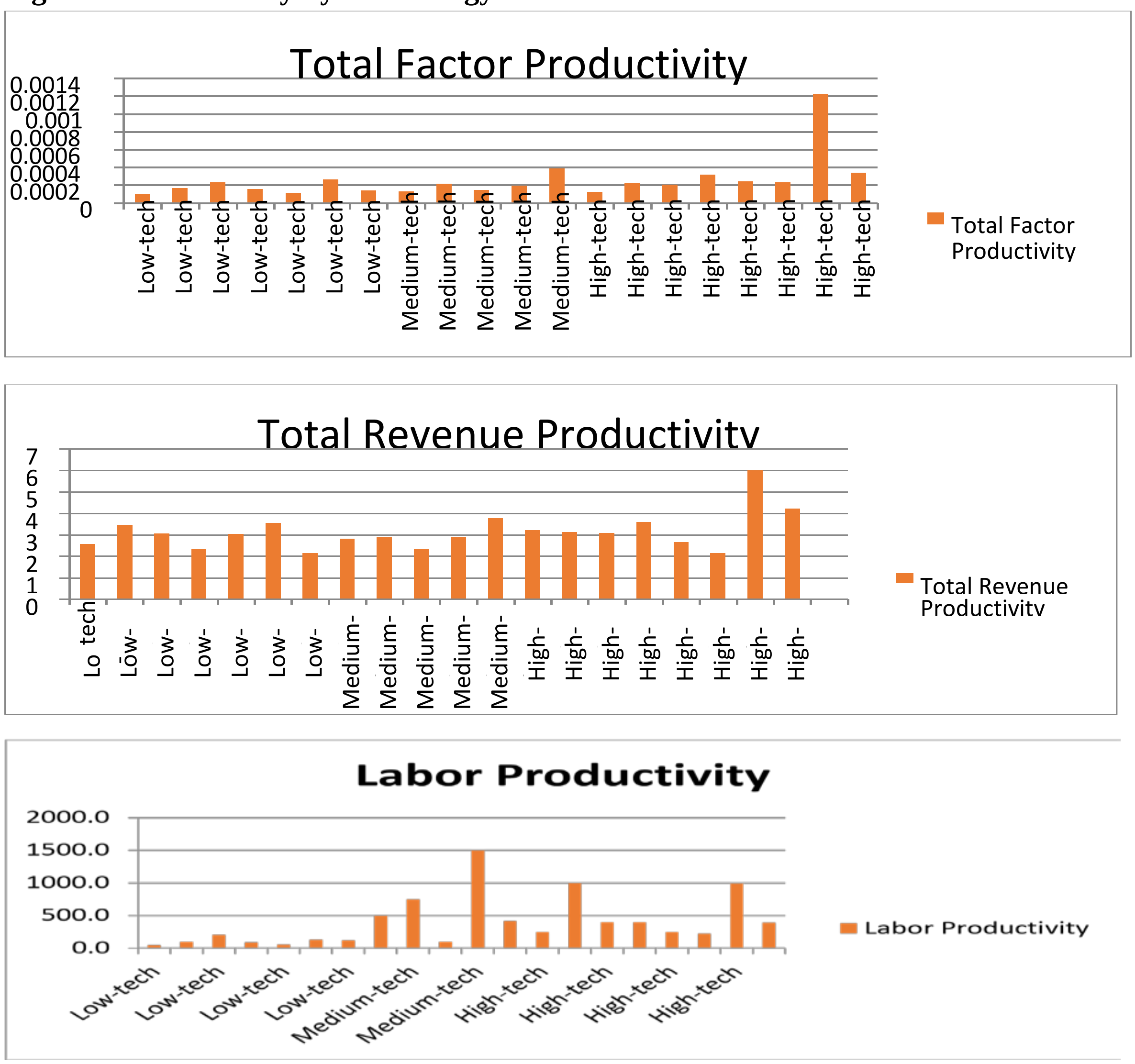


Figure 7: Productivity by Technology Level



Estimating the Technology Adoption (High Tech, Medium Tech and Low Tech) and the Relationship between Productivity and Technology

There are varieties of models that have been used to determine the decision of technology adoption. In this study, we have followed the rank ordered logit model of technology adoption. It was first presented by David (1969) with its further modification by David (1975) and later by Davies (1979) followed by Stoneman (1986). This model and its multiple variants had been used in the firm level studies of technology adoption (e.g. Fairaa et al., 2002 and Parhi, 2008). This model is based on observation of decision to adopt technology or not by firms and holds strong theoretical and empirical base. And mostly importantly, this model is influenced by host of factors such as firm size, firm age, firm's production size, ownership, finance, owners education, firm's profitability, spending on research and development and export destinations. This model assumes a certain threshold level and technology adoption takes places if the threshold level is crossed. Moreover, the empirical application of rank ordered logit model of technology is conducted in terms of proportional odds assumption. Therefore, choice of technology adoption is discrete and firms either invest in technology adoption or do not invest. As this discrete choice dependent variable is categorical in nature therefore ordinary least squares will not generate best linear unbiased estimates which implies ordinary least square estimates will be biased and inefficient. To counter this problem binary dependent variable techniques could be used. In this study we have applied the ordered logit estimation technique. Ordered Logit model holds additional features such as the dichotomous dependent variables which allows for more than two ordered response categories. For this study, high tech firms are the one which has adopted technology i.e. machinery in cutting, stitching and printing process of the gloves, -tech firms are the one who has adopted technology in cutting and stitching only whereas low tech firms are the one who have just adopted technology in stitching of the gloves. The following model was stipulated to determine the results

$\boldsymbol{Technology\ Adoption}$ **=** $\boldsymbol{\alpha_0}$ **+** $\boldsymbol{\alpha_1}$ **age of firm +** $\boldsymbol{\alpha_2}$ **firm profitability+** $\boldsymbol{\alpha_3}$ **research and development+** $\boldsymbol{\alpha_4}$ **firm size+** $\boldsymbol{\alpha_8}$ **owners education +** $\boldsymbol{e}$ **(1)**

Besides this, simple ordinary least square regression have been conducted to determine how technology adoption and socio-economic factors affect the total factor productivity, total revenue productivity and labor productivity following equations were estimated:

$\boldsymbol{TFP}$ **=** $\boldsymbol{\alpha_0}$ **+** $\boldsymbol{\alpha_1}$ **age of firm +** $\boldsymbol{\alpha_2}$**retained earnings+** $\boldsymbol{\alpha_3}$ **firm profitability+** $\boldsymbol{\alpha_4}$ **technology adoption+** $\boldsymbol{\alpha_5}$ **firm size+** $\boldsymbol{\alpha_6}$ **production capacity+** $\boldsymbol{\alpha_7}$ **research and development+** $\boldsymbol{\alpha_8}$ **owners education+** $\boldsymbol{\alpha_9}$ **owner child education+** $\boldsymbol{e}$ **(2)**

$\boldsymbol{TRP}$ **=** $\boldsymbol{\alpha_0}$ **+** $\boldsymbol{\alpha_1}$ **age of firm +** $\boldsymbol{\alpha_2}$**retained earnings+** $\boldsymbol{\alpha_3}$ **firm profitability+** $\boldsymbol{\alpha_4}$ **technology adoption+** $\boldsymbol{\alpha_5}$ **firm size+** $\boldsymbol{\alpha_6}$ **production capacity+** $\boldsymbol{\alpha_7}$ **research and development+** $\boldsymbol{\alpha_8}$ **owners education+** $\boldsymbol{\alpha_9}$ **owner child education+** $\boldsymbol{e}$ **(3)**

$\boldsymbol{LP}$ **=** $\boldsymbol{\alpha_0}$ **+** $\boldsymbol{\alpha_1}$ **age of firm +** $\boldsymbol{\alpha_2}$**retained earnings+** $\boldsymbol{\alpha_3}$ **firm profitability+** $\boldsymbol{\alpha_4}$ **technology adoption+** $\boldsymbol{\alpha_5}$ **firm size+** $\boldsymbol{\alpha_6}$ **production capacity+** $\boldsymbol{\alpha_7}$ **research and development+** $\boldsymbol{\alpha_8}$ **owners education +** $\boldsymbol{\alpha_9}$ **owner child education+** $\boldsymbol{e}$ **(4)**

Empirical Estimations

The empirical findings in Table 5 analyze the factors affecting technology adoption using Ordinary least squares (OLS) and Ordered logit estimation techniques. The results reveal that the age of a firm is negatively and significantly affecting technology adoption (the OLS estimates are significant while the ordered logit estimates results are insignificant). This can be explained since old firms are less inclined to innovate and adopt advanced technologies. Moreover, it also implies that young firms (newly established firms) are more interested in adopting technology. In general old firms are more comfortable with their respective conventional approaches of gloves production which they have mastered which in turn has led to large profits. Thus, they show resistance to adopting change and upgrading technology. Even though, the discussion above implied that technology adoption at each stage of gloves production will lead to higher output, better quality and above all cost reductions, there is a significant capital cost for firms wanting to move up from medium to high technology levels Based on discussions with firm owners, it was found that the majority of workers in the gloves production process are unskilled and adopting latest technologies requires not only new machines but also a newly trained workforce. And since this is time consuming and costly, most of the firms are reluctant to change their existing production practices. The empirical findings are consistent with the existing literature which finds that many new firms start up as large enterprises and are more likely to adopt advanced technologies in order to have a high market share (Tariq et al., 2009; Fariaa et al., 2002; Bortamuly and Goswami, 2014).

Besides this, retained earnings and firm profitability are found to have a positive and significant relationship with technology adoption. This suggests that firms with higher profitability are more prone to climb the technology ladder in contrast to less profitable firms. Likewise, high technology ladder firms have an added advantage of enjoying high profits in contrast to low technology ladder. This is also in line with the existing empirical result which finds that firms with high profit margins adopt the latest machines to sustain a competitive edge in the market (Stoneman and Kwon, 1996; Suri, 2011).

Apart from this, the impact of research and development is showing mixed results. If we consider our OLS estimates then R&D has a significant yet inverse relationship with level of technology adoption. It implies as firms reach a higher technology ranking they are less likely to spend on research and development. This may also be because these firms have adopted relatively advanced technology thus have restricted their respective further cost funding on research and development in specific. On the other hand, the ordered logit results show a positive yet insignificant relationship between R&D and the level of technology adoption. The existing literature finds evidence that under certain conditions there is a positive relationship between higher spending on research and development and technology adoption (Lee, 1983; Albert et al., 2005). Firm size is another variable which affect the decision of adopting technology. But unfortunately, our research findings did not provide any significant estimates of the impact of this variable.

Apart from this, table 7,8 and 9 shows factors affecting total factor, revenue and labor productivities. Multiple factors both social and economic are considered in our estimations. The age of firms is positively and significantly affecting productivity across specifications which imply older firms are more productive in contrast to newly established firms. The literature varies across countries with some studies finding that new entrants in the market are more interested in reaching highest productivity levels but as time passes these firms grow in size and their productivity growth stabilizes and eventually becomes stagnant (Huergo and Jaumandreu, 2004).

An extremely interesting though counterintuitive result is that there is a significant but negative relationship of firms' retained earnings and profitability with various measures of productivity (except for labor productivity). This can be due to multiple reasons. First, investment objectives by insiders which includes firm managers, owners, founders and family are unclear in the sense that if their wealth and especially income streams are linked to the wealth of the firm they manage, then there are less likely to favor any high risk (risk loving) strategies which could lead to lower productivity (Ishengoma,2004). Second, keeping in view agency theory, discrete shareholding of large enterprises is related to information asymmetries which results in poor control of management which is further in direct conflict with stakeholder's interests. Thus, managers may aim at maximizing their respective utilities at the expense of decreased productivity (Hill and Snell, 1989). Third, as a firm grows older they may become more profitable even though their productivity becomes stable and stagnant in contrast to new firms (Huergo and Jaumandreu, 2004). Last, it is possible that firms with different factor combinations are likely to have different productivities across firms. For instance, a study conducted by Teal (1999) on garments and furniture manufacturers explained the reason behind negative link between productivity and firm investments is due to high labor costs associated in manufacturing sector. Moreover, he further reveals that micro firms are more likely to have lower productivity in comparison to large firms. In addition, Tanzanian manufacturing sector also experienced decreases in productivity due to high investments in firm. It is because investment in manufacturing sector reduces labor productivity.

The key result that comes from our empirical estimations is that technology adoption is affecting firm level productivities across specifications significantly and positively. It provides additional evidence for our main research hypothesis that all those firms which are ranked higher on the technology ladder tend to be more productive than firms that are lower on the technology ladder. The reasons for this are multifold: First adopting new technologies smooth's out the production process by making it efficient and effective. Second, technology can be the main method by which firms lower their average cost and achievement of economies of scale in the long run. Our results are supported by the finds of Mayer (2001) who provided a theoretical linkage between the import of technologies in domestic manufacturing and higher growth. Moreover, Hasan (2002) conducted a similar exercise for Indian manufacturing firms and found that embodied technology inputs resulted in high and significant productivity growth rates. Bartelsmann, van Leeuwen and Nieuwehuijsen (1996) on the other hand found a negative relationship between the adoption of advanced technologies and productivity growth levels in a study of Dutch firms.

The empirical results in this thesis found that production capacity and research and development are also positively affecting productivities across specifications. This implies that firms operating at full capacity with optimal resource allocation are experiencing higher productive outcomes. Similarly, research and development is a significant factor for firms that are trying to remain competitive. Lichtenberg and Siegel (1991) find the same result for a sample of 2000 US firms. Similarly, Hall and Mairesse (1995) find estimates are also consistent with our empirical estimations. In contrast, Ahan (2001) is of the view that in reality research and development is not the same as actual innovation input which means that R&D may not have an actual impact on productivity growth. This argument is logical sinee empirical studies only use input data which is by and large available. Also, Comin (2002) provided evidence that research and development makes a very insignificant contribution to firm level productivities.

Besides this, if we include only the lag of retained earnings as independent variable in regression analysis it provides interesting results and impacts on productivity as shown in appendix section. In table 9, by estimating factors affecting total factor productivity then only research and development provides significant and positive relationship. In contrast, table 10 shows firm profitability and owner's education having positive and significant impact on total revenue productivity. Similarly, firm profitability, technology adoption and research and development have positive and significant impact on labor productivities.

As we can see from empirical analysis above there is one high tech firm with highest productivity level thus classified as an outlier. Therefore, empirical estimations were also conducted after eliminating this firm from the sample data but unfortunately it did not bring significant outcomes as shown in Table 12,13 and 14.

Table 5: Factors Affecting Technology Adoption (OLS Estimates) and (Ordered Logit Estimates)

VARIABLES	Technology Adoption(OLS)	Technology Adoption (Ordered Logit)
Age of firm	-0.128**	-0.427
	(0.0483)	(0.312)
Retained Earnings	16.23***	59.09*
	(5.038)	(33.20)
Firm Profitability	1.05e-09***	7.35e-09**
	(3.18e-10)	(3.35e-09)
Research and Development	-3.44e-09*	1.36e-07
	(1.70e-09)	(4.62e-07)
Firm Size	-0.150	-1.569
	(0.231)	(1.596)
Owner's Education	-0.0940	-0.599
	(0.0766)	(0.477)
Constant cut1		-3.133
		(5.753)
Constant cut2		0.283
		(6.176)
Constant	1.636	
	(0.951)	
Observations	20	20
R-squared	0.694	

Dependent Variable: Technology Adoption (it is a dummy variable where 1= Low tech firm which is using machinery in stitching process only, 2= Medium Tech firm which has employed machinery in cutting and stitching of gloves and 3= High-Tech firms which has employed machinery in cutting, stitching and printing of gloves)
Independent Variables: Age of firm (it is number of years since the firm started manufacturing gloves), Retained Earnings (It is percentage of firm retained earnings for year 2015), Firm profitability is measured by the annual profit of the firm , Research and development is the yearly cost incurred by firm on R&D, Firm size is also a dummy variable in 1=small firm with 0-50 number of employees, 2= medium firm with 50-250 employees and 3=large firms with greater than 250 employees, Owner's Education (it is a dummy variable where 16= Masters, 14=Bachelors, 12= Intermediate, 10= Matric/Olevels, 8= Middle, 0= Less than Middle) and Owner's Child Education (it is a dummy variable where 16= Masters, 14=Bachelors, 12= Intermediate, 10=in schools)
Standard errors in parentheses
*** $p<0.01$ it represents significance level at 1%
** $p<0.05$ it represents significance level at 5%
* $p<0.1$ it represents significance level at 10%
Source: Authors own calculation

Table 6: Factors Affecting Total Factor Productivity (TFP)

VARIABLES	TFP
Age of firm	1.84e-05**
	(7.67e-06)
Retained Earnings	-0.00175*
	(0.000802)
Firm Profitability	-2.84e-13**
	(1.22e-13)
Technology Adoption	7.52e-05**
	(2.95e-05)
Firm Size	3.79e-06
	(2.59e-05)
Production Capacity	8.39e-11*
	(4.06e-11)
Research & Development	8.16e-13***
	(2.30e-13)
Owner Education	1.53e-05
	(8.75e-06)
Owner Child Education	-3.24e-05**
	(1.19e-05)
Constant	0.000364**
	(0.000144)
Observations	20
R-squared	0.947

Dependent Variable: TFP for year 2015

Independent Variables: Age of firm (it is number of years since the firm started manufacturing gloves), Retained Earnings (It is percentage of firm retained earnings for year 2015), Firm profitability is measured by the annual profit of the firm ,Technology Adoption (it is a dummy variable where 1= Low-tech firm which is using machinery in stitching process only, 2= Medium Tech firm which has employed machinery in cutting and stitching of gloves and 3= High-Tech firms which has employed machinery in cutting, stitching and printing of gloves), Firm size is also a dummy variable in 1=small firm with 0-50 number of employees, 2= medium firm with 50-250 employees and 3=large firms with greater than 250 employees, Production Capacity is the number of gloves produced on average by firms in year 2015, Owner's Education (it is a dummy variable where 16= Masters, 14=Bachelors, 12= Intermediate, 10= Matric/O-levels, 8= Middle, 0= Less than Middle), Owner's Child Education (it is a dummy variable where 16= Masters, 14=Bachelors, 12= Intermediate, 10=in schools) and Research and development is the yearly cost incurred by firm on R&D

Standard errors in parentheses

*** $p<0.01$ it represents significance level at 1%

** $p<0.05$ it represents significance level at 5%

* $p<0.1$ it represents significance level at 10%

Source: Authors own calculation

Table 7: Factors Affecting Total Revenue Productivity (TRP)

VARIABLES	TRP
Age of firm	0.0883**
	(0.0387)
Retained Earnings	-8.782*
	(4.045)
Firm Profitability	-7.81e-12
	(6.17e-10)
Technology Adoption	0.325*
	(0.149)
Firm Size	-0.0231
	(0.130)
Production Capacity	-1.71e-07
	(2.05e-07)
Research & Development	4.41e-09***
	(1.16e-09)
Owner Education	0.145***
	(0.0441)
Owner Child Education	-0.125*
	(0.0598)
Constant	2.743***
	(0.728)
Observations	20
R-squared	0.871

Dependent Variable: Total Revenue Productivity for year 2015
Independent Variables: Age of firm (it is number of years since the firm started manufacturing gloves), Retained Earnings (It is percentage of firm retained earnings for year 2015), Firm profitability is measured by the annual profit of the firm ,Technology Adoption (it is a dummy variable where 1= Low-tech firm which is using machinery in stitching process only, 2= Medium Tech firm which has employed machinery in cutting and stitching of gloves and 3= High-Tech firms which has employed machinery in cutting, stitching and printing of gloves), Firm size is also a dummy variable in 1=small firm with 0-50 number of employees, 2= medium firm with 50-250 employees and 3=large firms with greater than 250 employees, Production Capacity is the number of gloves produced on average by firms in year 2015, Owner's Education (it is a dummy variable where 16= Masters, 14=Bachelors, 12= Intermediate, 10= Matric/O-levels, 8= Middle, 0= Less than Middle), Owner's Child Education (it is a dummy variable where 16= Masters, 14=Bachelors, 12= Intermediate, 10=in schools) and Research and development is the yearly cost incurred by firm on R&D
Standard errors in parentheses
*** p<0.01 it represents significance level at 1%
** p<0.05 it represents significance level at 5%
* p<0.1 it represents significance level at 10%
Source: Authors own calculation

Table 8: Factors Affecting Labor Productivity (LP)

VARIABLES	LP
Age of firm	22.98
	(30.76)
Retained Earnings	-3,531
	(3,216)
Firm Profitability	8.44e-07
	(4.90e-07)
Technology Adoption	257.5*
	(118.5)
Firm Size	-53.49
	(103.7)
Production Capacity	-0.000326*
	(0.000163)
Research & Development	2.35e-06**
	(9.21e-07)
Owner Education	43.73
	(35.10)
Owner Child Education	9.971
	(47.58)
Constant	-321.4
	(578.9)
Observations	20
R-squared	0.764

Dependent Variable: Labor Productivity for year 2015

Independent Variables: Age of firm (it is number of years since the firm started manufacturing gloves), Retained Earnings (It is percentage of firm retained earnings for year 2015), Firm profitability is measured by the annual profit of the firm ,Technology Adoption (it is a dummy variable where 1= Lowtech firm which is using machinery in stitching process only, 2= Medium Tech firm which has employed machinery in cutting and stitching of gloves and 3= High-Tech firms which has employed machinery in cutting, stitching and printing of gloves), Firm size is also a dummy variable in 1=small firm with 0-50 number of employees, 2= medium firm with 50-250 employees and 3=large firms with greater than 250 employees, Production Capacity is the number of gloves produced on average by firms in year 2015, Owner's Education (it is a dummy variable where 16= Masters, 14=Bachelors, 12= Intermediate, 10= Matric/O-levels, 8= Middle, 0= Less than Middle), Owner's Child Education (it is a dummy variable where 16= Masters, 14=Bachelors, 12= Intermediate, 10=in schools) and Research and development is the yearly cost incurred by firm on R&D

Standard errors in parentheses

*** $p<0.01$ it represents significance level at 1%

** $p<0.05$ it represents significance level at 5%

* $p<0.1$ it represents significance level at 10%

Source: Authors own calculation

Conclusions

This study aims at analyzing technology adoption and productivity levels across firms classified as small, medium and large. The research questions address whether adopting latest technologies in gloves production process will lead to higher total factor, total revenue and labor productivity. In order to test the research hypothesis, this thesis focuses on the sports gloves manufacturing industry in Sialkot, Pakistan. An index of technological sophistication is developed primarily based on a mapping of the various technologies used in each step of gloves production process. It further helps in empirically estimating total factor productivity, total revenue productivity and labor productivity of the firms data collected. It helps in analyzing the correlates of productivity with technology adoption.

A causal inspection of the data reveals clustering of total factor productivity and total revenue productivity around the mean levels and thick lower tail of the total revenue productivity indicates significant number of low productivity firms keeping in view their actual potential. The results were further reinforced by labor productivity data which shows a fat lower tail implying large number of firms clustered around low labor productivity. Similarly, there are significant differences in total factor productivities of medium and high tech firms in comparison to medium to low tech firms.

Moreover, host of socio-economic factors affecting the level of technology is also considered. Both the quantitative and qualitative findings reveal that technology adoption in gloves manufacturing sector is of significance. The main findings were technology adoption to be positively related to productivity. Other, interesting results were level of retained earnings having negative affect on total factor productivity and total revenue productivity across firms. It suggests that firms with higher retained earnings are less interested in research and development and adoption of latest technologies as discussed above due to conventional production approach and mind-sets. Industrialist are considerably risk averse and more concerned about their current retained earnings rather than making investments and taking risk which could substantially pay off in future. Besides this, all of the firms is of opinion that 100 percent internal financing to be used for technology up gradation and business expansion. There are reluctant to get external financing in terms of loans to acquire latest technology to move up the higher technology ladder.

The results imply that policy makers must create awareness of the advantage of adopting the latest technologies. There is a need to upgrade the old production methodologies in order to capture a greater share of the sports gloves industry market share globally. There is need of collective efforts both at the end of Government and firms. There is already existing vocational training institute of sport manufacturing in Sialkot. This center should be utilized more effectively by arranging regular training programs and free seminars with regard to sport gloves machine education. In upcoming years a more skilled workforce, will also be become a requirement. Moreover, effective incentive plans should be incorporated in firms to provide motivation to workforce to work effectively and efficiently. Producing high quality, low cost and defect free manufacturing is required to target major export destinations. Thus, education of technology is of utmost importance. Lastly, it is suggested that government should lower the import duties on advance machinery to make it affordable for medium to low tech firms. For future studies data should be collected across countries to make comparative analysis and application of advanced econometric models.

APPENDIX

Table 9: Factors affecting Total Factor Productivity with Retained Earnings Lag variable

VARIABLES	TFP
Age of firm	1.24e-06
	(2.39e-06)
Retained earnings_1	-0.000147
	(0.000134)
Firm profitability	-3.34e-14
	(1.13e-13)
Technology adoption	2.60e-05
	(2.98e-05)
Firm size	-1.22e-05
	(3.46e-05)
Production capacity	2.47e-11
	(4.41e-11)
Research & development	6.71e-13**
	(2.67e-13)
Owner education	6.41e-06
	(9.93e-06)
Owner child education	-1.76e-05
	(1.66e-05)
Constant	0.000354*
	(0.000188)
Observations	19
R-squared	0.931

Dependent Variable: TFP for year 2015

Independent Variables: Age of firm (it is number of years since the firm started manufacturing gloves), Retained Earnings Lag (It is lag of percentage of firm retained earnings for year 2015), Firm profitability is measured by the annual profit of the firm ,Technology Adoption (it is a dummy variable where 1= Low-tech firm which is using machinery in stitching process only, 2= Medium Tech firm which has employed machinery in cutting and stitching of gloves and 3= High-Tech firms which has employed machinery in cutting, stitching and printing of gloves), Firm size is also a dummy variable in 1=small firm with 0-50 number of employees, 2= medium firm with 50-250 employees and 3=large firms with greater than 250 employees, Production Capacity is the number of gloves produced on average by firms in year 2015, Owner's Education (it is a dummy variable where 16= Masters, 14=Bachelors, 12= Intermediate, 10= Matric/O-levels, 8= Middle, 0= Less than Middle), Owner's Child Education (it is a dummy variable where 16= Masters, 14=Bachelors, 12= Intermediate, 10=in schools) and Research and development is the yearly cost incurred by firm on R&D

Standard errors in parentheses

*** $p<0.01$ it represents significance level at 1%

** $p<0.05$ it represents significance level at 5%

* $p<0.1$ it represents significance level at 10%

Source: Authors own calculation

Table 10: Factors affecting Total Revenue Productivity with Retained Earnings Lag variable

VARIABLES	TRP
Age of firm	0.00845
	(0.0109)
Retained earnings_1	-1.026
	(0.611)
Firm profitability	1.14e-09*
	(5.15e-10)
Technology adoption	-0.0193
	(0.136)
Firm size	-0.0590
	(0.158)
Production capacity	-4.03e-07*
	(2.01e-07)
Research & development	3.08e-09**
	(1.22e-09)
Owner education	0.112**
	(0.0453)
Owner child education	-0.102
	(0.0757)
Constant	3.222***
	(0.858)
Observations	19
R-squared	0.866

Dependent Variable: TRP for year 2015

Independent Variables: Age of firm (it is number of years since the firm started manufacturing gloves), Retained Earnings Lag (It is percentage of firm retained earnings lag for year 2015), Firm profitability is measured by the annual profit of the firm ,Technology Adoption (it is a dummy variable where 1= Low-tech firm which is using machinery in stitching process only, 2= Medium Tech firm which has employed machinery in cutting and stitching of gloves and 3= High-Tech firms which has employed machinery in cutting, stitching and printing of gloves), Firm size is also a dummy variable in 1=small firm with 0-50 number of employees, 2= medium firm with 50-250 employees and 3=large firms with greater than 250 employees, Production Capacity is the number of gloves produced on average by firms in year 2015, Owner's Education (it is a dummy variable where 16= Masters, 14=Bachelors, 12= Intermediate, 10= Matric/O-levels, 8= Middle, 0= Less than Middle), Owner's Child Education (it is a dummy variable where 16= Masters, 14=Bachelors, 12= Intermediate, 10=in schools) and Research and development is the yearly cost incurred by firm on R&D

Standard errors in parentheses

*** $p<0.01$ it represents significance level at 1%

** $p<0.05$ it represents significance level at 5%

* $p<0.1$ it represents significance level at 10%

Source: Authors own calculation

Table 11: Factors affecting Labor Productivity with Retained Earnings Lag variable	
VARIABLES	LP
Age of firm	-15.17*
	(7.714)
Retained earnings_1	179.9
	(432.1)
Firm profitability	1.34e-06***
	(3.65e-07)
Technology adoption	245.5**
	(96.09)
Firm size	-91.21
	(111.7)
Production capacity	-0.000473***
	(0.000142)
Research development	2.46e-06**
	(8.63e-07)
Owner education	20.40
	(32.05)
Owner child education	68.03
	(53.57)
Constant	-805.9
	(607.1)
Observations	19
R-squared	0.805

Dependent Variable: LP for year 2015

Independent Variables: Age of firm (it is number of years since the firm started manufacturing gloves), Retained Earnings Lag (It is percentage of firm retained earnings lag for year 2015), Firm profitability is measured by the annual profit of the firm ,Technology Adoption (it is a dummy variable where 1= Low-tech firm which is using machinery in stitching process only, 2= Medium Tech firm which has employed machinery in cutting and stitching of gloves and 3= High-Tech firms which has employed machinery in cutting, stitching and printing of gloves), Firm size is also a dummy variable in 1=small firm with 0-50 number of employees, 2= medium firm with 50-250 employees and 3=large firms with greater than 250 employees, Production Capacity is the number of gloves produced on average by firms in year 2015, Owner's Education (it is a dummy variable where 16= Masters, 14=Bachelors, 12= Intermediate, 10= Matric/O-levels, 8= Middle, 0= Less than Middle), Owner's Child Education (it is a dummy variable where 16= Masters, 14=Bachelors, 12= Intermediate, 10=in schools) and Research and development is the yearly cost incurred by firm on R&D

Standard errors in parentheses

*** p<0.01 it represents significance level at 1%

** p<0.05 it represents significance level at 5%

* p<0.1 it represents significance level at 10%

Source: Authors own calculation

Table 12: Factors affecting Total Factor Productivity with Retained Earnings Lag variable and Excluding the Outlier Firm with highest productivity

VARIABLES	TFP
Age of firm	1.33e-07
	(2.48e-06)
Retained earnings_1	-0.000113
	(0.000133)
Firm profitability	- 1.40e-13
	(1.38e-13)
Technology adoption	4.36e-05
	(3.20e-05)
Firm size	1.15e-05
	(3.84e-05)
Production capacity	7.49e-11
	(5.84e-11)
Research & development	- 1.41e-11
	(1.17e-11)
Owner education	1.23e-05
	(1.07e-05)
Owner child education	-1.35e-05
	(1.64e-05)
Constant	0.000199
	(0.000220)
Observations	18
R-squared	0.530

Dependent Variable: TFP for year 2015
Independent Variables: Age of firm (it is number of years since the firm started manufacturing gloves), Retained Earnings Lag (It is lag of percentage of firm retained earnings for year 2015), Firm profitability is measured by the annual profit of the firm ,Technology Adoption (it is a dummy variable where 1= Low-tech firm which is using machinery in stitching process only, 2= Medium Tech firm which has employed machinery in cutting and stitching of gloves and 3= High-Tech firms which has employed machinery in cutting, stitching and printing of gloves), Firm size is also a dummy variable in 1=small firm with 0-50 number of employees, 2= medium firm with 50-250 employees and 3=large firms with greater than 250 employees, Production Capacity is the number of gloves produced on average by firms in year 2015, Owner's Education (it is a dummy variable where 16= Masters, 14=Bachelors, 12= Intermediate, 10= Matric/O-levels, 8= Middle, 0= Less than Middle), Owner's Child Education (it is a dummy variable where 16= Masters, 14=Bachelors, 12= Intermediate, 10=in schools) and Research and development is the yearly cost incurred by firm on R&D

Standard errors in parentheses

*** $p<0.01$ it represents significance level at 1%

** $p<0.05$ it represents significance level at 5%

* $p<0.1$ it represents significance level at 10%

Source: Authors own calculation

Table 13: Factors affecting Total Revenue Productivity with Retained Earnings Lag variable and Excluding the Outlier Firm with highest productivity

VARIABLES	TRP
Age of firm	0.00240
	(0.0108)
Retained earnings_1	-0.838
	(0.577)
Firm profitability	5.59e-10
	(6.03e-10)
Technology adoption	0.0770
	(0.140)
Firm size	0.0708
	(0.167)
Production capacity	-1.28e-07
	(2.54e-07)
Research & development	-7.75e-08
	(5.09e-08)
Owner education	0.144**
	(0.0465)
Owner child education	-0.0799
	(0.0714)
Constant	2.375**
	(0.957)
Observations	18
R-squared	0.780

Dependent Variable: TRP for year 2015

Independent Variables: Age of firm (it is number of years since the firm started manufacturing gloves), Retained Earnings Lag (It is percentage of firm retained earnings lag for year 2015), Firm profitability is measured by the annual profit of the firm ,Technology Adoption (it is a dummy variable where 1= Low-tech firm which is using machinery in stitching process only, 2= Medium Tech firm which has employed machinery in cutting and stitching of gloves and 3= High-Tech firms which has employed machinery in cutting, stitching and printing of gloves), Firm size is also a dummy variable in 1=small firm with 0-50 number of employees, 2= medium firm with 50-250 employees and 3=large firms with greater than 250 employees, Production Capacity is the number of gloves produced on average by firms in year 2015, Owner's Education (it is a dummy variable where 16= Masters, 14=Bachelors, 12= Intermediate, 10= Matric/O-levels, 8= Middle, 0= Less than Middle), Owner's Child Education (it is a dummy variable where 16= Masters, 14=Bachelors, 12= Intermediate, 10=in schools) and Research and development is the yearly cost incurred by firm on R&D

Standard errors in parentheses

*** $p<0.01$ it represents significance level at 1%

** $p<0.05$ it represents significance level at 5%

* $p<0.1$ it represents significance level at 10%

Source: Authors own calculation

Table 14: Factors affecting Labor Productivity with Retained Earnings Lag variable and Excluding the Outlier Firm with highest productivity

VARIABLES	LP
Age of firm	-7.666
	(5.242)
Retained earnings_1	325.9
	(471.2)
Firm profitability	9.87e-07*
	(4.71e-07)
Technology adoption	246.7*
	(114.2)
Firm size	-34.71
	(137.2)
Production capacity	-0.000344
	(0.000205)
Research & development	-7.59e-06
	(4.14e-05)
Owner education	37.50
	(37.79)
Constant	-439.3
	(644.5)
Observations	18
R-squared	0.733

Dependent Variable: LP for year 2015

Independent Variables: Age of firm (it is number of years since the firm started manufacturing gloves), Retained Earnings Lag (It is percentage of firm retained earnings lag for year 2015), Firm profitability is measured by the annual profit of the firm ,Technology Adoption (it is a dummy variable where 1= Low-tech firm which is using machinery in stitching process only, 2= Medium Tech firm which has employed machinery in cutting and stitching of gloves and 3= High-Tech firms which has employed machinery in cutting, stitching and printing of gloves), Firm size is also a dummy variable in 1=small firm with 0-50 number of employees, 2= medium firm with 50-250 employees and 3=large firms with greater than 250 employees, Production Capacity is the number of gloves produced on average by firms in year 2015, Owner's Education (it is a dummy variable where 16= Masters, 14=Bachelors, 12= Intermediate, 10= Matric/O-levels, 8= Middle, 0= Less than Middle), Owner's Child Education (it is a dummy variable where 16= Masters, 14=Bachelors, 12= Intermediate, 10=in schools) and Research and development is the yearly cost incurred by firm on R&D

Standard errors in parentheses

*** p<0.01 it represents significance level at 1%

** p<0.05 it represents significance level at 5%

* p<0.1 it represents significance level at 10%

Source: Authors own calculation

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