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Full Length Research Paper

Technology spillover impacts on total productivity of the manufacturing sector in Pakistan

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Productivity measurement, impacts of technology spillovers and trend towards indigenous R&D is seriously lacking in manufacturing sector of Pakistan. There are very few studies carried out in this development sensitive area. This research was conducted to see the impacts of technology spillovers on total productivity of manufacturing sector in Pakistan. Furthermore, it was intended to check the effects of increase in capital stocks, labor employed, collaboration with academia, and technology transfer on the total productivity and technology spillovers. This study was carried out with the help of data provided by Federal Bureau of Statistics (FBS), Economic Surveys (ES), State Bank of Pakistan (SBP), Ministry of Industries and Production (MIP) and Planning Commission (PC) of the manufacturing sector of Pakistan and consisted of all major industrial groups including food, tobacco, textile, chemical, cement, fertilizers, automobile, electrical machinery and materials. The data was analyzed using descriptive statistics, correlation, regression and reliability tests on SPSS-17. The results showed that textile sector, although largest manufacturing sector, is least productive, while tobacco sector is most productive sector. Automobile, petroleum and machinery and equipment manufacturing sector are other potential sectors. Furthermore, the study realized the presence of both horizontal and vertical spillovers in all sectors with varying intensities and their positive effect on productivity. This study faced several limitations in the availability of data related to statistics of material inputs, employed labor and R&D investment.

Key words: Technology spillovers, foreign direct investment (FDI), productivity, performance management, horizontal spillovers, vertical spillovers, technology gap, economic growth.

INTRODUCTION

The studies on the economic effects of technology spillovers are a common interest of economists, engineers and policy makers. This area leads to an ever increasing trend towards globalization. Externalities of spillovers may benefit the developing and third world countries. But an optimal technology gap, effective forward and backward linkages and investment in R&D are pre-requisites for the success of such technology spillovers. Productivity measurement, impacts of technology spillovers and trend towards indigenous R&D is seriously lacking in manufacturing sector of Pakistan. There are very few studies carried out in this development sensitive area.

This research was conducted to see the impacts of technology spillovers on total productivity of manufacturing sector in Pakistan. Furthermore, it was intended to check the effects of increase in capital stocks, labor employed, collaboration with academia and technology transfer on the total productivity and technology spillovers. This study was carried out with the help of data provided by FBS, ES, SBP, MIP and PC of the manufacturing sector of Pakistan and consisted of all major industrial groups including food, tobacco, textile, chemical, cement, fertilizers, automobile, electrical machinery and materials.

Spillover effects are the economical effects of

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externalities on those who are not directly involved in it. International Monetary Fund (IMF) defines foreign direct investment (FDI) as an acquisition of a reasonable amount of ownership in any firm located in another country. It may also be defined as an enterprise in which the foreign investors have twenty five percent or more capital and voting share. Cincera and Pamukçu (2004) classified the technology spillovers (TSO) in two broad categories including horizontal spillovers (HS) and vertical spillover (VS). Each category is driven by different spillover mechanisms. HS are also called intra-industry spillovers while VS are called inter-industry spillovers. Cincera et al. (2004) stated that HS can occur either when the new technologies are introduced in local markets by foreign firms, by the competitive pressure offered by the new foreign firms and resultantly local firms start their own R&D activities or by the training of workers from foreign firms. VS can occur through two broadly classified channels including backward linkages and forward linkages. Backward linkages are the channels through which the foreign firms enter the local market with collaboration of local firms and train the employees of local firms and suppliers. They assist them in purchasing of raw materials and provide them the technical assistance. On the other hand, the forward linkages is opposite to backward linkages and in this channel, the local firm tend to purchase technology from the foreign suppliers because of the superior quality.

Fan (2002) summarized different theories of spillover effects. Dependency theory views the foreign investment as being harmful to the developing countries due to the reason of income inequality, hurdles in growth and distortion of labor due to over influence of outsiders. Karl Marx's work on development and underdevelopment, Paul Baran's work on economic analysis, Frank's contribution on the development of underdevelopment and Samir Amin's work on unequal development are all major contributions in support of dependencies theories. Industrialization theory by Hammer shifted the focus of economists and industrialist from dependency theory and neoclassical theories.

According to industrialization theory, the transfer of technology is not just a mere exchange of technology, rather, an exchange of a complete system in which capital, manpower, equipment and knowledge are all combined. Caves (1971, 1974), Kindleberger (1984), Koizumi and Kopecky (1977), Findlay (1978), Gerschenkron (1962) and Arrow (1971) all contributed in the extension of industrialization theory of FDI.

Innovative activities being done in multinationals have an impact on local firms. Motohashia and Yuan (2010) studied the impact of horizontal and vertical spillovers on automobile and electronics industry of China. Motohashia et al. (2010) stated that the impact of horizontal spillovers is negligible in both industries. In assembly sector, as far as the automobile sector is concerned, both the multinational and local firms have vertical spillovers to firms that supply local parts. Furthermore, the effect of vertical spillovers is very limited in electronics industry. Motohashia et al. (2010) stated that FDI not only increases the exports and employment opportunities but also enhances the knowledge stocks in the host countries. Motohashia et al. (2010) further stated that TSO, due to innovative activities of multinationals, is the driving force in the productivity growth of host country. So, the development strategy from industry to industry should be modified based upon the modular or integrated architecture of the industry. The productivity of modular architecture industry can be enhanced by importing the components of key importance, whereas for the integrated architecture industries, strong linkages and partnership networks of assemblers and part suppliers are required.

Kohpaiboon (2006) stated that FDI is a major factor in the enhancement of growth of host country by bringing in both the technology and capital. TSO depends upon the policies and specific factors of both the host and donor country and it is not an automatic process. Trade regime policy is one of such contributing factor. Kohpaiboon (2006) used two measures including nominal rate of protection (NRP) and effective rate of protection (ERP) to analyze the nature of trade policy in an industry. If the productivity of non affiliated local firms of the host country is enhanced due to FDI, only then is TSO said to take place. TSO is thus the result of the coordination of both foreign and local firms producing different but substitutable products for the host country market. Kohpaiboon (2006) stated that as the cost of the technology transfer is very high; so it is very difficult for the host country to enhance its productivity if its trade regime policies are restrictive. Furthermore, Kohpaiboon (2006) included the quality of labor as a proxy for measurement of productivity.

Pangarkar and JieWub (2011) explained that high level of globalization enhances the performance of any emerging market. Greater amount of slack resources will help in better and more enhanced productivity of emerging firms. Emerging markets will be increasing their competitiveness in more competitive markets because of the reason that globalization leads to enhanced competitive pressure and more chances to learn. Globalization helps in increase of multi factor productivity of organizations. Pangarkar et al. (2011) developed hypothesis stating that higher imports, exports and globalization in any industry is always a result of improved and better performance of firms in that industry. Pangarkar et al. (2011) deployed the return on assets (ROA) as a dependent variable for the measurement of the performance of firms and this accounting tool takes into account the impact of both the capital expenditures and efficiency of operations in the firm.

Watanabe et al. (2000) stated that accelerated growth of TSO is a result of increase in the flow of manpower, equipment and knowledge together with an increase in technology and capital stock. Effective utilization of TSO or assimilation capacity (AC) has become an increasing concern due to stagnation in research and developments (R&D). Watanabe et al. (2000) revealed various mechanisms of TSO in Japan including its contribution to production and the role of AC. Watanabe et al. (2000) stated that stagnation in R&D activities of a firm always leads to substitution of spillover technology in place of indigenous technology and decrease of AC; both resulting in the change of competitiveness structure of any firm in international markets. This is because of the fact that AC is always dependent upon the comparative advantages and disadvantages of any firm. Watanabe et al. (2000) stated that one of the major disadvantages of TSO is the decrease in the R&D of the host firm. GDP of any firm is a function of its capital stock, labor and total factor productivity (TFP). TFP can be further decomposed into technology stock (TC), TSO stock (TSOS) and time trends (T). Furthermore, TS can be measured by the variables including expenditures spent for research, time required, commercialization, and rate of obsolescence of technology. AC plays the vital role in constructing a virtuous cycle of for the socio economic development and future trajectories of the host countries. The key decisive factor in the measure of AC is the quality of labor.

Hur and Watanabe (2001) also studied the factors contributing for the increase of AC and effects of spillovers by using a kinetic approach. Hur et al. (2001) concluded that R&D is an externality which has a very positive and significant effect and to enhance the AC, the institutional effects are vital. Hur et al. (2001) elaborated that the major approaches to determine how much R&D in an industry is spillable are the case study and regression approach. Case studies are just limited to calculating the rate of returns (ROR); so, these do not provide any clear illustrative picture. Regression approach, on the other hand, estimates either a production function or cost function. Hur et al. (2001) stated that TSO is always associated with AC and absorption capacity (ABC) of the host.

Watanabe and Asgari (2003) provided some premium policy implications highlighting the scenario of creating an identity for the optimum dependency between TS and TSO; which is the most urgent issue to be addressed in a global TSO context. Sinani and Meyer (2004) found that efficiency of the TSO depends upon the characteristics of FDI and host firms. FDI contributes directly in the addition of labor, capital, exports and new technology of the host; whereas it affects the efficiency and labor productivity indirectly. But for attaining the benefits of FDI, an investor supportive policy is a pre-requisite.

Watanabe et al. (2004) studied the role of government policies in limiting the spurring of TSO. Watanabe et al.'s (2004) attempt should be made for identification of trajectories for restructuring virtuous cycles between effective AC and quality of participants. Nakagawa et al. (2009) concluded that the economic paradigm is the major contributing factor in the changing structure of TSO. These changes include the changes in business structure, institutional changes, national policies and market structure.

Muller and Schnitzer (2006) studied the effects of TSO in international joint ventures. Muller et al. (2006) argued that although multinationals are fearful to transfer technology due to chances of spillovers, in most of the cases, joint ventures are more beneficial for multinationals as compared to host countries. Furthermore, Muller et al. (2006) stated that positive externalities of TSO depend upon the structure of organization, transfer of technology and policies of the host country. Madsen (2007) in his research explained that the effective spillovers can occur only when knowledge is transferred and transmitted through the channels of trade.

Lai et al. (2009) suggested that optimal size of the technology gap is required for positive spillovers to occur. Lai et al. (2009) explained that a double edged role is played by the technology gap in TSO of FDI via channels including the choice set of technology and ABC for technology. Countries which are lagging behind in technology and are trying to gain FDI without any analysis are in danger of facing a negative effect of TSO.

Liu and Buck (2007) stated that for the enhancement of innovation activities in indigenous firms, learning by importing and exporting are significant characteristics. Furthermore, the TSO by multinationals working in the host country is possible only when the ABC of host country is taken into consideration. Liu et al. (2007) developed hypothesis stating that domestic innovation is always positively associated with the R&D of multinationals, level of imports of advanced technologies, level of exports, domestic R&D and ABC. Furthermore, Fosfuri and Rønde (2004) stated that firms can enjoy highest benefits of clustering only if the industry is facing a higher growth potential, relatively a soft competition and it is difficult for a single firm to make effective innovation.

Liu (2008) explained that although FDI is beneficial for the host country, most of them are short term gains. Liu (2008) presented a framework which states that FDI may have a decreasing trend for short term productivity but have opposite effect for long terms productivity growth. Lai et al. (2006) investigated a relationship between the economic growth, ABC and TSO. The research work explained that the long term economic growth depends upon the ABC and higher labor and capital stocks; while the technology gap relationship with economic growth is uncertain and difficult to predict. Furthermore, Lai et al. (2006) stated that FDI is more potential and significant channel for TSO as compared to imports. The positive effect of TSO is dependent on the openness and labor capital investment of the host country.

Murakami (2007) explained the effect of entry of foreign owned firms in the manufacturing sector of Japan. Initially, it may have a negative effect but on the long run, it has positive influences on the TFP growth due to TSO.

Seck (2011) stated that the benefits of technology diffusion on economic growth are very substantial and on each ten percent increase of R&D stock of foreign firms, a total of more than two percent increase in productivity of host firms take place. Similarly, Branstetter and Chen (2006) carried out a regression analysis which concluded that both R&D and purchase of advanced technology have positive impacts on the productivity growth of Taiwan. Hasan (2001) stated that the import of both the embodied and disembodied technology has a positive and highly significant impact on the productivity of Indian manufacturing sector.

Diao et al. (2003) provided an equilibrium mechanism explaining the TSO and productivity growth. Lisa Correa (2008) provided a mechanism on the diffusion of technology in the telecommunication industry. Lee et al. (2011) also studied the impact of diffusion of IT in the growth of productivity of Chinese electronics industry. Melville et al. (2007) also explained the importance of IT diffusion for productivity enhancement. Similarly, Boothby et al. (2010) explained the importance of backward linkages and training in the effective utilization of TSO for the productivity growth. Fuentelsaz et al. (2007) explained the HS in intra-firm productivity growth.

METHODOLOGY

The data was collected from different sources including the manufacturing section of Economic Surveys (ES) of Pakistan issued by the Ministry of Finance, Federal Bureau of Statistics (FBS), Planning Commission (PC), Board of Investment (BOI), Ministry of Industries and Production (MIP) and State Bank of Pakistan (SBP). The data set consists of 35, 878 reporting firms belonging to different groups of manufacturing sector, majorly food, tobacco, textile, chemical, cement, fertilizers, automobile, electrical machinery, and materials. The data was analyzed using the descriptive statistics, regression and correlation analysis on SPSS 17. Table 1 provides the classification and number of industries in manufacturing sector. For the ease of computation, A and B are grouped in food processing, C in tobacco, D, E, F, G and H in textile, I, J and K in wood work and paper, L in printing, M, N, and O in chemical, P in petroleum, Q, R, and S in rubber and plastics, U, V, W and X in steel and metals, Y, Z, SE and SA in machinery and equipments and TE in automobile categories. Table 2 groups the industries in the new grouping. Figure 1 provides the overall FDI, FDI for manufacturing sector and FDI per capita in dollars. Table 3 provides the percentage share of FDI for each group of industries out of yearly share of manufacturing. The details of variables used in the analysis and measurement of productivity and data related to productivity and production function will be discussed further.

Table 4 shows the percentage of each fully foreign owned (FFO), partially foreign owned (PFO) and local owned (LO) firms.

ANALYSIS

The analysis of this work is distributed into three main components including total productivity measurement, descriptive statistic analysis of all the results and econometric analysis using the regression based analysis in SPSS 17. The analysis is done for a period of ten years from 2001 to 2010.

Total productivity measurement

For the measurement of total productivity, Craig- Harris Productivity Model was used for calculation. As in the economic surveys of Pakistan, the value of all the inputs has already been merged in section of industrial cost of major manufacturing groups; so, the requirement of partially productivities does not arise. The outputs are included in the section of value of production of major groups. The variable used for the measurement of total productivity includes: total productivity (TP), outputs (OU) and inputs (IN). Table 5 shows the group wise inputs for manufacturing sector for the years 2001 to 2010. Table 6 shows the group wise outputs for the manufacturing sector during the same period. Table 7 shows the total productivity of all major groups.

Descriptive statistics

The descriptive statics test on SPSS 17 was obtained for all the industrial groups for minimum, maximum, mean and standard deviation valued of FDI, TP, IN, OU, FFO, PFO and LO for the period of years including 2001 to 2010. Results of descriptive statistics of FFO, PFO and LO firms are shown in Table 8, while results for the descriptive statistics of (a) TP, (b) OU, (c) IU and (d) FDI are shown in Table 9.

Econometric analysis

To evaluate the presence of TSO in manufacturing sector of Pakistan, Translog Cost Function is used. The assumed function is:

$$\ln(OU_{D\,i,t}) = \alpha_0 + \alpha_K \ln CT_{i,t} + \alpha_L \ln LB_{i,t} + \beta_3 \ln RD_{i,t} + \beta_4 \ln SO_{i,t} \quad \beta_5 \ln IT_{i,t} + \beta_6 \ln CB_{i,t} + \beta_7 \ln MS_{i,t} + € _{i,t} \qquad (1)$$

Variables used in the research includes the total output (OU), capital stock (CS), labor employed (LB), research and development activities (R&D), spillovers (SO), imported technology (IT), collaboration with academic institutions (CB) and market share (MS). The elasticities of substitution are derived from the work of Khan and Barki (2002) and Allen elasticities. OU_D is the averaged deflated OU with respect to the base year 1999 to 2000 for the period between years 2001 to 2010. OU_D is deflated by using the Wholesale Price Index for each year. CS is the averaged deflated value of IN against the base year 1999 to 2000 for the same time duration. LB is the number of labor employed in manufacturing by multiplying the share of labor with the share labor of each group with the total of manufacturing labor. R&D is also taken by multiplying the OU by the percentage of research and activities in the respective group.

CB and IT are either 1 or 0 based upon YES or NO result of the each category of industry. MS is the percentage of OU share of each group. All values are

Table 1. Classification and number of reporting firms in each industry of manufacturing sector.

Industry	Code	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Food manufacturing	A	880	975	1015	1323	1860	1921	1765	1823	2012	2065
Beverage industries	B	43	45	39	37	36	42	35	27	29	47
Tobacco industries	C	12	12	12	13	13	13	13	14	10	13
Manufacture of textile	D	1,063	1063	1036	1267	1329	1412	1467	1369	1225	1365
Manufacture of wearing apparel (except footwear)	E	209	212	215	254	326	355	365	353	315	420
Manufacture of leather and leather products	F	82	85	67	86	142	155	163	152	171	165
Manufacture of footwear	G	13	14	15	21	36	42	52	62	75	63
Ginning, pressing and balling of fiber	H	334	371	498	515	540	545	565	523	612	625
Manufacture of wood and cork products	I	35	35	36	48	62	65	71	76	68	82
Manufacture of furniture	J	33	35	35	91	130	135	162	167	118	170
Manufacturing of paper and paper products	K	99	99	99	112	133	135	142	145	152	165
Printing, publishing	L	133	135	92	135	47	23	25	92	112	165
pharmaceutical products	M	NA	112	165	190	228	213	225	212	192	230
Manufacture of industrial chemical	N	13	15	126	292	494	475	465	494	494	494
Manufacture of other chemicals	O	43	95	112	265	396	375	323	312	365	398
Petroleum refining	P	92	65	63	65	NA	92	NA	NA	NA	112
Manufacture of rubber products	Q	29	29	29	29	30	30	32	32	32	40
Manufacture of plastic products	R	25	28	28	28	28	30	30	33	31	35
Manufacture of pottery, china and earthenware	S	85	95	98	126	142	138	138	135	142	145
Manufacture of glass and glass products	T	155	155	155	155	155	NA	165	143	140	138
Manufacture of non-metallic mineral products	U	15	15	15	30	34	32	28	30	34	34
Iron and steel basic industries	V	192	222	245	251	482	262	276	382	512	506
Non-ferrous metal basic industries	W	168	170	170	176	245	240	252	260	260	260
Manufacture of fabricated metal products	X	157	150	122	80	41	55	40	23	40	42
Manufacture of machinery (except electrical)	Y	127	127	127	136	144	145	147	151	152	152
Manufacture of electrical machinery	Z	58	78	112	225	372	312	322	375	375	375
Manufacture of transport equipment	TE	38	47	52	52	67	67	67	72	72	75
Scientific equipments	SE	48	48	48	48	47	42	44	44	40	45
Manufacture of sports and athletic goods	SA	NA	4	4	8	10	10	8	9	10	4
Total	TO	**4,181**	2264	2180	2640	7569	3388	3376	3277	3433	3570

Table 2. Grouping of industries in new classifications.

Industry group	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Food Processing (FP)	923	1020	1054	1360	1896	1963	1800	1850	2041	2112
Tobacco (TB)	12	12	12	13	13	13	13	14	10	13
Textile (TX)	1,701	1077	1051	1267	2373	1412	1519	1369	1225	1365
Wood work and paper (WP)	167	169	170	257	325	335	375	388	338	417
Printing (PR)	133	135	92	135	47	23	25	92	112	165
Chemical (CH)	56	222	403	747	1118	1063	1013	1018	1051	1122
Petroleum (PT)	92	65	63	65	NA	92	NA	NA	NA	112
Rubber and plastics (RP)	139	152	155	183	200	198	200	200	205	220
Steel and metals(SM)	532	557	552	537	802	589	596	695	846	842
Machinery and equipment (ME)	223	257	291	417	573	509	521	579	577	576
Automobile (AT)	38	47	52	52	67	67	67	72	72	75
Total (TO)	4,181	2264	2180	2640	7569	3388	3376	3277	3433	3570

averaged for the data during the period of years between 2001 and 2010. The calculations are shown in Table 10. Table 11 shows the natural log of all these values. By using SPSS-17 descriptive statistics test, a number of

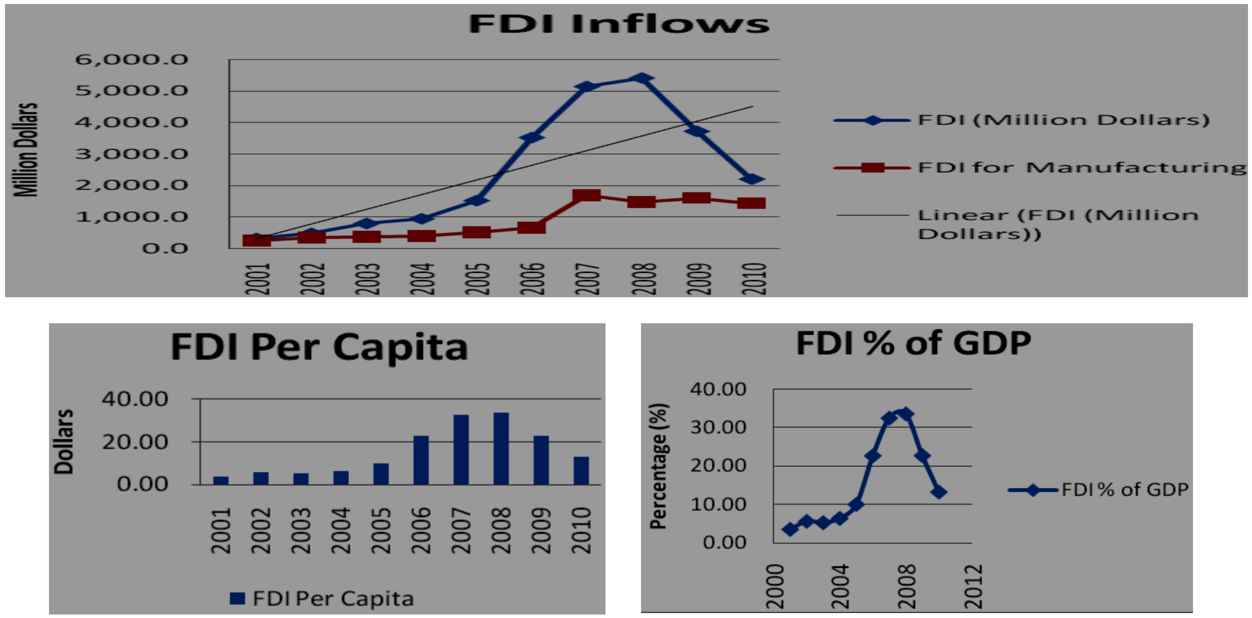

Figure 1. FDI inflows data for manufacturing.

Table 3. Percentage share of FDIs to each industrial group.

Group	2002		2003		2004		2005		2006		2007		2008		2009		2010	
	FDI	%	FDI	%	FDI	%	FDI	%	FDI	%	FDI	%	FDI	%	FDI	%	FDI	%
FP	-5.9	-1.71	7.9	2.2	4.4	1.1	20.4	3.9	64.6	9.8	142.5	8.4	57.3	3.9	194	12.0	94	6.5
TB	0.9	0.26	NA	NA	0.5	0.1	6.7	1.3	2.5	0.4	389.5	23	9.2	0.6	1.4	0.1	14.2	1
TX	18.9	5.48	27.3	7.5	38.9	10	45.8	8.8	50.5	7.6	62.4	3.7	31.9	2.2	40.9	2.5	32.6	2.3
WP	0.7	0.20	1.4	0.4	1.7	0.4	NA	NA	0.1	0	1.2	0.1	1.1	0.1	0	0.0	80.7	5.6
PR	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
CH	20.4	6.00	92.9	26	31.9	8.2	94.7	18	39.1	5.9	129	7.6	255.3	17	163.7	10.2	133	9.2
PT	277.6	80.46	190.4	52	274.4	71	218	42	351	53	724	43	751.8	51	920.7	57.1	856.6	60
RP	0.2	0.06	NA	NA	NA	NA	NA	NA	4.7	0.7	4.3	0.3	3.7	0.3	1.7	0.1	1.9	0.1
SM	0.3	0.09	0.2	0.1	1.5	0.4	15.6	3	7.5	1.1	13.5	0.8	17.6	1.2	14.9	0.9	21.4	1.5
ME	26.5	8.00	17.6	4.8	16.9	4.4	16.5	3.2	21	3.2	26	1.5	51.8	3.5	40.7	2.5	39.3	2.7
AT	1.1	0.32	0.6	0.2	3.3	0.9	33.1	6.4	33.1	5	50.4	3	111.5	7.5	82.5	5.1	33.2	2.3
TO	345	*	363.6	*	387.8	*	518.6	*	660.6	*	1698.4	*	1478.6	*	1612.7	*	1439	*

FDI: Foreign direct investment in each group; % = percentage of total share of manufacturing sector for respective year.

Table 4. Percentage of fully foreign owned (FFO), partial foreign owned (PFO) and local owned (LO) firms.

Group	2001			2002			2003			2004			2005		
	% FFO	% PFO	% LO	% FFO	% PFO	% LO	% FFO	% PFO	% LO	% FFO	% PFO	% LO	% FFO	% PFO	% LO
FP	2.4	24.1	73.3	2.0	20.8	77.3	10.6	27.6	61.8	4.9	16.2	78.9	1.1	12.0	86.9
TB	8.3	25	66.6	8.3	30.0	61.7	0.0	33.3	66.7	7.7	30.7	61.6	15.4	23.0	61.6
TX	0.7	20.1	73.3	1.1	30.00	68.9	4.9	21.1	74.0	4.2	23.0	72.8	4.7	13.5	81.8
WP	4.1	11.9	83.8	1.2	17	81.8	7.6	14.1	78.3	15.9	47.4	36.7	2.1	34.4	63.5
PR	2.2	7.51	90.2	5.2	25.9	68.9	13.0	20.6	66.4	2.2	21.4	76.4	6.4	23.4	70.2
CH	7.1	26.7	73.9	1.4	7.2	91.4	1.4	5.9	92.7	1.2	16.5	82.3	5.5	26.0	68.5
PT	2.1	23.9	73.9	12.3	27.6	60.1	4.8	11.1	84.1	3.1	20.0	76.9	0.0	0.0	0.0
RP	5	15.1	79.8	3.9	7.8	88.3	10.9	12.2	76.9	4.9	15.8	79.3	2.0	9.0	91.0
SM	1.1	17.1	81.7	5.2	10.0	84.8	3.4	3.9	92.7	5.7	15.6	78.7	1.6	3.8	94.6
ME	2.6	6.72	90.5	4.6	11.2	84.2	3.0	7.2	89.8	3.1	9.3	87.6	2.2	8.5	89.3
AT	2.6	18.4	81.5	4.2	19.1	76.7	21.1	36.5	42.4	3.8	9.6	86.6	4.5	17.9	77.6
TO	1.7	18.3	73.5	4.5	31.3	64.2	11.6	30.8	57.6	8.8	36.4	54.8	3.2	14.2	82.6
Group	**2006**			**2007**			**2008**			**2009**			**2010**		
FP	0.6	20.6	78.8	6.2	12.2	81.6	6.9	11.4	81.7	10.4	15.7	73.9	4.3	13.8	81.9
TB	7.7	15.3	77.0	7.7	30.7	61.6	21.4	28.5	50.1	0.0	40.0	60.0	15.4	23.0	61.6
TX	6.9	11.2	81.9	1.5	1.6	96.9	14.0	16.3	69.7	9.9	17.8	72.3	8.2	16.7	75.1
WP	0.6	8.3	91.1	7.2	10.9	81.9	0.7	9.7	89.6	7.9	11.2	80.9	6.2	14.6	79.2
PR	6.4	23.4	70.2	12.0	32.0	46.0	2.1	13.0	84.9	11.6	18.7	69.7	8.4	23.0	68.6
CH	6.2	3.3	96.4	1.4	2.2	96.4	6.2	16.4	77.4	4.4	13.8	81.8	17.1	26.3	56.6
PT	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	10.7	23.2	66.1
RP	2.0	9.5	88.5	0.0	7.5	92.5	2.0	9.0	89.0	2.4	8.7	88.9	2.7	8.1	89.2
SM	2.6	6.4	91.0	3.0	8.7	88.3	5.3	8.2	86.5	5.6	13.7	80.7	6.2	8.0	85.8
ME	4.0	12.7	83.3	4.0	8.8	87.2	3.6	10.7	85.7	2.3	4.6	93.1	3.8	6.2	90.0
AT	9.0	22.3	68.7	13.4	31.3	55.3	5.5	22.2	72.3	6.9	12.5	80.6	5.3	14.6	80.1
TO	3.2	11.3	85.5	6.8	13.5	79.7	13.9	24.7	61.4	14.3	26.7	59.0	15.0	30.1	54.9

tests were performed. First of all, by using the data of Table 12, a descriptive statistics test was performed to measure the minimum, maximum, mean and standard deviation values. Then, Pearson correlation for same data was performed. Then, zero order, partial and part correlations model, co-linearity statistics and R^2 change analysis tests were performed using the regression analysis. Cronbach's alpha was performed using the reliability test. The results of the test are shown in the Table 13. Similarly, all the listed analysis except the descriptive analysis test was performed for the data of Table 11 as well. The results of the data are displayed in Table 13. It is important to see that all the variables including OUD, CS, LB, RD, and MS have a Cronbach's alpha greater than 0.7. So, the variables are reliable. Similarly, ln (OU_D), ln (CS), ln (RD), ln (IT), ln (CB) and ln (MS) also have a Cronbach's alpha greater than 0.7. Similarly, all the data have positive correlation as depicted by

Table 5. Major industrial costs (IN) including labor, energy, capital and others in million Rs.

Group	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
FP	146118	192233	245782	367782	437657	468522	610089	738599	706500	695932
TB	6015	6021	6032	6037	6055	6072	6081	7002	6089	6083
TX	317193	398258	458263	582599	675577	725483	892533	853254	822201	790052
WP	19183	23253	27527	36252	41369	46879	62012	59259	64012	61998
PR	1899	2566	3596	4485	5914	6523	6972	7285	7696	7385
CH	77941	11253	198657	251123	333320	395283	423295	576888	725922	691002
PT	76537	132521	145526	163285	215825	232825	237926	242856	255632	238211
RP	10025	12352	14259	18632	21589	23987	27654	32321	30258	28147
SM	48186	58159	96357	132657	162920	178561	192856	202857	188523	194652
ME	38719	42875	47958	52369	77727	84558	101258	131584	162597	121252
AT	37257	40257	44968	49842	51279	56897	61853	52893	59685	57658
TO	779073	919748	1288925	1665063	2029232	2225590	2622529	2904798	3029115	2892372

Table 6. Value of production (OU) in million Rs.

Group	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
FP	204176	252232	289261	425896	484269	578534	648552	805264	785213	778214
TB	23954	25723	33562	45289	52402	48250	43252	54257	55635	58250
TX	439177	48576	64827	83229	944183	102567	113986	119869	108968	100052
WP	25393	30589	36285	40353	47892	52923	78965	82567	80000	78000
PR	3173	3689	4387	5265	6285	7082	8232	8560	9123	8022
CH	138784	19428	224568	278232	173772	302024	475026	602986	765932	700258
PT	94253	158362	176825	188952	327222	307852	303582	383657	392568	368721
RP	14398	18326	20256	24569	28569	30256	33000	37981	35652	27005
SM	89777	67852	112654	158005	160096	184652	198632	208333	202516	204322
ME	61500	57000	67852	81250	92475	102562	126523	148968	202500	198000
AT	50476	56875	62385	65896	72331	75832	68523	63258	71206	72592
TO	1145061	738652	1092862	1396936	2389496	1792534	2098273	2515700	2709313	2593436

Table 7. TP of all groups in manufacturing sector.

Group	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
FP	1.40	1.31	1.18	1.16	1.11	1.23	1.06	1.09	1.11	1.12
TB	3.98	4.27	5.56	7.50	8.65	7.95	7.11	7.75	9.14	9.58
TX	1.38	0.12	0.14	0.14	1.40	0.14	0.13	0.14	0.13	0.13
WP	1.32	1.32	1.32	1.11	1.16	1.13	1.27	1.39	1.25	1.26
PR	1.67	1.44	1.22	1.17	1.06	1.09	1.18	1.18	1.19	1.09
CH	1.78	1.73	1.13	1.11	0.52	0.76	1.12	1.05	1.06	1.01
PT	1.23	1.19	1.22	1.16	1.52	1.32	1.28	1.58	1.54	1.55
RP	1.44	1.48	1.42	1.32	1.32	1.26	1.19	1.18	1.18	0.96
SM	1.86	1.17	1.17	1.19	0.98	1.03	1.03	1.03	1.07	1.05
ME	1.59	1.33	1.41	1.55	1.19	1.21	1.25	1.13	1.25	1.63
AT	1.35	1.41	1.39	1.32	1.41	1.33	1.11	1.20	1.19	1.26
TO	1.47	0.80	0.85	0.84	1.18	0.81	0.80	0.87	0.89	0.90

the Pearson correlation 2-tailed test which proves that output increase with an increase in the capital stock,

Table 8. Descriptive tests for FFO, PFO and LO firms.

FFO	N	Minimum	Maximum	Mean	Std. Deviation
FP	10	11	212	79.50	64.269
TB	10	0	3	1.20	0.919
TC	10	2	191	84.00	65.240
WP	10	2	41	15.50	13.730
PR	10	2	14	6.30	4.832
CH	10	3	192	40.90	58.406
PT	10	0	12	2.70	4.111
RP	10	2	17	6.40	4.195
SM	10	6	53	27.50	15.102
ME	10	6	23	15.30	5.982
AT	10	1	11	4.70	3.199
Total	10	61	534	284.00	159.217
Valid N (listwise)	10				
PFO					
FP	10	212	391	261.20	60.639
TB	10	2	4	3.40	0.699
TC	10	25	342	243.20	88.389
WP	10	20	122	51.10	36.659
PR	10	8	38	19.40	11.047
CH	10	15	296	113.30	111.084
PT	10	0	26	8.60	10.341
RP	10	12	29	18.70	4.373
SM	10	22	116	63.00	28.182
ME	10	15	73	39.70	18.203
AT	10	5	21	12.40	5.232
Total	10	456	1078	833.60	192.795
Valid N (listwise)	10				
LO					
FP	10	651	1729	1254.50	416.014
TB	10	6	10	7.90	0.994
TC	10	773	1944	1204.80	450.606
WP	10	94	347	236.50	97.447
PR	10	14	120	72.60	36.488
CH	10	37	1080	693.60	363.635
PT	10	0	74	26.40	29.136
RP	10	111	196	160.30	30.236
SM	10	434	782	601.60	135.641
ME	10	202	537	403.70	131.886
AT	10	20	60	43.60	12.773
Total	10	1255	6441	2888.30	1926.251
Valid N (listwise)	10				

labor employed, R&D and MS.

Similarly, P-P plot of regression for standard residual for dependent variable against RD and LB was plotted for both the data of Tables 10 and 11. The results show that R&D and LB have a relationship almost very close to linear trend. The results are shown in Figure 2.

Conclusion

The analysis and tables clearly proves the evidences found in literature that an increase in FDI, imports, exports and R&D increases the spillovers and have a clear impact in the increase of total productivity. It is

Table 9. Descriptive tests for TP, OU, IN and FDI for all industries.

TP	N	Minimum	Maximum	Mean	Std. Deviation
FP	10	1.060	1.400	1.17700	0.107502
TB	10	3.980	9.580	7.14900	1.946806
TC	10	0.120	1.400	0.38500	0.529743
WP	10	1.110	1.390	1.25300	0.092382
PR	10	1.060	1.670	1.22900	0.187406
CH	10	0.520	1.780	1.12700	0.382624
PT	10	1.160	1.580	1.35900	0.168619
RP	10	0.960	1.480	1.27500	0.156009
SM	10	0.980	1.860	1.15800	0.256982
ME	10	1.130	1.630	1.35400	0.180567
AT	10	1.110	1.410	1.29700	0.103177
Total	10	0.800	1.470	0.94100	0.216459
Valid N	10				
OU					
FP	10	204176	805264	525161.10	229223.492
TB	10	23954	58250	44057.40	12379.771
TC	10	48576	944183	212543.40	280052.781
WP	10	25393	82567	55296.70	22557.273
PR	10	3173	9123	6381.80	2151.122
CH	10	19428	765932	368101.00	253896.071
PT	10	94253	392568	270199.40	106521.546
RP	10	14398	37981	27001.20	7673.495
SM	10	67852	208333	158683.90	51487.989
ME	10	57000	202500	113863.00	53819.919
AT	10	50476	75832	65937.40	7877.470
Total	10	738652	2709313	1847226.30	714978.752
Valid N	10				
IN					
FP	10	146118	738599	460921.40	221547.136
TB	10	6015	7002	6148.70	301.022
TC	10	317193	892533	651541.30	203079.297
WP	10	19183	64012	44174.40	17237.868
PR	10	1899	7696	5432.10	2137.794
CH	10	11253	725922	368468.40	243770.152
PT	10	76537	255632	194114.40	60482.745
RP	10	10025	32321	21922.40	7861.855
SM	10	48186	202857	145572.80	58570.175
ME	10	38719	162597	86089.70	42379.829
AT	10	37257	61853	51258.90	8281.972
Total	10	779073	3029115	2035644.50	841695.701
Valid N	10				
FDI					
FP	9	-5.90	194.00	64.3556	68.45866
TB	9	0.00	389.50	47.2111	128.44780
TC	9	18.90	62.40	38.8000	13.04598
WP	9	0.00	80.70	9.6556	26.64916
PR	9	0.00	0.00	0.0000	0.00000
CH	9	20.40	255.30	106.6667	74.55439

Table 9. Contd.

PT	9	190.40	920.70	507.1667	298.99902
RP	9	0.00	4.70	1.8333	1.95448
SM	9	0.20	21.40	10.2778	8.08761
ME	9	16.50	51.80	28.4778	12.61069
AT	9	0.60	111.50	38.7556	38.02407
Total	9	345.00	1698.40	944.9222	593.02170
Valid N	9				

Table 10. Averaged values for translog cost production function.

Group	OU_D	CS	LB	RD	IT	CB	MS
FP	3429.464	2997.67	99320	55674.56	0	0	28.43
TB	297.439	42.47	4180	1520.75	1	1	2.39
TX	1441.013	4390.54	400300	15801.04	1	1	11.51
WP	362.777	291.39	14060	1859.94	0	0	2.99
PR	42.485	36.16	4560	147.7	0	0	0.35
CH	2253.668	2295.51	57000	34550.1	1	1	19.93
PT	1800.178	1318.5	3540	28585.32	1	1	14.63
RP	183.458	145.78	8200	1407.35	0	0	1.46
SM	1056.811	972.84	43200	9732.6	1	0	8.59
ME	725.527	552.81	64300	18187.8	1	1	6.16
AT	456.147	350.73	6030	10378.44	1	1	3.57
TO	12048.94	13394.38	704690	2892372			100

Table 11. Averaged natural log values for translog cost production function.

Group	$\ln(OU_D)$	ln(CS)	ln (LB)	ln (RD)	ln (IT)	ln (CB)	ln (MS)
FP	8.1	8	4.6	6.3	NA	NA	3.3
TB	5.7	3.7	1.4	2.7	0	0	0.9
TX	7.3	8.4	6	5.1	0	0	2.4
WP	5.9	5.7	2.6	2.9	NA	NA	1.1
PR	3.7	3.6	1.5	0.4	NA	NA	-1
CH	7.7	7.7	4	5.8	0	0	3
PT	7.5	7.2	1.3	5.7	0	0	2.7
RP	5.2	5	2.1	2.6	NA	NA	0.4
SM	7	6.9	1.5	4.6	0	NA	2.2
ME	6.6	6.3	4.2	5.2	0	0	1.8
AT	6.1	5.9	1.8	4.6	0	0	1.3
TO	9.4	9.5	6.5	10.3	0		4.6

Table 12. Analysis results for Table 10.

Descriptive statistics	N	Minimum	Maximum	Mean	Std. Deviation
OUD	12	42.49	12048.94	2008.1589	3317.29323
CS	12	36.16	13394.38	2232.3983	3770.23224
LB	12	3.54	665.79	110.9650	207.44602
RD	12	1.50	28923.70	2558.5167	8304.53560
MS	12	0.35	100.00	16.6675	27.56761
Valid N (listwise)	12				

Table 12. Contd.

Correlations		OUD	LB	RD	CS	MS
OUD	Pearson correlation	1	0.854**	0.959**	0.970**	1.000**
	Sig. (2-tailed)		0.000	0.000	0.000	0.000
	N	12	12	12	12	12
LB	Pearson correlation	0.854**	1	0.844**	0.951**	0.851**
	Sig. (2-tailed)	0.000		0.001	0.000	0.000
	N	12	12	12	12	12
RD	Pearson correlation	0.959**	0.844**	1	0.937**	0.958**
	Sig. (2-tailed)	0.000	0.001		0.000	0.000
	N	12	12	12	12	12
CS	Pearson correlation	0.970**	0.951**	0.937**	1	0.969**
	Sig. (2-tailed)	0.000	0.000	0.000		0.000
	N	12	12	12	12	12
MS	Pearson correlation	1.000**	0.851**	0.958**	0.969**	1
	Sig. (2-tailed)	0.000	0.000	0.000	0.000	
	N	12	12	12	12	12

Regression analysis (dependent variable: OUD)

Model		Correlations			Collinearity statistics	
		Zero-order	Partial	Part	Tolerance	VIF
1	RD	0.959	0.217	0.003	0.071	14.068
	LB	0.854	0.112	0.002	0.011	91.280
	MS	1.000	0.984	0.075	0.006	174.272
	CS	0.970	-0.041	0.000	0.002	404.098

Regression analysis (predictors: (constant), CS, RD, LB, MS; dependent variable: OUD)

Model	Change statistics				
	R square change	F Change	df1	df2	Sig. F Change
1	1.000[a]	9517.019	4	7	0.000

Reliability analysis

Cronbach's alpha	No. of Item
0.752	5

**Correlation is significant at the 0.01 level (2-tailed).

Table 13. Analysis results for Table 11.

Correlation		OUD	LB	RD	CS	MS
OUD	Pearson correlation	1	0.998**	1.000**	1.000**	0.982**
	Sig. (2-tailed)		0.000	0.000	0.000	0.000
	N	13	13	13	13	13
LB	Pearson correlation	0.998**	1	0.998**	0.998**	0.988**
	Sig. (2-tailed)	0.000		0.000	0.000	0.000
	N	13	13	13	13	13

Table 13. Contd.

RD	Pearson correlation	1.000**	0.998**	1	1.000**	0.985**
	Sig. (2-tailed)	0.000	0.000		0.000	0.000
	N	13	13	13	13	13
CS	Pearson correlation	1.000**	0.998**	1.000**	1	0.982**
	Sig. (2-tailed)	0.000	0.000	0.000		0.000
	N	13	13	13	13	13
MS	Pearson correlation	0.982**	0.988**	0.985**	0.982**	1
	Sig. (2-tailed)	0.000	0.000	0.000	0.000	
	N	13	13	13	13	13

Regression analysis (dependent variable: OUD)

Model		Correlations			Collinearity statistics	
		Zero-order	Partial	Part	Tolerance	VIF
1	LB	0.998	-0.513	0.000	0.002	421.038
	MS	0.982	-0.117	0.000	0.020	51.277
	CS	1.000	1.000	0.060	0.004	277.917

Model Summary (predictors: (constant), CS, MS, LB; dependent variable: OUD)

Model	Change statistics				
	R square change	F Change	df1	df2	Sig. F Change
1	1.000	7150013.154	3	9	0.000

Reliability analysis

Cronbach's alpha	No. of items
0.752	5

**Correlation is significant at the 0.01 level (2-tailed).

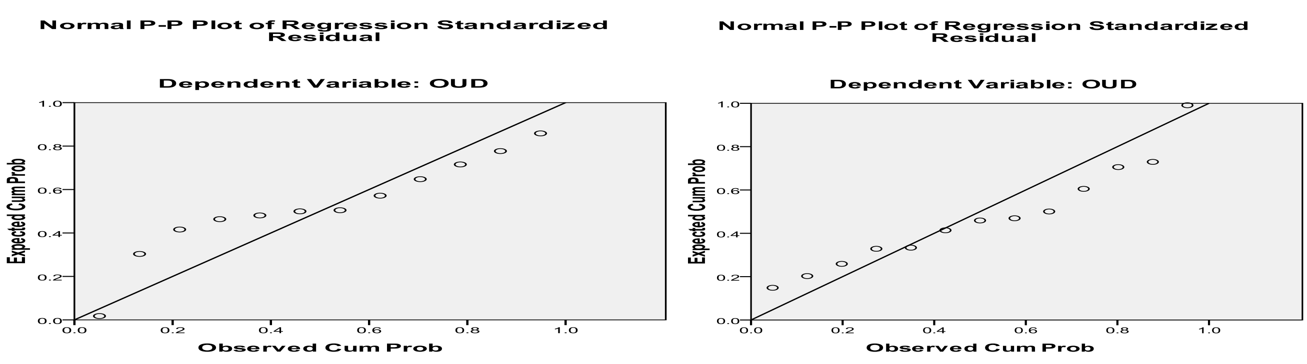

Figure 2. P-P plot for regression.

obvious from the analysis that the productivity of TB group has highest productivity. The reason behind this is supported by the econometric analysis and it included highest number of R&D expenditures, a continuous trend towards, higher number of forward and backward linkages, collaboration with academia and presence of FFO and PFO subsidiaries.

All other groups also depict the same effects but the changes are not so obvious because of policy implications and crisis in the country. It is also important to note that TX is the largest sector of Pakistan but it is seriously lagging in total productivity due to absence of R&D and IT. There are either no or highly low evidences of TSO found in TX sector. In the descriptive analysis, it is also obvious that TP is lowest for TX sector while highest for TB sector. TB sector also showed highest mean TP. As far as outputs is concerned, the minimum is shown by PR in the last ten years while highest by FP. Highest FDI, competitive RD, IT, presence of FFO and high TS and TSO make the PT sector also one of the most productive and competitive sector in Pakistan economy.

Results also prove that the variables included in estimated econometric model are all positively correlated and are all reliable too. So, an increase in IT, CB, CS, LB and MS increases the production function and so the productivity and output of any manufacturing group and by the increase of all these factors, the SO and TSO increases and technology gap decreases. All manufacturing groups show the presence of both horizontal and vertical spillovers but trends are higher in PT and TB sector while limited in PB, TX and FP sector. AT and ME have a high potential for growth due to the presence of FFO and PFO firms and an increasing FDI. It is also obvious that manufacturing sector produced positive results between 2001 and 2007 but there are slight shift towards opposite trend between the last three years of the decade due to potential problems of energy crisis and security. The results showed that textile sector, although the largest manufacturing sector, is least productive; while tobacco sector is the most productive sector. Automobile, petroleum and machinery and equipment manufacturing sector are other potential sectors. Furthermore the study realized the presence of both horizontal and vertical spillovers in all sectors with varying intensities and their positive effect on productivity. This study faced several limitations in the availability of data related to statistics of material inputs, employed labor and R&D investment.

It is also obvious from this study that manufacturing sector produced positive results between 2001 and 2007 but there are slight shift towards opposite trend between last three years of the decade due to potential problems of energy crisis and security. This research would be carried out at individual industrial group and firm levels in the future to have a clearer picture of technology spillovers at firm level.

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