Technology Transfer, Technological Capability, Absorptive Capacity and Firm Performance: An Investigation of the Textile and Clothing Firms in Pakistan

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Abstract: Research on the web of technological linkages that stimulate firm performance is still evolving, especially when they differ with industry, timing and location. Generally, firms in emerging nations need technologies to build technological capabilities; however in some cases firms are limited in their capacity to acquire the technology because of their low level of absorptive capability. The rising share of resource-based textile exports, which exceeds clothing exports, demonstrate that little or no functional upgrading has taken place in the clothing and textile industry of Pakistan. Hence, using structural equation modeling we examine in this paper the mediating effect of absorptive capacity on the relationship between technological capabilities and technology transfer, and firm performance in a sample of 503 textile and clothing firms in Pakistan. The results show that, absorptive capacity mediates positively and significantly the relation between technology transfer, technological capabilities and firm performance with the former being stronger than the latter.

Keywords: Absorptive capability, firm performance, Smart PLS, technological capabilities, technology transfer
JEL classification: L6

1. Introduction

Early neoclassical attempts to estimate technology as a residual (Solow, 1956), including the more sophisticated model that endogenised technology (Romer 1986; see also

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Lucas, 1988), failed to convince innovation economists over its efficacy. This framework came under further criticisms following the works of Krugman (1994) and Young (1994, 1995) who had claimed that South Korea, Singapore and Taiwan grew by factor inputs instead of technical change. While the IMF (2017) focused on limitations of the residual approach used in total factor productivity estimations, Rasiah (2015) identified several problems with the methodology used. Not only that the perfect substitution between capital and labour assumption caused problems, but also the measurements did not address latent embodied technologies and non-pecuniary knowledge flows associated with public goods that stimulate innovations, including tacit knowledge (see also Dosi, 1988)[1]. Indeed, the latecomer catch up experiences in manufacturing of the United States, Germany, Japan, South Korea and Taiwan was very much based on technology transfer (Amsden, 1989; Freeman, 1984; Fukasaku, 1992; Hamilton, 1791; List, 1885; Wade, 1990). A number of countries have acquired and adapted foreign technology successfully to fuel economic growth, but most developing countries have failed to do so successfully (Dyer & Nobeoka, 2000; Dyer & Singh, 1998; Gupta & Govindarajan, 2000; Simonin, 1999, 2004; Szulanski, 1996, 2000; Zander & Kogut, 1995). Local firms are important actors in the framework of technology transfer and the manner in which they access external sources of knowledge by their specific technological efforts are critical for successful technology knowledge transfer. Therefore, technology transfer is important in the manufacturing sector for emerging and developing economies, such as in Pakistan's textile and clothing industry, since successful technological knowledge accumulation and domestic technological development efforts can play an important role in the economic development of host nations (Lall, 1992, 1998; Rasiah, 2018). The lack of industrial upgrading in Pakistan is both a consequence of a lack of localised accumulation of technological capabilities, as well as a result of a lack of technology transfer from abroad. Technology transfer is important for Pakistan's manufacturing sector as it is dominated by low value-added textiles and clothing exports as a consequence of low technological upgrading. An insufficient level of technical and vocational training and education has limited the capabilities of firms to absorb new practices in the industry. We choose to treat technology transfer separately as at the time of diffusion they often directly influence performance, and sometimes limited to operational use. Therefore, by using a large random sample, this study attempts to examine technology transfer and technological capabilities, and how they support absorptive capacity, which then impacts on firm performance. The rest of the paper is organised as follows. Section 2 analyses the extant literature on technology. Section 3 represents the methodology and collection of data. Section 4 analyses the outcomes of the study. Section 5 finishes with the conclusions.

2. Theoretical Considerations

Technology transfer is not confined to only the physical movement of components or machinery from one body to another but also the skills and knowledge required applying and operating them (Cummings & Teng, 2003; De Toni et al. 2011, 2012;

[1] See Rasiah (1995) for a critique of such models.

Howells 1996; Malik, 2002). It also often involved strong participation in the adaptation of imported technologies. Technology development has always been the main concern for developing economies as it is the critical explanatory variable that has driven economic divergence between these nations and the advanced nations (Haug, 1992). There is consensus among development economists, such as Amsden (1989, 1991), Lall (1992), and Rasiah et al. (2015), that latecomer nations could benefit through acquiring and adapting imported technologies from the developed economies to accelerate their catch up process.

However mainstream accounts, starting with Arrow (1962), focused on learning by doing and took on the assumption that technologies can easily be duplicated and reused. Dynamic learners are always creating their own paths of innovation so that they creatively adapt and transform current stocks of knowledge into new products (Rasiah, 2015). Technology acquisition has traditionally been the first step to perform operational activities (Archibugi & Coco, 2005; Dutrénit, 2007; Ernst et al., 1998; Hobday & Rush, 2007; Lall, 1987; Morrison et al., 2008; Tallman et al., 2004). However, catch up firms then adapt extensively technologies acquired from abroad before themselves innovating products new to the universe (Argote, 1999; Freeman, 1987; Garud & Nayyar, 1994). The claim that firms in the developing countries focused on capital accumulation through emphasis on infrastructure development (Rodrik, 2009; Summers, 2003) obfuscates the reality that firms require to evolve knowledge creating capabilities to upgrade technologies transferred (Rasiah, 2019). Consequently, organisations should be capable of transformative learning, as well as to absorb this knowledge (see Brown & Duguid, 1991; Lichtenthaler, 2009). In short, technology transfer plays an important role in enhancing recipient firms' economic performance.

To compete in the international market, the acquisition of technologies and further development of technological capabilities are important (Bell & Pavit, 1995; Biggs et al., 1988; Ernst et al., 1998; Lall, 1987, 1992, 1996, 1998, 2001; Rasiah, 2004, 2005, 2006, 2007). Technological capabilities refer to firms' ability to effectively use technological information and knowledge for assimilation, adaptation to raise economic performance (Rasiah, 2004). Industrial growth is largely achieved through changes in organisational process and product innovations (Kim, 1997; Kim et al., 2009; Rasiah, 1995). Although the growth and impact of technological capabilities has been examined extensively (such as Kim, 1997; Lall, 1992; Nelson, 1996; Rasiah, 1995; Seibert, 1997), there are still gaps in the way the concept has been used to analyse firm performance. Much of the problem arises from the difficulty in measuring technology owing to its dynamic public goods properties, and the wide variance in the way it evolves in different industries and sectors.

At infancy, latecomer firms lack technological capabilities even if they have the knowhow to produce new products (Figeuiredo, 2002). Either through scaling up in incubators or through learning by adaptive innovations through both technologies transfer and endogenous development, firms gradually acquires the technological capabilities to start and deepen operations (Torres & Jasso, 2017). The development of technological capabilities helps firms build and able to manage technological changes, which are embodied in human capital, machinery and equipment and organisational structures (Bell & Pavitt, 1995; Rasiah, 1995). Among the characteristics of technological

capability include firms' functional knowledge of production and marketing, services, R&D and engineering (Teece & Pisano, 1994).

Firms' capability to absorb scientific and market knowledge had a significant effect on their product and process innovation output (Murovec & Prodan; 2009). Greater levels of absorptive capability allows manufacturing firms to improve both the commercial and quality success of the latest product launched in the market, and also the efficiency of their processes (Chen et al., 2009). Furthermore, absorptive capability allows firms to efficiently acquire and use external and internal knowledge, which ultimately enhance their innovation capabilities (Daghfous, 2004).

The work of Cohen and Leviathan (1989) and Lall (1992, 2001) shows that adoption and diffusion of technology require well-coordinated and extensive technical efforts coupled with the ability to adapt and absorb. They enable technologically backward nations to catch up with the most progressive technologies (Barro & Sala-i-Martin, 1997; Eaton & Kortum, 1995; Grossman & Helpman, 1994; Romer, 1994). Absorptive capabilities, including organisational learning and knowledge management, is a critical path through which firms learn and progress (Fiol & Lyles, 1985; Hedberg, 1981; Kedia & Bhagat, 1988; Levitt & March, 1988). Consequently, firms that successfully encourage learning also rely on their capacity to recognise and appropriate synergies from latest external knowledge through exploitation and assimilation (Cohen & Levinthal, 1990).

This capacity of a firm, classified as absorptive capacity is critical for sourcing and acquiring external knowledge for innovation (Liao et al., 2007; Zahra & George, 2002). A firm's learning culture escalates the creation, diffusion and internalisation of latest ideas within firm's members, and so, supports the growth of its members, and helps in creating and sourcing ideas and new knowledge exploration in firms (Lee & Choi, 2003). Therefore, the relations between absorptive capability and organisational learning culture have a major effect on a firm's knowledge invasions. The features of the organisational learning culture, for example knowledge acquisition, diffusion and sharing are expected to be accompanied by high levels of absorptive capability such that organisations with high absorptive capability are more capable to source, acquire and internalise latest knowledge.

The extant literature has focused mostly on discreet industries, such as automobiles, steel and electronics. There are few studies that have addressed technology transfer and technological capabilities in the textile and clothing industries, which is the main engine of manufacturing development in poor countries, such as Bangladesh, Cambodia and Pakistan. Hence, this study seeks to bring fresh evidence to fill the gap in the literature by using a large data set gathered from textile and clothing firms in Pakistan.

Figure 1 shows the theoretical framework along with the hypotheses. As presented in the framework and examined critically earlier in the literature review, we examine the notion that the more an organisation has a deep understanding of knowledge accumulation from external resources through technology transfer (TT), and is endowed with the ability to upgrade its technological capabilities to use this knowledge (TC) and absorptive capability (AC), the more will be its ability to adapt and assimilate external knowledge to stimulate its diffusion, internalisation and adapted transformation of novel knowledge, the better will be its performance (PERF).

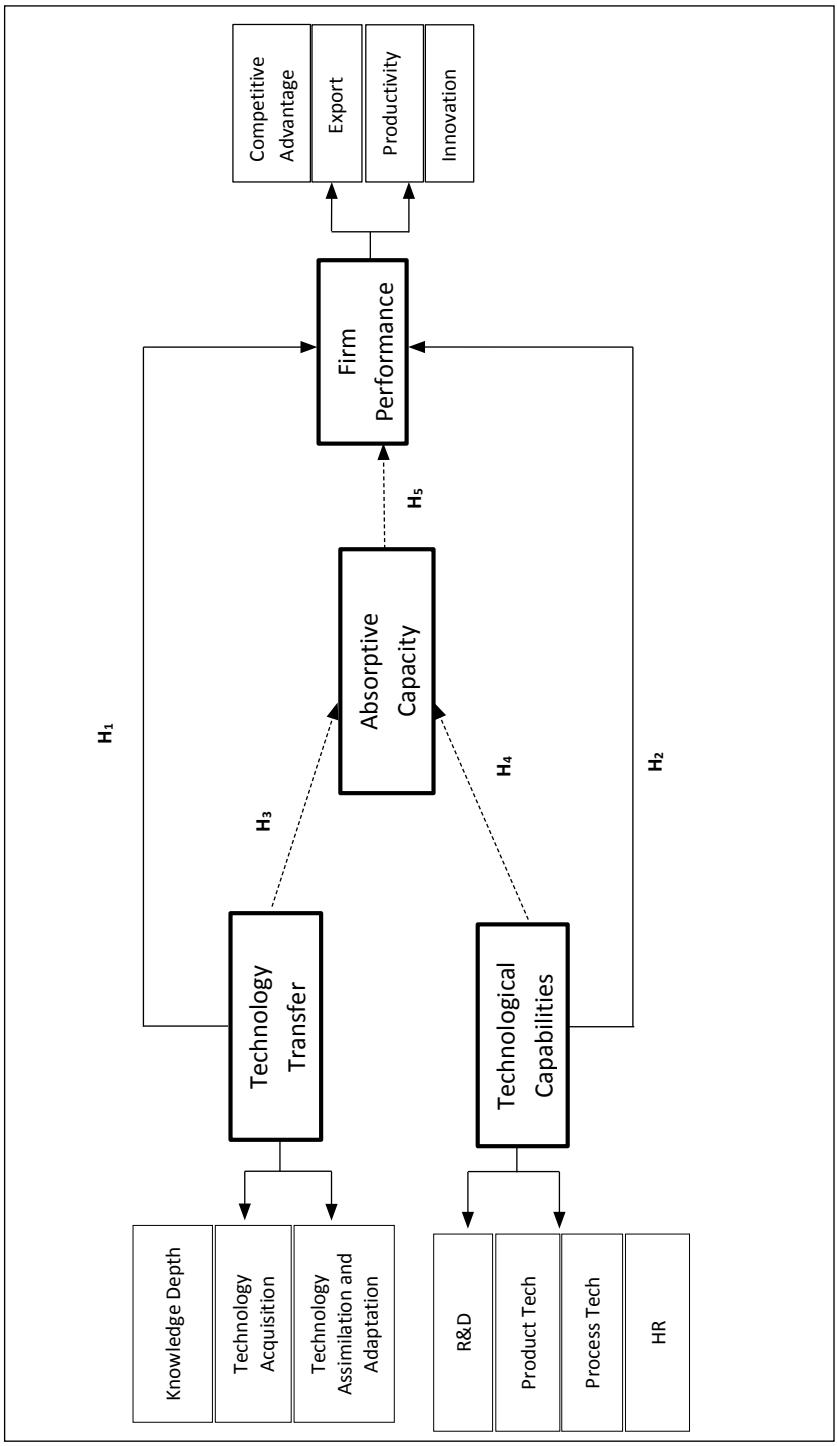

Figure 1. Theoretical framework

The development of technological capability is essential to operate textile and clothing firms which make it suitable as an initial step towards industrialisation, especially among underdeveloped countries (Keane & Velde, 2008). In fact, over two-thirds of world textiles and clothing exports over the last three decades since the 1980s originated from production at developing nation sites. Indeed, few countries have experienced extraordinary productivity growth rates in this sector to support rapid economic growth, such as South Korea, Taiwan, Vietnam, Bangladesh, Sri Lanka, Cambodia, Mauritius, Malaysia, Thailand and the Philippines. Textiles and clothing sector are very much interrelated in terms of trade policy and technology (Nordas, 2004). Hence, testing the following hypotheses on Pakistan's textile and clothing firms will help us understand the potential impact of technology transfer, technological capability and absorptive capacity on firm performances.

H_1: Technology transfer is expected to have a positive relationship with firm performance.
H_2: Technological capabilities are expected to have a positive relationship with firm performance.
H_3: Absorptive capacity is expected to positively mediate the relationship between technology transfer and firm performance.
H_4: Absorptive capacity is expected to mediate positively the relationship between technological capability and firm performance.
H_5: Absorptive capacity is expected to have a positive relationship with firm performance.

3. Methodology and Data

Collection of primary data constitutes the basis of this study. A random survey approach targeting 600 medium and large textile and clothing firms (employing up to 250 and more persons – this criteria is provided by the State Bank of Pakistan and the Small and Medium Enterprises Development Authority (SMEDA)) were used (see Appendix B). Firms with employment size below 250 persons were dropped following our pilot study that showed low technological capabilities in these firms, which was also confirmed by officials of the Pakistan Textile and Clothing Association. The response rate of 82% was high because of the close relationships between one of us and the Pakistan Textile and Clothing Association officials.

3.1 Sampling

We targeted registered textile and clothing firms under state associations, such as the Securities and Exchange Commission of Pakistan (SECP), All Pakistan Textile and Manufacturing Association (APTMA), Pakistan Stock Exchange (PSX) (formerly Karachi Stock Exchange, KSE), and Chamber of Commerce listing. Owing to the difficulty associated with a full country-wide survey, we chose firms located in the three cities of Karachi, Lahore and Faisalabad where textile and clothing firms are mostly concentrated (Table 1). The breakdown by these cities is shown in Table 1.

Table 1. Distribution of firms by city

District	Number of firms
Karachi	1,511
Faisalabad	1,128
Lahore	466

Source: Wadho & Chaudhry (2016).

By using the Krejcie and Morgan (1970) selection criterion the number of firms to be chosen came to 498 firms with a 95% confidence level and a margin of error of 5% (Hair et al., 2009). We sent questionnaires to 600 firms rather than the 498 firms with the additional firms chosen using the same criteria shown in Table 2. Faisalabad eventually yielded a smaller share owing to a large share of its firms with employment size below 250 persons.

Table 2. Sampled firms

City	Total firms	% share	Sample based on Krejcie and Morgan (1970)	Sample chosen
Faisalabad	1,128	47	169	164
Lahore	466	16	70	85
Karachi	1,151	41	259	351
Total	2,745	100	498	600

Source: Calculated using data from Wahoo & Chaudhry (2016).

3.2 Questionnaire

Two pilot studies were undertaken before the questionnaires were finalised, viz., the first was sent to academics who have published articles on the textile and clothing industries, and the second was administered to 20 firms recommended by the All Pakistan Textile Mills Association (APTMA). The first pilot study was important in formulating the model and its requisite questions for analysis, while the second was important to address firms understanding, as well as the type and nature of how the elements of technology transfer, technological capability, and absorptive capacities in these firms. While the initial questions were developed from the literature review, we relied on academic experts competent on the textile and clothing industry to finalise them. The academics overwhelmingly recommended close-ended questions for modelling purposes with questions as proxies to capture technology transfer, technological capabilities, absorptive capacity and firm performance. Furthermore, we checked the content validity through formal pretest procedure, which resulted in a list of related questions for the original data collection.

3.2.1 Respondents

The survey questionnaires were sent to CEOs, members of top management, middle management and lower management in the 600 selected firms with an official cover letter to ensure the confidentiality of their responses. In total, 128 (25.4%) of the top managers, 303 (60.2%) of the middle managers, and 72 (14.3%) of assistant managers and supervisors filled up the questionnaires. The breakdown by size amounted to 183 (36.4%) firms with up to 250 employees and 320 (63.6%) firms with over 250 employees. A total of 503 questionnaires were completed, which represented 82% response rate.

3.2.2 Variables

Rasiah (2002, 2003, 2004), Rasiah and Gachino (2005), Lall (1992), and Figueiredo (2002) had provided an insightful investigation of technological capability in such sectors as textiles and garments, food, and beverages and electronics, metal engineering in Brazil, Kenya, Malaysia, Indonesia, Philippines and Thailand. Their results confirmed that technological capabilities have significant and positive relationship with firm performance. In addition to deploying technological capability as an explanatory variable, this study goes further to include technology transfer and absorptive capacity as additional explanatory variables to examine their relationship with firm performance. Technology transfer (TT) and technological capabilities (TC) were operationalised as second-order construct variables. TT was constructed using three proxies: knowledge depth (KD), technology acquisition (AC), and technology assimilation and adaptation (ASS). Estimation of KD, AC and ASS were adapted from measures used by Lall (1992), Teece and Pisano (1994), Figueiredo (2002), Dutrenit (2007), and Rasiah (2004). TC was constructed using four proxies: process technologies (PROC), product technologies (PR), human resource (HR), and research and development (R&D) (Rasiah, 2004). The mediator variable, i.e. absorptive capacity (AC) was operationalised as a first order construct, which was aimed to capture different aspects of absorptive capacity by means of organisations learning culture (Biggs et al., 1988; Cohen & Levinthal, 1989). We used a measure developed by Jansen et al. (2005). Owing to the difficulty of obtaining reliable responses, firm performance was measured directly using the proxies of competitiveness (COMP) (Spanos & Prastacos, 2004), exports (EXP) (Rasiah, 2004), innovation (INNO) (Dahlmen & Westphal, 1982 and productivity (PROD) (Teece & Pisano, 1994).

3.3 Analytic Techniques

We adopted structural equation modeling (SEM) introduced by Hair et al. (1998), using Smart PLS version 3.0 to analyse the data. The partial least square (PLS) executes an outer or measurement model and inner model or structural model. Whereas the model determines the overall psychometric properties of the scale used to measure the variables, the structural model determines the predictive relationships amongst the variables. Moreover, Smart PLS version 3 can handle formative and reflective constructs in one model at the same time.

By following Anderson and Gerbing's (1988) approach for testing hypotheses, we first screen the measurement model to determine convergent validity and discriminant reliability of the constructs before estimating the parameters of the structural model for predictive relationships.

3.3.1 Structural Equation Model

We assess confirmatory factor analysis by means of testing convergent validity and discriminant validity to assess construct validity. For convergent validity we test the loadings of each item to its postulated basic construct (Anderson & Gerbing, 1988). The t-statistics results for all the items' loadings to their latent construct were found significant at the 5% level. The Cronbach's alpha statistics give confirmation of composite reliability and the values exceeded 0.7, which indicate that it is suitable for further analysis. Lastly, the average variance extracted (AVE) shows the variance described by a construct compared to the amount of variation caused by measurement errors. All constructs' variances were beyond the threshold value of 0.5. For discriminant validity we test Fornell-Larcker criterion (1981) and heterotrait-monotrait ratio of correlations (HTMT) approach. The results confirmed the square root of the AVE was more than the inter-construct squared correlation values for all variables. As the model used is complex and has both reflective and formative constructs, they were screened for multicollinearity. For this purpose we used SPSS software to run multiple regressions. The results of the multicollinearity tests show no correlations among the independent variables and are significant at the 5% level. Therefore, multicollinearity did not appear as a problem in the predictor constructs of the structural model (Tabachnick & Fidell, 1996). The results of convergent validity, discriminant validity and multicollinearity can be found in Appendix A.

The total explanatory power of our structural model, the amount of predictive variances supported by the exogenous and endogenous variables and the strength and magnitude of their paths corresponds with the hypotheses.

3.3.2 Structural Model

Figure 2 displays the structural model with estimated parameters and t-values of all paths, which is used to assess the mediating effect of absorptive capacity on the impact of technology transfer and technological capabilities on firm performance. We perform bootstrapping with the 503 firm responses for the statistical significance of the paths defined in the model.

Table 3 presents t-values of estimates in the model without the mediator, which are highly significant at the 1% level. Technological capabilities show a stronger association with firm performance with a mean value of 0.49 than that of technology transfer which is 0.24. When viewed from the dimensions, AC, AS and KD showed mean contributions towards TT of 0.03, 0.03 and 0.04 respectively. HR, PR, PROC and RD showed mean contributions towards TC of 0.41, 0.51, 0.28 and 0.45 respectively.

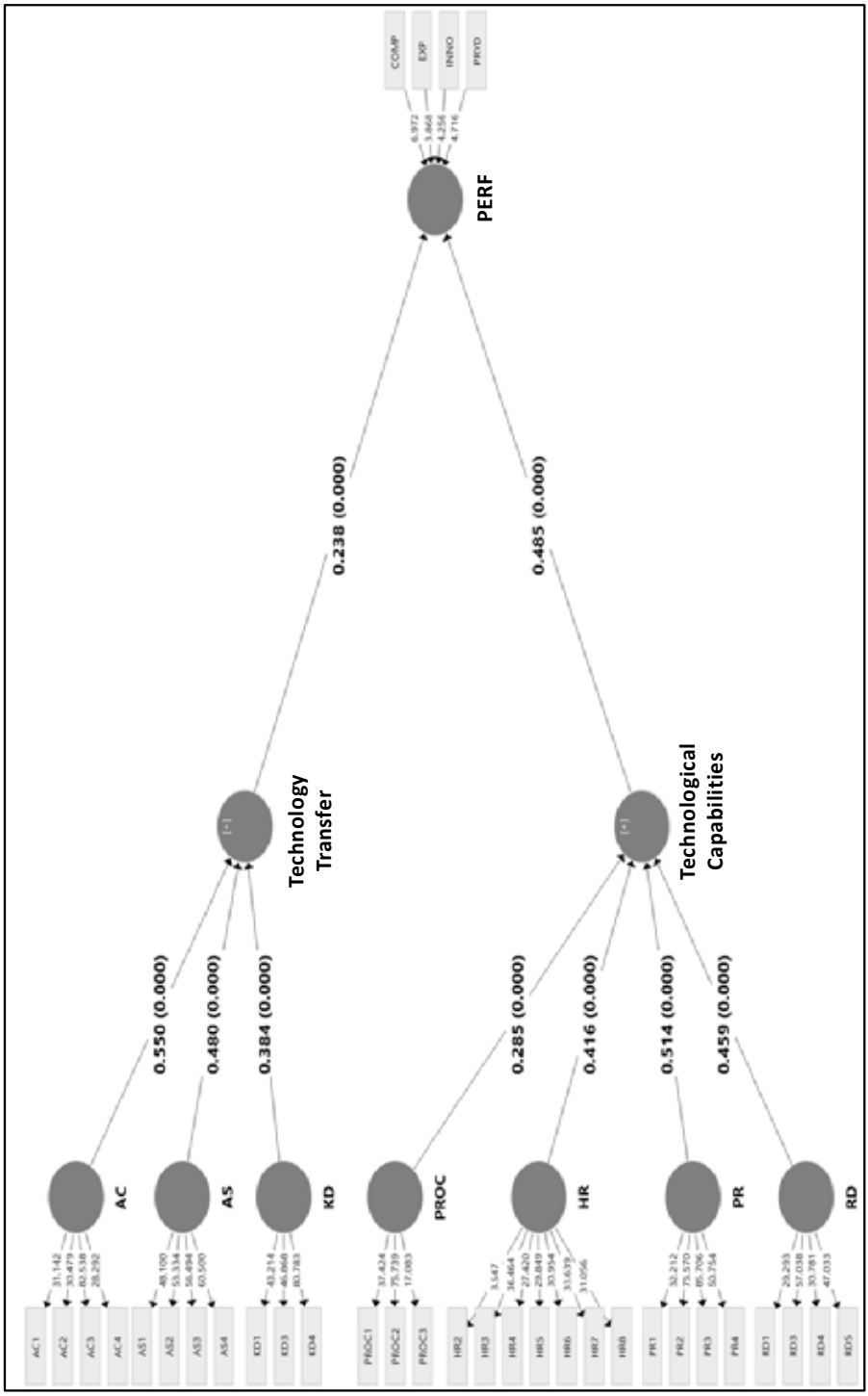

Figure 2. Structural model
Source: Estimated by authors.

Table 3. Factor loading results

Path	Original sample (O)	Sample mean (M)	Standard deviation (STDEV)	t-statistics (O/STDEV)	p-values
TC → PERF	0.485	0.494	0.036	13.485	0
TT → PERF	0.238	0.241	0.047	5.086	0
AC → TT	0.550	0.550	0.029	19.084	0
AS → TT	0.480	0.479	0.030	15.899	0
KD → TT	0.338	0.379	0.036	10.696	0
HR → TC	0.416	0.414	0.055	7.579	0
PR → TC	0.514	0.509	0.038	13.392	0
PROC → TC	0.285	0.282	0.051	5.617	0
RD → TC	0.459	0.453	0.036	12.858	0

Source: Estimated by authors.

3.3.3 Path Analysis/Mediating Effect of Absorptive Capability

Mediating effect can be examined in two ways, *viz*., (a) direct paths (between the exogenous and endogenous variables) and indirect paths (from exogenous variable to mediator to endogenous variable at the same time (James et al., 2006; Judd & Kenny, 1981), and (b) using the Sobel test to inspect the mediating effect (Baron & Kenny, 1986; Shah & Shin, 2007). Figure 3 demonstrates path analysis following the introduction of the mediator in the model.

4. Results and Analysis

Table 4 shows that TT is positively correlated with firm performance, which is highly significant (at 1%). The relationship between TC and firm performance is also highly significant (1% level). The latter relationship is stronger than the former. Thus, both technology transfer and technological capabilities positively affected overall firm performance supporting Hypothesis 1 and 2. The indirect path between technology transfer, absorptive capacity and firm performance was also significant ($t = 6.49$, $p = 0.00$), which supports Hypothesis 3. The indirect path between technological capabilities, absorptive capabilities and firm performance was also significant ($t = 10.73$, $p = 0.00$), supporting Hypothesis 4. The direct effect of absorptive capacity on firm performance was significant ($t = 7.65$, $p = 0.00$), confirming Hypothesis 5. Hence, the empirical evidence validates all hypotheses defined.

If the path between the exogenous variable TT and the mediating variable AC and the dependent variable PERF is controlled it weakens the relationship between TT and PERF, suggesting that AC partially mediates the relationship between TT and PERF. The results from the bootstrapping procedure confirm this, which is supported by the positive and significant relationships shown by the direct and indirect paths (Table 5). The results demonstrate that AC plays a complementary mediating role in the relationship between TT and PERF.

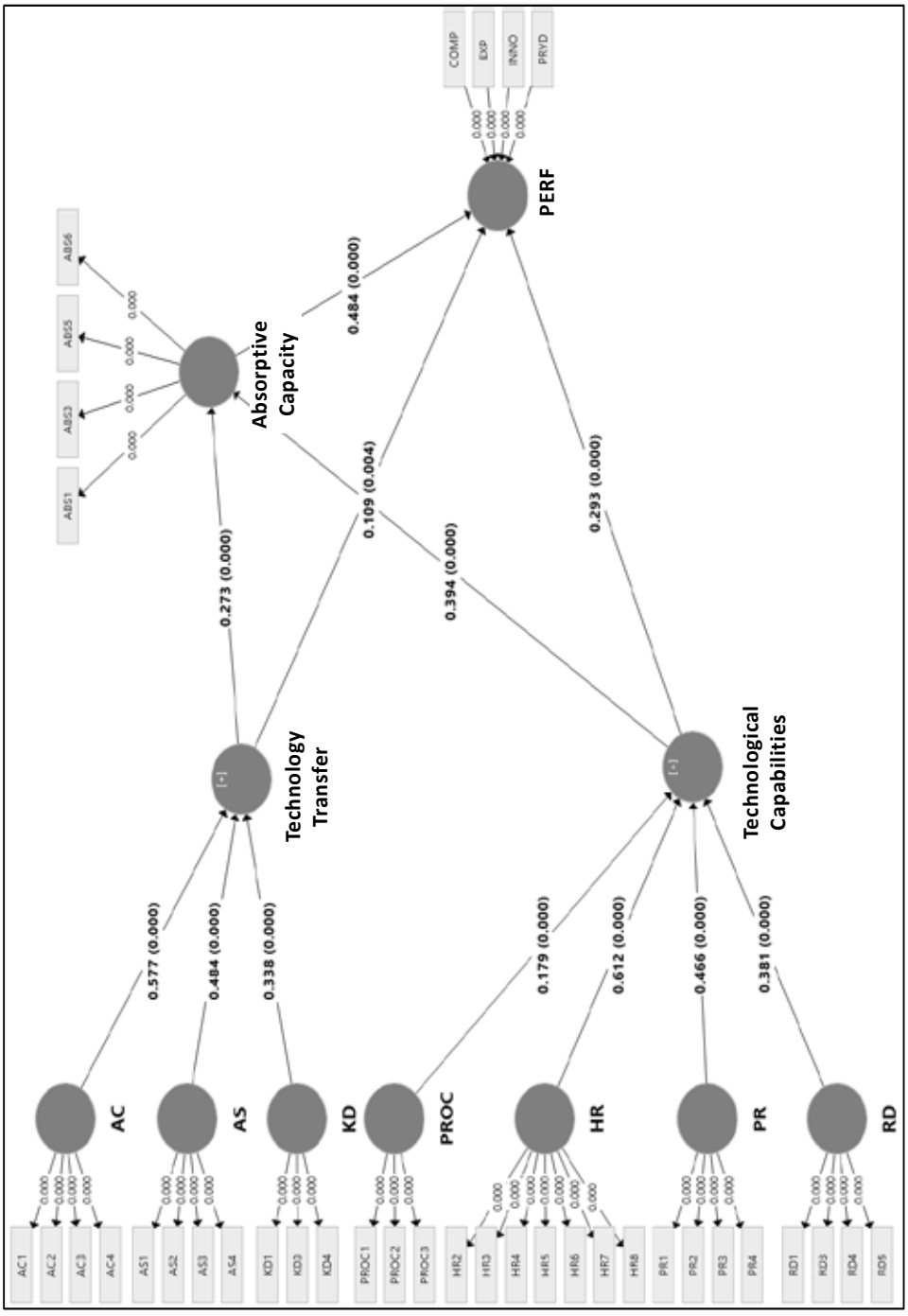

Figure 3. Path analysis
Source: Estimated by authors.

Table 4. Mediating effect results

Path	Original sample	Sample mean	Standard deviation	t-Stats	p-values
Path a					
TT → AC	0.273	0.278	0.042	6.495	0.000
TC → AC	0.394	0.394	0.037	10.738	0.000
Path b					
AC → PERF	0.484	0.293	0.038	7.656	0.000
Path c					
TT → PERF	0.109	0.112	0.038	2.908	0.004
TC → PERF	0.293	0.483	0.036	13.344	0.000

Source: Estimated by authors.

Table 5. Results of bootstrapping procedure and total effect

Results of bootstrapping					Total effect			
Path	ab	SE	Z	P	Construct	Direct effect	Indirect effect	Total
TC → AC → PERF	0.1906	0.018	6.245	0.000	*TT*	0.109	0.132	0.241
TT → AC → PERF	0.132132	0.016	4.969	0.000	*TC*	0.293	0.190	0.483

Source: Estimated by authors.

Similarly, the relationship between TC and PERF weakens when the paths between the exogenous variable of TC and mediating variable of AC, and the dependent variable PERF are controlled, suggesting that AC partially mediates the relationship between TC and PERF. The bootstrapping procedure confirmed the mediating effect, which is further supported by the positive and significant relationships shown by the direct and indirect paths (Table 5). The results indicate that AC plays a complementary mediating role in the relationship between TC and PERF.

Furthermore, the findings in Table 6 show that the paths between the second-order construct (*TT*) and its three first-order variables of *AC*, *AS* and *KD* are statistically significant, which means that these three variables demonstrate a significant mediating effect in the relationship between *TT* and *PERF*. Similarly, the paths between the other second-order construct (*TC*) and its first-order variables of *PROC*, *HR*, *PR* and *RD* are also statistically significant, which means that these variables have a significant mediating effect on the relationship between *TC* and *PERF*.

Table 6. Second order construct

Construct	Dimension	Path coefficient
Technology transfer	AC	0.577
	AS	0.484
	KD	0.338
Technology capabilities	PROC	0.179
	HR	0.612
	PR	0.466
	RD	0.381

Source: Estimated by authors.

Some researchers have recommended that R^2 and Q^2 could be used to measure the fitness of the empirical model (e.g. Chin, 1998; Cohen, 1998; Tenenhaus et al., 2005). The findings show 26.4% of variance in the absorptive capacity could be explained by the proposed empirical model, which is highly significant because its predictive relevance statistic is greater than zero (Table 7). Furthermore, the findings also show that 50.4% of the variance in firm performance could be explained by the empirical model that is also highly significant because its predictive relevance statistics is greater than zero.

Table 7. Results of fitness statistics in the model

R^2 and Q^2 values			f^2 values		
Endogenous latent variable	R^2 adjusted	Q^2	Predictor	Absorptive capacity	Performance
Absorptive Capacity	0.268	0.160	*AC-PERF*		0.346
Performance	0.504	0.217	*TC-PERF*	0.206	0.139
			TT-PERF	0.098	0.021

Source: Estimated by authors.

Following Chin (1998) we used f^2 to measure the fitness of the empirical model. The findings indicate that the size effect for AC is sufficiently high (Table 7). Also, the size effect of TC is higher than the size effect of TT, demonstrating that TC has a bigger effect than TC on PERF.

5. Conclusions

We attempted to examine the mediating effect of AC on the relationship between *TT* and *TC* on *PERF*. The findings show that *TC* and *TT* both impact positively on firm performance with the former being stronger than the latter. Also, AC mediates positively both relationships. Similarly, firms' capacity to raise productivity, exports,

innovation and competitiveness from the impact of TC is also augmented by AC (Gold et al., 2001; Holsapple & Joshi, 2001; Leek et al., 2003; Madu, 1989; Orlikowski, 2000). The results show that successful technology knowledge transfer and firm level technological capability building are critical drivers of industrial performance in Pakistan's textile and clothing industry. This evidence can be broadened to encompass the whole of South Asia whereby technology transfer and absorptive capacity should be viewed as key drivers of technological capabilities and manufacturing performance. These capabilities are important to assist firm-level upgrading to more complex skills and knowledge concentrated activities to stimulate rapid growth in value added, productivity and eventually in wages. While the empirical evidence is from Pakistan, these findings can be tested on other developing economies and on other industries by taking account of industry, location and time differences. It is likely that the positive mediating effect of AC on the relationship between TC and TT, and PERF will be stronger among the high technology industries, such as electronics and biotechnology. Future studies should focus on refining the data used, and adding more first-order variables that are appropriate to capture TC, TT, AC and PERF to better examine their multi-dimensional effects. There should also be studies that address profoundly institutional influences on technological upgrading to offer policy relevant recommendations for developing countries.

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Appendix A

Convergent validity

	Cronbach's alpha	Composite reliability	Average variance extracted (AVE)
Absorptive capacity	0.844	0.889	O.616
Acquisition	0.803	0.872	0.631
Assimilation	o.863	0.907	0.709
Competition	0.771	0.855	0.600
Export	0.839	0.882	0.556
Human resources	0.857	0.891	0.543
Innovation	0.888	0.918	0.692
Knowledge depth	0.808	0.887	0.724
Product technologies	0.874	0.914	0.727
Process technologies	0.775	0.870	0.691
Production	0.848	0.908	0.767
Research and development	0.807	0.874	0.635

Correlation matrix for the constructs (Fornell-Larcker criterion)

	AC	AS	ABC	COMP	EXP	HR	INNO	KD	PR	PROC	PRYD	RD
AC	**0.795**											
AS	0.293	**0.842**										
ABC	0.300	0.244	**0.785**									
COMP	0.335	0.185	0.519	**0.774**								
EXP	0.142	0.115	0.330	0.193	**0.746**							
HR	0.197	0.077	0.348	0.354	0.102	**0.737**						
INNO	0.196	0.161	0.474	0.349	0.411	0.280	**0.832**					
KD	0.230	0.180	0.120	0.104	0.069	0.072	0.037	**0.851**				
PR	0.071	0.033	0.258	0.159	0.307	0.105	0.296	-0.025	**0.853**			
PROC	0.094	0.086	0.121	0.147	0.059	0.053	0.105	0.008	0.086	**0.831**		
PRYD	0.093	0.106	0.449	0.196	0.282	0.163	0.354	0.052	0.337	0.077	**0.876**	
RD	0.064	0.099	0.278	0.154	0.234	0.082	0.200	0.009	0.238	0.159	0.234	**0.797**

Heterotrait-monotrait ratio of correlations (HTMT)

	AC	AS	ABS	COMP	EXP	HR	INNO	KD	PR	PROC	PRYD	RD
AC												
AS	0.349											
ABS	0.359	0.284										
COMP	0.430	0.225	0.641									
EXP	0.176	0.134	0.390	0.237								
HR	0.235	0.093	0.408	0.436	0.126							
INNO	0.229	0.183	0.549	0.425	0.475	0.315						
KD	0.287	0.212	0.144	0.138	0.087	0.092	0.086					
PR	0.090	0.050	0.298	0.193	0.353	0.122	0.334	0.054				
PROC	0.121	0.103	0.148	0.186	0.088	0.066	0.124	0.046	0.110			
PRYD	0.109	0.123	0.529	0.243	0.330	0.187	0.407	0.073	0.390	0.094		
RD	0.082	0.121	0.336	0.190	0.284	0.108	0.235	0.059	0.283	0.204	0.282	

Multicollinearity assessment

Construct	Indicators	VIF
Technology transfer	AC	1.134
	AS	1.110
	KD	1.072
Technological capabilities	HR	1.016
	PR	1.071
	PROC	1.030
	RD	1.085
Performance	COMP	1.277
	EXP	1.238
	INNO	1.504
	PRYD	1.419
Second order		
Absorptive capacity	AC	2.539
Technological capabilities	TC	1.071
Technology transfer	TT	1.174

Appendix B

Technological knowledge building and firm performance
(A survey on Pakistan textile and clothing industry)

General information

(i) Firm name and website (if any): .....

(ii) Year of establishment ..... (iii) Total number of employees .....

(iv) What is your designation in the firm? .....

(v) ISO certification (Please specify) .....

Please read and respond each statement carefully and mark your degree of agreement to the following questions by ticking (√) in the appropriate box along with rating scale.

(1) = Strongly Disagree, (2) = Disagree, (3) = Neutral, (4) = Agree, (5) = Strongly Agree

TECHNOLOGY TRANSFER		Rating scale				
A	**Knowledge depth**	1	2	3	4	5
1	Your firm prefer technical knowledge while hiring employees					
2	Your firm believes in everyday technical knowledge to upgrade technology					
3	In your opinion high level of technical education is important for better performance					
4	In your opinion global integration to get technical knowledge depth is important					
B	**Acquisition**	1	2	3	4	5
1	Your firm believes in technology acquisition for technical upgrading					
2	Your firm has ability to access and purchase new technologies					
3	Your firm has separate budget to buy new technologies					
4	In your opinion latest technologies improve quality of work and performance					
C	**Assimilation**	1	2	3	4	5
1	Your firm has an ability to absorb latest technologies					
2	In your firm employees can easily understand the operating techniques of the machines					
3	In your opinion technological assimilation plan is important for your firm					
4	Your firm can undergo an assimilation process which modifies ideas for production					

TECHNOLOGICAL CAPABILITIES

A	**Product related technology**	1	2	3	4	5
1	Your firm has product designs and technical specifications					
2	Your firm considers structured R&D collaboration in product-related areas					
3	Your firm considers technical consultation to improve existing and new production technology					
4	In your firm regular feedback on product performance is important					
B	**Process related technology**	1	2	3	4	5
1	Your firm has in-house process innovations					
2	Your firm has the capability of assimilating new imported product technology and adaptation to market needs					
3	Your firm has ability of repairing, quality control preventive maintenance, and assimilation of process technology					
4	Your firm believes in technical support to improve existing process technology					
C	**Human resource**	1	2	3	4	5
1	In your firm, skills, knowledge and training outcome are incorporated in processes and product services					
2	In your firm, soft skill training increase employee's productivity					
3	Your employees receive on the job training including cross training between different departments, organisational practices to improve your firm's performance					
4	In your opinion, firms should invest more in training programs to improve training outcomes					
5	In your opinion, training durations should be increased for effective training					
6	In your opinion, employee's technical training can improve firms performance					
7	In your firm, employees' level of technical skills is important to perform smooth operation					
8	In your opinion, number of employees having extraordinary technical skills are few in industry					
9	In your firm, employees introduce innovative ways in performing their task					
10	In your firm, employees are able to perform multi-task operations					
11	In your opinion, on the job training leads to better performance					

RESEARCH AND DEVELOPMENT	1	2	3	4	5
1 Your firm's R&D expenditure is higher as compared to your competitors					
2 Your firm believes in investing in R&D which helps in making original design and brand					
3 Your firm has a process of reverse engineering (duplicate or reproduce manufacturers product)					
4 Your firm has quick feedbacks from manufacturing to design and engineering					
5 Your firm has better mechanisms for transferring technology from research to product development					
ABSORPTIVE CAPABILITY	1	2	3	4	5
1 Your firm analyses and interprets changing market demands promptly					
2 Your employees record and store newly acquired knowledge for future reference					
3 Your firm explore new opportunities to serve your clients					
4 Your firm quickly recognises the practicality of latest external knowledge to present knowledge					
5 Your firm thoroughly grasps the opportunities that offer new external knowledge					
6 Your employees meet occasionally to discuss concerns of market trends and latest product development					
7 Employees in your frim are clearly aware of how the firm's activities should be performed					
8 Your firm constantly reviews how to better exploit external knowledge					
FIRM PERFORMANCE					
M Innovation	1	2	3	4	5
1 Our firm explore and use opportunities for a new product and process ideas					
2 Our firm is up to date in implementing modern technological innovations in processes					
3 Our firm has continuous customer feedback into technological innovation process to improve products					
4 Our firm is creative in its mode of operations					
5 Your firm's turnover and export performance has increased after innovation within the last 3 years					
6 IT plays a considerable role in product and production processes					

		1	2	3	4	5
7	In your opinion, information technology helps in enhancing firms supply chain performance					
8	In your opinion, computer generated solutions increase your firm's performance					
9	In your opinion, IT better fulfils customer's demands and requirements					
10	Do your firm believe in using enterprise resource planning (ERP)?					
N	**Competitive advantage**	1	2	3	4	5
1	Your firm has an edge on your competitors due to quality product and better marketing strategies					
2	Your firm has an edge on your competitors due to better reputation in the global market (special techniques, patents, copyrights, licence)					
3	Your firm has an edge on your competitors due to latest production machinery, low cost of labour and raw material					
4	Your firm introduces new products to remain competitive in the market					
5	Your firm's cost of production is decreasing during the last 3 years					
6	Your firm's annual profit is higher compared to your competitors					
7	Your firm is planning to expand your business in the near future					
O	**Export**	1	2	3	4	5
1	Your firm's export performance has increased for the last 3 years					
2	Your firm's export volume is high compared to your competitors					
3	Your firm entered in foreign markets much earlier as compared to your competitors					
4	Your firm have diversification in products exported as compared to your competitors					
5	Your firm explores new export markets as compared to your competitors					
6	In your opinion, better marketing strategies can help to improve exports					
P	**Productivity**	1	2	3	4	5
1.	The revenue of your firm has increased during the last 3 years					
2	Your firm's growth as compared to others is high					
3	In your opinion, there is a need to reduce wastage of raw material					
4	The overall productivity of your employees is higher as compared to your competitors					
5	Your employees managed production processes more efficiently					