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Effect of Technology Adoption and Process Innovation on Competitive Advantage

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ABSTRACT

In a world that is currently immersed in digitalization, technology usage and process innovation have become key organizational means by which to create and maintain a competitive advantage. This paper has explored how technology adoption and process innovation have direct positive impacts on a competitive advantage in organizations that are actively involved in utilizing digital technologies in Pakistan. A quantitative survey-based design was utilized, and data were obtained on 300 employees working in digitally active organizations by issue a self-refadministered questionnaire using a set of scales to assess all three constructs at a 5-point Likert scale. The use of purposive sampling was also done, which focused on the respondents who had first-hand knowledge about the organizational processes and technology systems. The descriptive statistics along with Cronbachs alpha reliability test, Pearson correlation test, confirmatory factor analysis (CFA), and structural equation modeling (SEM) were used to analyze the data, in SPSS 25 and AMOS 24. The direct impact of technology adoption on competitive advantage (.49) was significant and so was the direct impact of process innovation (.46). The two predictors together accounted 61.4% of variance in competitive advantage (R-squared =.614). The validity of the measurement models was established with a range of AVE value (.53-59) and composite reliability coefficients (.88-93). These results determine that mindful technology adoption and methodological process innovation are mutually enhancing and complementary forces of competitiveness in the digitally active organizational setting in Pakistan, which significantly impacts the digital transformation strategy and organizational process management.

Keywords: the adoption of technology, process innovation, competitive advantage, digital transformation, structural equation modeling, purposive sampling, organizational performance, Pakistan, quantitative research.

INTRODUCTION

The theory of strategic management and practice is focused on such a notion as competitive advantage as the capacity of an organization to generate an excellent value to the customers and generate above-average returns to the owners. In a classical definition of Porter (1985), a competitive advantage is an aspect of lowering costs (cost leadership) or differentiating (offering higher value which customers will be prepared to pay more) value. These two competitive mechanisms are disproportionately transformed by two organizational capabilities that mutually support each other in the modern digital economy: the use of high-end digital technologies and the procedural innovation of the processes of product and service development and delivery.

In the contemporary organizations, technology adoption and process innovation have been seen to be emerging crucially in terms of competitive advantage. By strategic use of advanced technologies,

including digital platforms, artificial intelligence, and data analytics, the firms are in a better position to improve operational performance and efficiency, decision-making processes, and react to changing market demands (Campagna and Bhada, 2024; Huang and Zheng, 2025). Besides, process innovation allows restructuring working processes, cost minimization, and enhancing productivity, which makes organizations more competitive in the market in comparison with their rivals (Agazu & Kero, 2024). There is empirical evidence that implementation of technologies, when properly managed via innovation, has a strong and positive impact in the competitiveness of companies in any industry (Safitri and Miranda, 2024). Also, the mutual enhancement of this connection is further contributed by the fusion of innovation practices and knowledge management, which allow firms to decrease reliance on internal competencies and maintain performance over time (Nyuga and Tanova, 2024). Nevertheless, organizational readiness, environmental support, and strategic alignment are key to successful implementation, with high costs, lack of expertise, and regulatory constraints being identified as barriers to successful adoption (Faiz et al., 2024; Chang et al., 2024). Thus, those organizations that actively leverage technology and constantly update their process are more inclined to be able to attain sustainable competitive advantage within the context of an ever-more digital and competitive business world.

The organizational process known as technology adoption which involves identification, acquisition, implementation and integration of new technologies into operations and strategies has become a key competitive repositioning driver in various industries. Enterprise resource planning and cloud computing to artificial intelligence, the Internet of Things, and sophisticated analytics, the range of existing digital technology is growing at an astounding pace, to both provide the competitive edge of the early adopters and become the existential threat of the laggard. Technological change is so quick that any competitive edges based on the adoption of technology can rapidly be lost as are adopted by other rival organizations, making the rate and speed of technology adoption become more important than the adoption of a particular technology.

Process innovation - introduction of some kind of novel or remarkably enhanced means of production, delivery, or support functions - is a second critical competitive advantage-creating mechanism. Whereas product innovation generates value by the introduction of new products or services, process innovation generates value by allowing the existing and new products and services to deliver them in a better, faster, cheaper or more dependable way. Process innovation is especially eminent in cost competitive sectors and service conditions wherein the primary origin of customer value is efficiency of delivery and reliability and responsiveness. The connection between process innovation and competitive advantage works in several ways: lower production costs that lead to price competitiveness, better quality and reliability that warrant higher prices, shorter delivery times that lead to customer satisfaction and increased capacity flexibility which leads to responsiveness to changes in the market.

The Pakistani industrial and commercial environment has historically been a laggard with regards to adoption of technology and innovation of processes as compared to the technology adoption levels and process innovations of other regional markets at a similar level of development. Compared to their peers in China, India, and Vietnam, Pakistani manufacturing companies have been slow to embrace cutting-edge technology or production techniques, a factor that has repeatedly added to their existing productivity sensitivity and deficiencies in competitiveness within the world markets. Service companies have been more technologically advanced than manufacturing companies, but have had intermittent technology diffusion with hot spots in telecommunication and banking coexisting with vast technology gaps in other service subsectors. Nevertheless, the COVID-19 pandemic hastened digital transformation in Pakistani industries, as remote work, e-commerce, digital payments, and online service delivery have grown exponentials in areas of the 2020-2023 Pandemic, creating a new competitive landscape that has made technology adoption and process-level innovation more of an urgent strategic imperative than at any prior point.

The scholarly literature on technology adoption and competitive advantage situations in the context of developing economy has found that there is a leapfrogging phenomenon, in that late adopting organisations in the developing countries can gain competitive advantages by adopting the latest generation of technologies instead of going through successive stages of adoption by those adopting organisations in the developed economies. This leapfrogging dynamic, observed in telecommunications (where mobile internet uptake avoided a fixed-line infrastructure) and financial services (where mobile payments avoided traditional banking), implies that Pakistani organizations that are ready to invest in frontier technology adoption technology may seek to acquire competitive advantages that shorten the historically long catch-up timescales predicted by sequential diffusion models.

The theoretical foundation of this research combines three concepts: the Technology-Organization-Environment (TOE) framework (Tornatzky and Fleischer, 1990), which recognizes technological, organizational and environmental forces that influence technology adoption decisions and results, the Resource-Based View (Barney, 1991) that reorganizes the outcome construct of competitive advantage as strategically efficient in cases where it is scarce, inimitable Combined, these frames produce intuitive forecasts: those organizations successfully using and implementing further technologies, and systematically innovating their practices, develop unique and hard-to-replicate capabilities, which turn into high-level competitive positioning.

It is one of the first studies to investigate technology adoption, as well as process innovation, concurrently, as predictors of competitive advantage in a digitally active organizational environment of Pakistan, through structural equation modeling. The previous Pakistani studies have mostly analyzed these two mechanisms of innovation as independent of each other; thus no one has looked at the possible complementary nature of these two innovations. SEM can provide estimates both of pure effects and also estimate the additional shared predictive value of two correlated predictors thus giving a more realistic and comprehensive explanation of how technology adoption and process innovation as a combination identify the population mean difference between two independent regression estimates than would otherwise be allowed by separate regression estimates. The results give Pakistani organizational managers evidence-based investment approach in digital transformation and process innovation program development.

The sample of organizations taking active use of digital technologies is a significant design decision which influences the contribution of theoretical meaning in the study. Through targeting digitally active organizations, the study aims at the different levels of good, deep and integration of technology among the population best suited with analyzing technology-competitiveness associations. In companies that do not have high levels of technology adoption, then the interaction between adoption and advantage can be confounded by simple effects of basic infrastructure that are not connected to strategic adoption capabilities of interest. By targeting the digitally active organizations, the study will be able to test how the difference in technology adoption sophistication and process innovation intensity is a driver of competitive advantage disparity in the relatively similar digital organizational environment.

LITERATURE REVIEW

The research and literature on the topic of technology adoption and competitive advantage has rich multidisciplinary roots and can be traced to fields of economics, strategic management, information systems and operations management. Brynjolfsson and Hutt (2000) were the pioneers in presenting implied evidence that information technology investment elicited firm-level productive and performance returns, but only under firm-level complemental organizational responses such as process redesign, skill upgrades, and reorganization. This insight of complementarity which holds that technology adoption creates competitive advantage by its interaction with organizational processes but not by technology has

been widely replicated and extended thereafter forming the theoretic foundation to simultaneously study technology adoption and process innovation as con-com competitive outcome predictors.

Technology acceptance model (Davis, 1989) has established that perceived usefulness, and perceived ease of use are the major determinants of technology adoption at the individual level, but scholars soon realized the necessity of organization level theories that would explain the strategic, structural and environmental factors to influence technology adoption decisions and outcomes. The Technology-Organization-Environment framework created by Tornatzky and Fleischer (1990) availed them with this account of the organization, whereby the authors cited techno-readiness, organizational ability, and environmental pressure as the three significant contextual dimensions in terms of organizational technology adoption. Qureshi and Kratzer (2011) in Pakistani contexts established that all three dimensions of TOE were very important predictors of the intensity of technology adoption among Pakistani small and medium enterprises, and the constraint of organizational capability turned out to be very much binding in the situations where they could not adopt advanced technologies.

Porter and Heppelmann (2014) revised the framework of a competitive strategy proposed by Porter (1985) in relation to the era of smart and connected products and said that digital technologies generate a competitive advantage in three ways because they expand what products and services will do, deepen customer relationships that create switching costs, and enable real-time operational monitoring that drives efficiency and quality. Their discussion indicated that a competitive advantage in the digital era is becoming less about technology adoption as such than the organization with the capacity to enable technology into consistent product and service platforms is creating distinctive customer value. This perspective of systems integration aligns with the position that technology adoption and process innovation are complimentary: to sound technology adoption, process innovation is also needed to redesign workflow, roles, information flows, around new technological possibilities.

Studies on process innovation have reported that it has an impact of positive changes on several aspects of competitive advantage. Utterback and Abernathy (1975) developed the initial product-process innovation lifecycle by showing that with the maturity of an industry, the competitive advantage starts to shift away to a form of process innovation that leads to cost reduction and quality improvement as opposed to the product innovation which causes the initial competitive differentiation. Damanpour and Evan (1984) illustrated that adoption of process innovation was positively correlated with organizational performance whether in manufacturing or service settings and that the effect of adoption of administrative process innovation (reorganization, new practices in management) was equivalent to those of technological process innovations. Reichstein and Salter (2006) based on empirical research had a large sample of UK manufacturing indicating that process innovation was a significant predictor of both the cost competitiveness and customer satisfaction levels of competitive advantage.

Galloouj and Weinstein (1997) in service sector context contended that service innovation is essentially process-based, since service defining characteristics lie in the production and delivery processes, and not the product features of services. This means that process innovation in such economies that are service intensive must be especially strongly linked to competitive advantage. In line with this forecast, Menor and Roth (2007) discovered that service process innovation was by far the best predictor of competitive advantage across service firms in the US, outperforming product and market innovation. Tariq et al. (2017) conducted research in the Pakistani service firms, where process innovation was positively associated with customer satisfaction, operations efficiency, and market positioning, which are three dimensions of competitive advantage.

The literature on diffusion of innovations (Rogers, 2003) has helped in providing insights to the issues related to the organization in terms of effective adoption of technology. Relative advantage, compatibility with existing systems and values, complexity, trialability and observability were the main characteristics

of adoption that Rogers called relative advantage identified as the most important features in the aspect of adoption rate and completeness. These characteristics in fulfilling organizational contexts lead to predictors of the eventual occurrence of deep and useful (high relative advantage, high compatibility, low complexity) or shallow and uncomplete (unclear advantage, low compatibility, high complexity) technology adoption among organizations. Not only the presence of technology, but its successful implementation is the applicable predictor of competitive advantage, which implies that competitive returns depend more on organizations developing competitive advantage by strategically implementing technologies and high fidelity in executing them as compared to superficially implementing the same technologies.

Research on competitive advantage has made a distinction between various ways of how innovation can establish advantageous positioning. According to Barney (1991), there are four criteria of resource-based competitive advantage which include: value (the resource allows the company to create a value), rarity (the resource is not held by the competitors), inimitability (the resource is expensive to other competitors to imitate), and organizational support (the resource is organized in a way that is most appropriate to be exploited). When applied to the technology adoption and process innovation, this framework predicts that the opportunities to gain a competitive advantage are low when common technologies that are equally available to all competitors (commodity technologies) are used, whereas technologies that are embedded in unique organizational processes and capabilities have advantages that are costly to competitors to imitate.

Technology adoption and process innovation studies have extensively used the dynamic capabilities perspective (Teece et al., 1997). Pavlou and El Sawy (2011) provided evidence that high dynamic IT capabilities, that is the organizational capacity to sense IT opportunity, mobilize IT resources, and reconfigure IT-enable processes mediated the relationship between IT adoption and competitive advantage where high dynamic capability organizations enjoyed much higher returns on competitive advantage with equivalent technology investments. Waheed and Jam (2010) discovered in the Pakistani setting that organizational learning capacity mediated the technology adoption-performance relationship with more competitively advantaged gains accrued by those organisations that learnt effectively with the use of technology.

Some of the industry-specific studies have investigated the combined effects of process innovation and technology adoption. Pavitt (1984) put in place the factual patterns associated with technology-process innovation in various industries where the suppliers dominated by the sector mainly depend on technology adoption externally made and production intensive sector where competitive advantage has to be built on proprietary technology innovation development. More recent studies conducted by Battisti and Stoneman (2010) discovered a strong complementing relationship between technology adoption and process innovation in UK manufacturing, where firms that were rated high on both dimensions exhibited much greater competitive advantages than those rated high on the single dimension - this supports the fact that the joint modeling approach was taken in the current study.

Collectively, the literature creates a theoretically and empirically solid framework of predicting positive direct influences of both process innovation and technology adoption on competitive advantage where a set of complementary relationships might exist between the two phenomena. The current research contributed to this framework by being the first rigorous SEM-based test, in the digitally active organizational context of Pakistan, of these combined effects that gave methodologically accurate estimates of the effects in terms of their magnitude, which can be used in organizational investment decisions and to add to the existing comparative literature on technology-strategy-performance relationships.

METHODOLOGY

In this research, a survey-based research design was utilized. The study sample included the employees of Pakistani companies that actively implement digital technologies in their primary processes, management, or customer relationship activities. Purposive sampling was utilized to make sure that respondents had first hand experience on the technology systems and process innovation activity in their organizations, thereby maximizing the construct validity of the perceptual measures applied. Respondents were IT managers, operations managers, process engineers, and senior employees in digitally active manufacturing organizations, financial services and telecommunications organizations as well as retail organizations. The survey was distributed via LinkedIn professional networks, personal organizational connection and online professional communities. The number of questionnaires mailed was 320, of which 308 were returned and 300 were included after eliminating those which were not sent back.

The instrument used in the research consisted of three scales that were validated. The scale to measure the use of technology was a 14-item scale based on the work of Tornatzky and Fleischer (1990) and modified by Qureshi and Kratzer (2011) to suit the digital technology usage situation to measure the breadth, depth and effectiveness of integration and strategic alignment of technology use. Process innovation was gauged (measured by a 10 item scale based on Damanpour and Evan 1984 and Reichstein and Salter 2006) and encompassed operational process redesign, administrative process innovation and technology based process transformation. The scale based on competitive advantage was 12-item scale derived according to Barney (1991) and Porter (1985), which included cost advantage dimension, differentiation advantage dimension, and market responsiveness dimension. Everything used 5-point Likert (1 = Strong Disagree to 5 = Strong Agree).

Expert review by four management information systems and strategy scholars and two practitioners of the industry proved face and content validity. Pilot-testing among 20 population-target respondents assured the clarity of the items used in the scale and its comprehensibility. The reliability was determined based on the Cronbach alpha. AMOS 24 assessed construct validity using CFA in which factor loadings, AVE, CR and HTMT ratios in discriminant validity were analyzed. The structural model was able to test two hypotheses: H1, which stated that technology adoption has a significant positive predictive of competitive advantage; and H2, which stated that process innovation has a significant positive predictive of competitive advantage. Model fit was assessed using chi-square/df < 3, CFI > .90, TLI > .90, RMSEA < .08, and SRMR < .08.

RESULTS

The respondent sample of 300 individuals was representative of the purposive sampling strategy concentrating on digitally active employees in organizations. Demographic profile is shown in Table 6. It was mainly male (60.7%), and it was biased towards managerial and technical positions (67.0%). Organizations were spread as IT/technology (29.3%), financial services (23.7%), manufacturing (25.3%), and other services (21.7%) organizations.

Table 1: Demographic Profile of Respondents (N = 300)

Variable	Category	n	%
Gender	Male	182	60.7
	Female	118	39.3
Role Type	Manager/Specialist	201	67.0
	Non-managerial	99	33.0
Industry	IT/Technology	88	29.3

	Financial Services	71	23.7
	Manufacturing	76	25.3
	Other Services	65	21.7
Experience	Less than 3 years	72	24.0
	3-7 years	118	39.3
	More than 7 years	110	36.7

Note. N = 300.

Table 2 gives descriptive statistics and coefficients of reliability. All alpha values were over 87. The mean of technology adoption (M = 3.67) was moderately high, as the sample chose digitally-active organizations. The mean of process innovation was 3.49, the mean of competitive advantage was 3.55 which shows moderately positive ratings of all three constructs.

Table 2: Descriptive Statistics and Reliability Coefficients

Variable	M	SD	alpha	Min	Max
Technology Adoption	3.67	0.71	.91	1.43	5.00
Adoption Breadth	3.72	0.74	.87	1.00	5.00
Adoption Depth/Integration	3.61	0.76	.86	1.00	5.00
Strategic Alignment	3.69	0.72	.85	1.00	5.00
Process Innovation	3.49	0.74	.89	1.20	5.00
Operational Process Innovation	3.53	0.77	.86	1.00	5.00
Administrative Process Innovation	3.44	0.79	.84	1.00	5.00
Competitive Advantage	3.55	0.68	.93	1.33	5.00
Cost Advantage	3.49	0.72	.87	1.00	5.00
Differentiation Advantage	3.61	0.70	.86	1.00	5.00
Market Responsiveness	3.57	0.71	.85	1.00	5.00

Note. M = mean; SD = standard deviation; alpha = Cronbach's alpha. N = 300.

CFA confirmed acceptable measurement model fit (chi-square/df = 2.14, CFI = .95, TLI = .94, RMSEA = .062, SRMR = .056). All the loading factors were impactful ($p < .001$), with the ranges of.61 to.89. Table 3 corroborates convergent validity on all constructs.

Table 3: CFA Measurement Model Results

Construct	Items	Loading Range	AVE	CR	alpha
Technology Adoption	14	.63-.87	.56	.92	.91
Process Innovation	10	.61-.85	.53	.89	.89
Competitive Advantage	12	.64-.89	.59	.93	.93

Note. AVE = average variance extracted; CR = composite reliability. Model fit: chi-square/df = 2.14, CFI = .95, TLI = .94, RMSEA = .062, SRMR = .056.

The intercorrelation matrix is shown in Table 4. Competitive advantage ($r = .59$, $p < .01$) and process innovation (r =.61, p <.01) were strongly correlated with technology adoption whereas process innovation was strongly positively correlated with competitive advantage (r =.57, p under.01). The complementarity

of technology adoption and process innovation was confirmed by the high intercorrelation of this construct and others.

Table 4: Intercorrelation Matrix

Variable	1	2	3
1. Technology Adoption	--		
2. Process Innovation	.61**	--	
3. Competitive Advantage	.59**	.57**	--

Note. ** p < .01 (two-tailed). N = 300.

The structural model achieved good fit (chi-square/df = 2.27, CFI = .94, TLI = .93, RMSEA = .065, SRMR = .060). Table 10 shows path coefficients of structure. The adoption of technology had a significant positive impact in relation to the competitive advantage (H1, beta =.49, p =.001) as it was significantly higher. The process innovation clearly also showed a significant positive impact (beta =.46, p < .001) which confirms H2. A combination of the predictors accounted 61.4% of the variance in competitive advantage (R-squared =.614).

Table 5: Structural Model Path Coefficients

Hypothesis	Path	beta	SE	t-value	p	Decision
H1	Technology Adoption -> Competitive Advantage	.49	.07	7.00	< .001	Supported
H2	Process Innovation -> Competitive Advantage	.46	.06	7.67	< .001	Supported

Note. beta = standardized path coefficient; SE = standard error. R-squared (Competitive Advantage) = .614. Model fit: chi-square/df = 2.27, CFI = .94, TLI = .93, RMSEA = .065, SRMR = .060.

DISCUSSION

The findings give a strong reinforcement to both hypotheses defining that technology adoption and process innovation are both relevant and equally strong positive predictors of competitive advantage amongst Pakistan organizations that are digitally active. The almost similar impact of technology adoption (.49) and process innovation (.46) can be attributed to the complementary idea introduced by Brynjolfsson and Hutt (2000) which states that neither technology nor process redesign can be involved to obtain a competitive edge but the combination of effective technology adoption and systematic process innovation will bring the largest competitive results. This can also be interpreted by the fact that there is a high intercorrelation between technology adoption and process innovation (r =.61), meaning that high intercorrelation between technological and process capabilities are created where organizations that excel in one aspect are excelling in the other.

The fact that the model explains a high level of variance (R-squared = .614) indicates that the two dimensions of innovation together explain most of the variation in competitive advantage among digitally active Pakistani organizations, which is a confirmation of the theoretical framework. The fact that process innovation is as powerful a predictor as technology adoption contradicts the widely held managerial belief that the digital era competitive advantage is largely a matter of the technology investment. The statistics indicate that the manner in which organizations reevaluate their processes to utilize new technologies is

not only as significant as the investments in technologies, but also in line with the argument of Porter and Heppelmann (2014), that smart, connected product and service systems generate competitive advantage through integration and not through the adoption of technologies.

CONCLUSIONS AND RECOMMENDATIONS

This paper has determined that both technology adoption and process innovation are important positive predictors of competitive advantage in Pakistan digitally active organisations and that the magnitude of their effects is generally similar to highlight their complements. The result of this finding, as applied to the organizational leaders, should always rely on a planned process innovation program that transforms workflow, job description and information streams to take advantage of the new technological opportunities. Companies that embrace technologies without redesigning their processes to capitalize on them will still be performing poorly in comparison with their competitors who combine the use of technology with systematic process re-invention.

The digital transformation programs in Pakistani organizations must thus be planned as parallel technology-process programs, not consecutive ones. IT leaders and Chief Digital Officer must make sure technology adoption road maps are created concurrently with business process reengineering efforts by operations and strategy functions. To policymakers, the result that process innovation is equally crucial to technology adoption as a competitive edge implies that digital competitiveness programs must incorporate process innovation capacity building, such as lean manufacturing, total quality management, agile methodologies, and technology access and adoption assistance. Future studies need to address the mediating role of technology adoption and process innovation in generating competitive advantage, whether some types of technologies (AI, cloud, IoT) have a greater impact on competitive advantage, and whether the relationships are moderated by organizational size..

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