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AMBIGUOUS EFFECT OF ENVIRONMENTAL TURBULENCE ON INNOVATION AND PERFORMANCE: ANALYZING TECHNOLOGY SECTORS

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A B S T R A C T

Environmental Turbulence (ET) refers to the uncertainty caused by unforeseen changes in a firm's external environment. Process Quality Management (PQM) is a sub-dimension of Total Quality Management (TQM). However, the literature has not examined the effects of ET on TQM and PQM applications. For firms that want to survive in a dynamic market structure, it is crucial to understand how sub-factors of ET (Market Turbulence (MT), Technological Turbulence (TT), and Competition Intensity (CI)) affect existing relations. We examined whether ET has a moderating or mediating effect on innovation, performance, and PQM. As a result of the study, we discovered that PQM has essential effects on reducing market turbulence and competition intensity.

1. INTRODUCTION

Technological developments that accelerated with the increase of globalization have made the market more dynamic, turbulent, and uncertain. Product preferences, customer expectations, production technologies, and competitive elements are subject to rapid change in uncertain markets (Wang et al., 2015). Traditional methods are not enough to have customers' loyalty and gain a sustainable competitive advantage. Firms should analyze the dynamics of the industry and develop effective strategies to keep up with the dynamic and changing conditions of the industry (Sahoo and Yadav, 2017; Yusr et al., 2017). Thereby, the ability to respond to global changes has become a critical success factor today. Innovation might be the key factor for companies to survive in today's world (Chen et al., 2010). Innovation is also critical for firms to increase their profitability and grow (Kyrgidou and Spyropoulou, 2012; Tajeddini, 2011). Therefore, firms need innovation more than ever to gain a competitive advantage and maintain market success.

Schumpeter first used the concept of innovation. Schumpeter (1934)described innovation as the commercial or industrial application of new things and the management of a new product, process, or production. According to OECD and Eurostat (2005), innovation is an improved product or process, a new marketing method, or a new organizational method. Accordingly, innovative firms focus on taking risks and developing new and unusual ideas. Therefore,

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innovation plays an essential role in responding to changes in global markets.

How the innovation is implemented within the firm is as important as the innovation itself. Total Quality Management (TQM), which focuses on the entire firm, is a dynamic management philosophy aimed at customer satisfaction and continuous improvement. In this way, firms have open communication channels, information is created, and every piece of information is shared with stakeholders. Thereby, firms prepare more valuable and innovative products/services and processes for their customers.Therefore, TQM is defined in the literature as a method that meets customer expectations and provides long-term success (Albuhisi and Abdallah, 2018). TQM is critical for gaining a competitive advantage (Hung et al., 2011; Wiele et al., 2006). TQM also provides increment in innovation and firm performance. (Lagrosen and Lagrosen, 2005; Feng et al., 2006; Hoang et al., 2006; Perdomo-Ortiz et al., 2006; Abrunhosa et al., 2008; Prajogo and Hong, 2008; Kim et al., 2012). Therefore, TQM might be defined as a prerequisite for innovation and should be preferred primarily by firms that expect innovative success in today's global market.

Since the global market is dominated by high uncertainty, innovation is not enough in today's dynamic business world. Firms cannot predict technological developments, customer changes, and competitive strategies unless recognize the uncertain environment. Therefore, it is essential to understand the factors that cause uncertainty. In this way, firms can predict which strategic steps they should take in uncertain markets. Since firms cannot control their external environment, ET is the most critical feature of the modern business world. ET is unpredictable and causes uncertainty in firms' external environment (Sull, 2009; Staniec, 2018; Wong, 2014; Tsai and Yang, 2014; Hancanich et al., 2006).

Previous studies addressed two critical gaps in the field of TQM and uncertainty. First, environmental turbulence's (ET) sub-dimensions were not included in the studies on TQM and PQM. ET has been studied with three sub-dimensions in the literature (Kohli and Jaworski, 1990; Ottesen and Gronhaug, 2004). Market Turbulence (MT) refers to the change in customers' preferences (Kohli and Jaworski, 1990). Technological Turbulence (TT) shows the rate of advancement of technologies in the industry (Jaworski and Kohli, 1993). Competition Intensity (CI) refers to the degree of competition in the market and the predictability of competition (Jaworski and Kohli, 1993; Chan et al., 2012; Tsai and Yang, 2013).

A recent study determined that ET factors affect each other (Ojha et al., 2021). According to this study, each ET factor has a positive relationship with itself. This finding shows that turbulence experienced within the sector will also affect other types of turbulence. As a result, a turbulence factor that the firm will be exposed to indicates that the firm will face intense turbulence in the medium-long term. Therefore, examining how existing relationships will be affected by ET factors is crucial. Secondly, data from developed countries were used in TQM and PQM studies. Whereas firms in developing countries are more exposed to uncertainty and the market is more dynamic in these countries. The ambiguous effects of ET and its sub-dimensions on the PQM, innovation, and performance are analyzed in the developing country. Turkey's medium-high and advanced technology firms form the main population of this study. Data are obtained from the Turkish Ministry of Industry and Technology.

This study consists of five parts and is organized as follows. The second part provides information about the theoretical background. The next part of the studypresents the methodology, hypotheses, and research design. Then, the research model isanalyzed with a sample of 560 firms, and the findings arepresented in the fourth part. Finally, the study resultsare discussed in light of the findings.

2. THEORETICAL BACKGROUND AND HYPOTHESIS DEVELOPMENT

Firms should develop products and services that meet customer expectations to gain a competitive advantage in a highly uncertain environment. One of the most critical conditions for firms to maintain their existence in the market is to adapt to changing conditions and market dynamics. Therefore, developing strategies that enable long-term sustainable competitive advantage has long been a priority for firms (Prajogo et al., 2018; Amrani et al., 2020). In addition, globalization makes the market uncertain and causes a more dynamic business world. Dynamic environments provide fertile grounds for developing innovation and affect innovation capacity (Gunday et al., 2011; Zhang et al., 2013). Firms with increased innovation capacity will offer personalized products/services that align with customer expectations and requests.

Firms operating in such global markets should integrate the innovative perspective into their products and internal processes (Psomas et al., 2018; Pinho, 2008; Evangelista and Vezzani, 2010; Crowley, 2017). Process innovation is complementary to product innovation (Psomas et al., 2018). Firms that focus on process innovation rather than product innovation produce innovative products more aligned with customer expectations (Ooi et al., 2012; Bhasin and Parrey, 2013). Empirical studies have found that firms that adopt both product and process innovation gain a more decisive sustainable competitive advantage (Hung et al., 2010; Ooi et al., 2012; Ruiz-Moreno et al., 2014). Hence, firms considering such competition dimensions as quality, price, personalized product/service delivery, and flexibility should integrate innovation into all their processes to ensure a reliable customer base. The easiest way to do this is to implement TQM practices actively and efficiently within the firm (Pearson, 2015; Antunes et al., 2017).

TQM is a management philosophy that allows firms to offer products/services in line with customer requests, expectations, and values (Antunes et al., 2017). TQM adopts the basic philosophy of continuous improvement, increased customer value, and eliminating processes that do not add value. In this respect, TQM allows firms to increase their performance and productivity, reduce costs and improve product quality (Zeng et al., 2015; Sadıkoglu and Zehir, 2010; Konency and Thun, 2011; Sıla, 2007; Silva et al., 2014). On the other hand, TQM practices improve the firm's operational and financial performance and help them achieve sustainable competitive advantage (Lagrosen and Lagrosen, 2005; Kaynak, 2003; Kim et al., 2012).

The literature has proven that TQM practices have positive effects on firm performance and innovation (Flynn et al., 1995; Choi and Eboch, 1998; Das et al., 2000; Ahire and Dreyfus, 2000; Cua et al., 2001; Ho et al., 2001; Shah and Ward, 2003; Hoang et al., 2006; Martinez -Costa and Martinez-Lorente, 2008; Lopez-Mielgo et al., 2009; Sarkees and Hulland, 2009; Sadıkoglu and Zehir, 2010; Kim et al., 2012; Schniederjans and Schniederjans, 2015; Antunes et al., 2017; Kanapathy et al., 2017). These empirical studies, which analyze the effects of TQM on firm performance and innovation, basically indicate that firms will gain expertise in R&D and expand their customer portfolio. Due to the positive effects of TQM on firm performance and innovation, researchers defined TQM as a strategic management instrument that provides a competitive advantage (Hung et al., 2011; Wiele et al., 2006).

TQM philosophy is a broad, deep, and versatile management philosophy encompassing seven components covering all aspects of firm operations. Therefore, many researchers consider TQM practices in depth and handle these components separately to analyze the impact of TQM practices on the firm. These seven TQM dimensions are divided into Soft TQM and Hard TQM (Zeng et al., 2015; Abdallah, 2013; Vecchi and Brennan, 2011; Jimenez-Jimenez and Martinez-Costa, 2009). Soft-TQM dimensions generally refer to management, relationships, and leadership in the literature. On the other hand, Hard-TQM dimensions encompass such issues as working systems, work processes, and control techniques used in quality management (Albuhisi and Abdallah, 2018).

As a Hard-TQM dimension, Process Quality Management (PQM) examines all processes, from the entry of the raw material to the delivery of the product/service to the final consumer. After examining all processes within the firm, all those processes that prolong the processing time and cause faulty products are identified and removed (Sezer, 2011: 72). When a firm focuses on PQM implementation, its innovation capability, ability to offer innovative products to customers and employee knowledge might improve (Ooi et al., 2012; Bhasin and Parrey, 2013; Moreno-Luzon et al., 2013; Hung et al., 2010; Ruiz-Moreno et al., 2014; Hoang et al., 2006; Kim et al., 2012; Sadıkoglu and Zehir, 2010; Schniederjans and Schniederjans, 2015; Zeng et al., 2015). In addition, PQM implementation significantly contributes to product/service performance, productivity/flexibility, and product quality standardization (Oh and Kuchinke, 2017; Prajogo et al., 2018; Silombela et al., 2018). Therefore, with PQM implementation, innovation is enabled in products and in all relevant processes, which helps firms gain a sustainable competitive advantage (Hung et al., 2010; Ooi et al., 2012; Ruiz-Moreno et al., 2014). However, there are still controversial findings regarding the relationship between PQM's performance and firm innovativeness. While some studies have found that PQM has positive effects on firm performance (Al-Dhaafri et al., 2016; Bouranta and Psomas, 2017; Shafiq et al., 2019), others have evidenced that PQM does not affect performance (Valmohammadi and Roshanzamir, 2015; Modgil and Sharma, 2016; Tortorella et al., 2020). Since the existing studies have not yet reached a consensus, there is still a need for a more in-depth analysis of the effects of PQM on both firm performance and innovation. Therefore, within the scope of this study, we primarily assume a positive relationship between PQM practices, firm innovation, and firm performance.

H_1:*There is a relationship between PQM and Firm Innovation.*

H_2:*There is a relationship between PQM and Firm Performance.*

Increasing globalization, changes in customer demands, increasing competition speed, and technological advances make it difficult to gain a sustainable competitive advantage for firms (Bhat et al., 2010). Firms must be open to innovations, adapt, and offer innovative products and services to survive and gain competitiveness (Chen et al., 2010). Accordingly, the most critical issue is to respond quickly to changes (Turulja and Bajgoric, 2019). Innovation allows quick response tochanges (Zaefarian et al., 2017; Chen et al., 2009). Considering the competitive features (Vagnoni and Khoddami, 2016) that PQM brings to the firm's internal structure, we assume that there is a relationship between firm innovativeness and firm performance.

H_3:*There is a relationship between Firm Innovation and Firm Performance*.

All kinds of uncertainties surrounding firms are called environmental turbulence (ET). ET, for which the literature does not offer a commonly acknowledged definition, is generally referred to as uncertainty caused by unpredictable changes in firms' external environment (Staniec, 2018; Wong, 2014; Tsai and Yang, 2014; Hancanich et al., 2006). ET is divided into three sub-dimensions in the literature: (i) market turbulence (MT), (ii) technological turbulence (TT), and (iii) competitive intensity (CI) (Kohli and Jaworski, 1990; Ottesen and Gronhaug, 2004). Terawatanavong et al. (2011) and Jaworski and Kohli (1993) define MT and TT as the essential type of uncertainty in their study. Tsai and Yang (2013) define MT and CI as the most critical types of turbulence experienced by firms. In this sense, turbulence typesmight associate with the structure,

sector, size, and competitiveness of firms and should be mutually evaluated.

Considering the turbulence factors might provide to make the right strategic decisions under the uncertainty pressures. In addition, firms in dynamic markets should constantly examine market dynamics and prepare strategic plans for possible changes. Previous studies indicate that as the ET increases, the pressures on the firms also increase, while this pressure negatively affects firm performance (Boyne and Meier, 2009; Pratono and Mahmood, 2015; Jaakkola, 2015; Chong et al., 2016; Cadogan et al., 2003; Rahim and Zainuddim, 2016; Tsai and Yang, 2014).

Firms operating in highly uncertain markets focus on innovation to decrease this negative pressure effect and increase their market shares. It is also known that firms achieve higher performance through innovative progress in a dynamic environment (Turulja and Bajgoric, 2019). However, MT, TT, and CI, which are the three sub-dimensions of ET, have different effects on firm performance and innovation. For example, MT positively affects innovation speed, while CI affects it negatively. TT does not affect the innovation rate (Ojha et al., 2021).Similarly, while MT and TT positively affect innovation, CI has no effect (bj and Carter, 2019). Accordingly, ET has an ambiguous effect on firms regarding innovation and performance. Therefore, our hypotheses are:

H_4:*ET, together with all its sub-dimensions, has a moderator effect on the relationship between PQM and Firm Innovation.*

$H_{5\text{-}6\text{-}7}$:*Market Turbulence (***H_5***),* T*echnological Turbulence (***H_6***), and Competition Intensity (***H_7***) have a moderator effect on the relationship between PQM and Firm Innovation.*

H_8:*ET, together with all its sub-dimensions, has a moderator effect on the relationship between Firm Innovation and Firm Performance.*

$H_{9\text{-}10\text{-}11}$:*Market Turbulence (***$H_9$***),* T*echnological Turbulence (***H_{10}***), and Competition Intensity (***H_{11}***) have a moderator effect on the relationship between Firm Innovation and Firm Performance.*

H_{12}: *ET, together with all its sub-dimensions, has a mediator effect on the relationship between PQM and Firm Innovation.*

$H_{13\text{-}14\text{-}15}$: *Market Turbulence (***H_{13}***),* T*echnological Turbulence (***H_{14}***), and Competition Intensity (***H_{15}***) have a mediator effect on the relationship between PQM and Firm Innovation.*

H_{16}: *ET, together with all its sub-dimensions, has a mediator effect on the relationship between Firm Innovation and Firm Performance.*

$H_{17\text{-}18\text{-}19}$: *Market Turbulence (***H_{17}***),* T*echnological Turbulence (***H_{18}***), and Competition Intensity (***H_{19}***) have a mediator effect on the relationship between Firm Innovation and Firm Performance.*

3. METHODOLOGY

3.1 Data Collection and Sampling

Within the scope of the study, firms operating in the medium-high and high technology sectors in Turkey (as outlined in the OECD ISIC Rev.03 (OECD, 2011)technology classification) have been determined as the main population. Data were obtained fromthe Turkish Ministry of Industry and Technology. Ministry created the database (LONCA), which contains information aboutthetechnology-oriented firms in Turkey (www.lonca.gov.tr). This study used the survey method as a data collection method. Data were collected from the top managers of the firms included in the sample. Questionnaires were sent via e-mail to the firms.Seven hundred forty-eight responses participated in the survey. Since the incomplete and inconsistent responses, analyses were carried out with a 560 data set.

In the study, how PQM affects firm innovation and firm performance under ET conditions has been examined. Pracher and Hayes (2004; 2008) suggested using bootstrapping methods to avoid the disadvantages of traditional approaches (Baron and Kenny, 1986; Sobel, 1982) and obtain more reliable results in mediator analysis. In addition, the study examines how mediating variables affect low, medium, and high-intensity relationships. Process macro software is an application that can be used by building on IBM SPSS and SAS programs and tests many different situational mediation effects models with path analysis based on linear regression over observed variables. Therefore, the SPSS Process macro was used for the mediator and moderator analyses (See: Hayes, 2018). The study was carried out in two stages. Firstly, the moderator effect of ET on relations was analyzed. Secondly, the mediating effect of ET on the relations was examined.

3.2 Scales

Multiple choice scales adapted from previous studies were used to test the developed hypotheses. Each variable was measured using a 1-5 type Likert scale, ranging from (1) "Strongly Disagree" to (5) "Strongly Agree". Questionnaires were translated from English, the original version, into Turkish by reversing (Brislin, 1980). In addition, the adaptation, necessity, openness, and specificity of all scales were evaluated by taking expert opinions. The theoretical model of the study is presented in Figure 1. The research questions, source, and factor loads are presented in Table 1.

Table 1: Scales and Factor Loads

VARIABLES		SOURCE	FL.
PROCESS QUALITY MANAGEMENT			
PQM1	Causes of scrap and rework are identified	Sahoo and Yadav (2017)	0,68
PQM2	At our firm, corrective action is taken immediately when a quality problem is identified		0,83
PQM3	At our firm, key processes are systematically improved to achieve better product quality and performance		0,88
PQM4	At our firm, manufacturing processes are controlled using defect prevention tools (such as statistical quality control)		0,79
PQM5	At our firm, improvement in the quality of products and processes is regularly monitored using informative charts and statistical process control		0,72
PQM6	Materials are purchased from suppliers whose quality has been formally certified		0,85
PQM7	Key suppliers have a quality assurance plan or manuals with written procedures		0,70
FIRM INNOVATİON			
FI1	Innovation, based on research results, is readily accepted in our company.	Tsai and Yang (2014)	0,93
FI2	In our company, management actively seeks innovative ideas.		0,98
FI3	In our company, innovation is readily accepted in management.		0,97
FI4	Our company encourages and supports innovative activities.		0,98
FI5	New ideas are quickly accepted in our company.		0,95
FIRM PERFORMANCE			
FP1	The new service exceeded market share objectives	Carbonell and Escudero (2015)	0,81
FP2	The new service exceeded sales growth objectives		0,85
FP3	The new service exceeded sales objectives		0,87
FP4	The new service exceeded the return of investment objectives		0,76
FP5	Rapid increase in revenue	Qian et al. (2016)	0,81
FP6	Rapid increase in sales volume		0,86
FP7	Rapid increase in market share		0,80
FP8	Rapid increase in profits		0,78
FP9	Relative to our principal competitors, our firm's performance over the past three years on sales growth rate:	Tsai and Yang (2013)	0,73
FP10	Relative to our principal competitors, our firm's performance over the past three years on return on assets		0,72
FP11	Relative to our principal competitors, our firm's performance over the past three years on market share growth		0,72
FP12	Relative to our principal competitors, our firm's performance over the past three years on overall performance		0,75
ENVIRONMENTAL TURBULENCE (ET)			
ET_MT1	In our kind of business, customers' product preferences change quite a bit over time.	Jaworski and Kohli (1993)	0,64
ET_MT2	Our customers tend to look for new product all the time.		0,62
ET_MT3	Sometimes our customers are very price-sensitive, but on other occasions, price is relatively unimportant.		0,66
ET_MT4	We are witnessing demand for our products and services from customers who never bought them before.		0,82
ET_MT5	New customers tend to have product-related needs that are different from those of our existing customers.		0,64
ET_MT6	We cater to many of the same customers that we used to in the past.		0,86
ET_TT1	The technology in our industry is changing rapidly.		0,91
ET_TT2	Technological changes provide big opportunities in our industry.		0,93
ET_TT3	It is very difficult to forecast where the technology in our industry will be in the next 2 to 3 years.		0,53
ET_TT4	A large number of new product ideas have been made possible through technological breakthroughs in our industry.		0,75
ET_TT5	Technological developments in our industry are rather minor.		0,16
ET_CI1	Competition in our industry is cutthroat.		0,84
ET_CI2	There are many "promotion wars" in our industry.		0,69
ET_CI3	Anything that one competitor can offer, others can match readily.		0,64
ET_CI4	Price competition is a hallmark of our industry.		0,64
ET_CI5	One hears of a new competitive move almost every day.		0,62
ET_CI6	Our competitors are relatively weak		0,66

3.3 Analysis

Firstly, the measurement validity and reliability were tested. In line with Kleijnen et al. (2007), reflective scales were used for all variables. A null model without any structural relationship was calculated to evaluate the psychometric properties of measurement tools. Composite Scale Reliability (CR) and Average Variance Extracted (AVE) were used to calculate reliability. The PLS-based CR value for all measurements is above the threshold value of 0.70, and the AVE values exceed the threshold value of 0.50 (see Table 2). In addition, the convergent validity was also tested by calculating the standardized loadings of the measurements on the related concepts. It was found that all measurements showed a standardized loading exceeding 0.50.

Table 2: Correlation, CR, AVE ve Reliability Values

#	Variables	1	2	3	4	5	6
1	*PQM*						
2	*FI*	0,472**					
3	*FP*	0,296**	0,340**				
4	*ET_MT*	0,434**	0,600**	0,234**			
5	*ET_TT*	0,223**	0,371**	0,127*	0,389**		
6	*ET_CI*	0,160**	0,376**	0,201**	0,442**	0,218**	
	CR	0,911	0,986	0,954	0,875	0,747	0,806
	AVE	0,598	0,934	0,633	0,540	0,517	0,510
	α	0,887	0,982	0,947	0,827	0,754	0,763

*p < 0,05, **p < .01

Note$_1$: The Diagonals Represent The Square Root Of The AVE Values

PQM: Process Quality Management, FI: Firm Innovation, FP: Firm Performance,
ET_MT: Market Turbulence, ET_TT: Technological Turbulence, ET_CI: Competition Intensity

The hypothesis tests were measured via the SmartPLS 3.0 software program. The PLS approach (Ringle et al., 2005) and resampling method were used to estimate the primary interaction and indirect effects. Moreover, the PLS approach tests the research model's hypotheses and predictive power. T statistics were calculated for all coefficients according to their stability in the sub-sample to determine the statistically significant relationships. The beta coefficients and their associated t-values show the direction and effect of each assumed relationship.

The findings provide empirical evidence for the direct impact of PQM on firm performance and innovation (see Table 3). H_1 and H_2 are accepted (β:0.227, $p<0.05$; β:0.555 $p<0.01$). Innovativeness positively affects firm performance (β:0.297, $p<0.01$), and H_3 is supported.

Table 3: Hypothesis Test Results

Relationships			Path Coefficient (β)	Hypothesis	Results
PQM	→	FP	0.227**	H_1	Support
PQM	→	FI	0.555***	H_2	Support
FI	→	FP	0.297***	H_3	Support

PQM: Process Quality Management, FP: Firm Performance, FI: Firm Innovation.

3.4 Moderator Analysis

Moderator variables affecting the relationship between PQM-Firm Innovation and Firm Innovation-Firm Performance were analyzed. Analyzes were performed using the SPSS Process macro.

We examined whether ET factors have a moderator effect on the existing relationship between PQM and Firm Innovation. All the findings obtained in this context are presented in Table 4. All ET factors as moderator variables in the first model, market turbulence as a moderator variable in the second model, technological turbulence as a moderator variable in the third model, and competition intensity variables as moderator variables in the fourth model were included in the analysis.

Table 4: Moderator Effect and Analysis Results Between PQM-Firm Innovation

		Coeff.	SE	t	p
Model 1 – *Environmental Turbulence*	Constant	-7,0865	,8803	-8,0497	,0000
	Process Quality Management (X)	2,2700	,2334	9,7269	,0000
	Environmental Turbulence (W)	2,8983	,2604	11,1322	,0000
	PQM X ET (XW)	-,5523	,0662	-8,3384	,0000
	R^2= 0,5536, MSE= 0,5027, F= 109,121, p<0,01				
		Coeff.	**SE**	**t**	**p**
Model 2 – *Market Turbulence*	Constant	-3,5161	,6572	-5,3500	,0000
	Process Quality Management (X)	1,5688	,1837	8,5412	,0000
	Market Turbulence (W)	1,7511	,1759	9,9535	,0000
	PQM X MT (XW)	-,3270	,0463	-7,0710	,0000
	R^2= 0,5081, MSE= 0,5538, F=90,907, p<0,01				
		Coeff.	**SE**	**t**	**p**
Model 3 – *Technological Turbulence*	Constant	-6,9594	1,0266	-6,7135	,0000
	Process Quality Management (X)	2,4230	,2434	9,9531	,0000
	Technological Turbulence (W)	2,7954	,3161	8,8442	,0000
	PQM X TT (XW)	-,5791	,0729	-7,9489	,0000
	R^2= 0,4324, MSE= 0,6391, F= 67,039, p<0,01				
		Coeff.	**SE**	**t**	**p**
Model 4 – *Competitive Intensity*	Constant	-8,5882	1,0125	-8,4819	,0000
	Process Quality Management (X)	2,7804	,2397	11,5988	,0000
	Competitive Intensity (W)	3,3553	,3140	10,6872	,0000
	PQM X CI (XW)	-,6979	,0734	-9,5069	,0000
	R^2= 0,4897, MSE= 0,5746, F= 84,448, p<0,01				

The results indicate that ET (R^2= 0.5536; p<0.01), market turbulence (R^2= 0.5081; p<0.01), technological turbulence (R^2= 0.4324; p<0.01), and competitive intensity (R^2= 0.4897; p<0.01) affected the relationship as a moderator variable. In addition, the interaction effect (XW) results of the established models are also significant. According to the findings, ET, market turbulence, technological turbulence, and competitive intensity factors have a moderator effect on PQM-Firm Innovation. The H_4, H_5, H_6, and H_7 hypotheses were accepted depending on the findings.

In addition, how the relationship between PQM-Firm Innovation changes was also examined when the moderator variables occurred at low, medium, and high intensity. The relationship between PQM-Firm Innovation changes is shown when the moderator variable moves one standard deviation to the left (low intensity) and one standard deviation to the right (high intensity). The findings are presented in Table 5.

Table 5: The Change Effect of The Moderator Variable Between PQM-Firm Innovation

	Intensity	W	Effect	SE	t	p	LLCI	ULCI
Environmental Turbulence	Low	3,1765	,5157	,0622	8,2853	,0000	,3931	,6383
	Middle	3,8824	,1259	,0682	1,8449	,0662	-,0085	,2602
	High	4,2941	-,1015	,0844	-1,2027	,2302	-,2678	,0647
Market Turbulence	Low	3,3333	,4787	,0676	7,0798	,0000	,3456	,6119
	Middle	4,2500	,1789	,0699	2,5601	,0110	,0413	,3166
	High	4,6667	,0427	,0788	,5412	,5888	-,1126	,1979
Technological Turbulence	Low	2,8000	,8015	,0717	11,1735	,0000	,6603	,9428
	Middle	4,0000	,1066	,0862	1,2371	,2171	-,0631	,2763
	High	4,6000	-,2408	,1196	-2,0138	,0550	-,4763	,0054
Competitive Intensity	Low	2,6667	,9194	,0707	13,0110	,0000	,7803	1,0585
	Middle	3,5000	,3378	,0657	5,1436	,0000	,2085	,4671
	High	4,1667	-,1274	,0957	-1,3317	,1841	-,3159	,0610

According to Table 5;

- When ET has a low-intensity moderator effect on the relationship between PQM-Firm Innovation, it positively affects the existing relationship (β:0.5157; p<0.01). The relationship becomes insignificant when the ET moderator effect increases.
- When market turbulence occurs at low (β:0.4787; p<0.01) and medium (β:0.1789; p<0.05) intensity on the relationship between PQM-Firm Innovation, the effect of the existing relationship is positive but decreasingly strong. On the other hand, as the intensity of market turbulence increases, the

relationship between PQM-Firm Innovation continues, but the strength of the relationship weakens. When market turbulence occurs intensely, the current relationship becomes insignificant.

- When technological turbulence has a low-intensity moderator effect on the relationship between PQM-Firm Innovation, it positively affects the existing relationship (β:0.8015; p<0.01). According to the findings, the existing relationship became insignificant as the moderator effect of technological turbulence increased on the relationship between PQM-Firm Innovation.
- The effect of the existing relationship is positive but decreasingly strong when the competition intensity occurs at low (β:0.9194; p<0.01) and medium (β:0.3378; p<0.01) intensity on the relationship between PQM-Firm Innovation. According to this result, as the effect of competition intensity increases, the relationship between PQM-Firm Innovation continues, but the strength of the relationship weakens. The existing relationship becomes insignificant when the competition intensity occurs in the high medium.

In the second stage of the analysis, whether ET factors have a moderator effect on the existing relationship between Firm Innovation-Firm Performance was examined. All the findings obtained in this context are presented in Table 6.

Table 6: Moderator Effect and Analysis Results Between Firm Innovation- Firm Performance

Model 1 – *Environmental Turbulence*		**Coeff.**	**SE**	**t**	**p**
	Constant	6,7890	,5620	12,0797	,0000
	Process Quality Management (X)	-,9577	,1466	-6,5335	,0000
	Environmental Turbulence (W)	-1,6299	,2169	-7,5156	,0000
	PQM X ET (XW)	,4276	,0506	8,4522	,0000
	R^2= 0,3066, MSE= 0,4143, F= 38,910, p<0,01				
Model 2 – *Market Turbulence*		**Coeff.**	**SE**	**t**	**p**
	Constant	4,5430	,4028	11,2772	,0000
	Process Quality Management (X)	-,3440	,1114	-3,0894	,0022
	Market Turbulence (W)	-,7943	,1569	-5,0611	,0000
	PQM X MT (XW)	,2117	,0369	5,7304	,0000
	R^2= 0,2148, MSE= 0,4692, F=24,0731 , p<0,01				
Model 3 – *Technological Turbulence*		**Coeff.**	**SE**	**t**	**p**
	Constant	5,2333	,5186	10,0906	,0000
	Process Quality Management (X)	-,3991	,1249	-3,1953	,0000
	Technological Turbulence (W)	-,8965	,1701	-5,2697	,0000
	PQM X TT (XW)	,2133	,0387	5,5133	,0000
	R^2= 0,2070, MSE= 0,4739, F= 22,972, p<0,01				
Model 4 – *Competitive Intensity*		**Coeff.**	**SE**	**t**	**p**
	Constant	6,7499	,5950	11,3443	,0000
	Process Quality Management (X)	-,7702	,1348	-5,7153	,0000
	Competitive Intensity (W)	-1,7547	,2444	-7,1805	,0000
	PQM X CI (XW)	,4121	,0532	7,7473	,0000
	R^2= 0,2846, MSE= 0,4275, F= 35,001, p<0,01				

All ET factors were included in the first model, market turbulence in the second model, technological turbulence in the third model, and competition intensity in the fourth model. As a result of the analyzes carried out, it was determined that ET (R^2:0.3066; p<0.01), market turbulence (R^2:0.2148; p<0.01), technological turbulence (R^2:0.2070; p<0.01), and competitive intensity (R^2:0.2846; p<0.01) affected the relationship as a moderator variable. In addition, the interaction effect (XW) results of the established models are also significant. Considering the results obtained, ET, market turbulence, technological turbulence, and competitive intensity factors have a moderator effect on Firm Innovation-Firm Performance for established models. The H_8, H_9, H_{10}, and H_{11} hypotheses were accepted depending on the findings.

In addition, how the relationship between Firm Innovation-Firm Performance changes if the moderator variables occur at low, medium, and high intensity was also examined. For this analysis, the moderator variable moves one standard deviation to the left (low intensity) and one standard deviation to the right (high intensity). The findings are presented in Table 7.

Table 7: The Change Effect of The Moderator Variable Between Firm Innovation-Firm Performance

	Intensity	W	Effect	SE	t	p	LLCI	ULCI
Environmental Turbulence	Low	3,1765	,4005	,0517	7,7479	,0000	,2987	,5022
	Middle	3,8824	,7023	,0742	9,4666	,0000	,5562	,8483
	High	4,2941	,8783	,0913	9,6219	,0000	,6986	1,0581
Market Turbulence	Low	3,3333	,3617	,549	6,5845	,0000	,2535	,4699
	Middle	4,2500	,5558	,0759	7,3260	,0000	,4064	,7052
	High	4,6667	,6440	,0881	7,3115	,0000	,4706	,8174
Technological Turbulence	Low	2,8000	,1980	,0439	4,5096	,0000	,1116	,2845
	Middle	4,0000	,4540	,0570	7,9614	,0000	,3417	,5662
	High	4,6000	,5819	,0744	7,8263	,0000	,4355	,7283
Competitive Intensity	Low	2,6667	,3287	,0431	7,6315	,0000	,2439	,4136
	Middle	3,5000	,6722	,0708	9,4933	,0000	,5327	,8116
	High	4,1667	,9469	,1018	9,2991	,0000	,7464	1,1474

According to the analysis results presented in Table 7;

- While ET has a moderate (β:0.4005; p<0.01), medium (β:0.7023; p<0.01), and high (β:0.8783; p<0.01) intensity moderator effect on the relationship between Firm Innovation-Firm Performance, the current relationship is positive and increasing strength. Accordingly, as the intensity of ET increases, the relationship between Firm Innovation-Firm Performance grows stronger.
- While market turbulence has a low (β:0.3617; p<0.01), medium (β:0.5558; p<0,01), and high (β:0.6440; p<0,01) intensity moderator effect on the relationship between Firm Innovation-Firm Performance, the current relationship is positive and increasingly strong. Accordingly, as the intensity of market turbulence increases, the relationship between Firm Innovation-Firm Performance strengthens.
- While technological turbulence has a low (β:0.1980; p<0.01), medium (β:0.4540; p<0.01), and high (β:0.5819; p<0.01) intensity moderator effect on the relationship between Firm Innovation-Firm Performance, the current relationship is positive and increasing strength. Thus, as the intensity of technological turbulence increases, the relationship between Firm Innovation-Firm Performance grows stronger.
- While competition intensity has a moderate (β:0.3287; p<0.01), medium (β:0.6722; p<0,01), and high (β:0.9469; p<0.01) intensity moderator effect on the relationship between Firm Innovation-Firm Performance, the current relationship It is positive and increasing strength. According to this result, as the intensity of competition increases, the relationship between Firm Innovation-Firm Performance grows.

3.5 Mediator Analysis

In the second stage of the study, the mediator effects of ET factors between PQM-Firm Innovation and Firm Innovation-Firm Performance were analyzed. Analyzes were performed using the SPSS Process macro.

All ET factors in the first model, market turbulence in the second model, technological turbulence in the third model, and competition intensity variables in the fourth model were included as mediator variables. All the findings obtained in this context are presented in Table 8.

Findings indicate that the model was significant (R^2:0.2224; p<0.01).ET (β:0.8128; p<0.01), market turbulence (β=0.5726; p<0.01), technological turbulence (β:0.3208; p<0.01) ve competitive intensity (β:0.4294; p<0.01) had a partial mediator effect on the relationship between PQM-Firm Innovation.According to the findings, (1) ET, market turbulence, technological turbulence, and competitive intensity partially mediate the relationship between PQM-Firm Innovation. While (2) all other variables except market turbulence have a strong mediator effect. Thus, H_{12},H_{13}, H_{14}, and H_{15} were accepted.

Table 8: PQM-Firm Innovation Mediator Analysis

Panel A: Key Impact			
	Coeff	**R^2**	**F-Value**
PQM	0,6429**	,2224**	76,0805**

Panel B: Mediator Effect				
	Model 1	**Model 2**	**Model 3**	**Model 4**
Process Quality Management	,3903**	,3549**	,5578**	,5758**
Environmental Turbulence	,8128**			
Market Turbulence		,5726**		
Technological Turbulence			,3208**	
Competitive Intensity				,4294**
Observations				
F-Value	102,4302**	93,9835**	55,8585**	60,9305**
R^2	,4360**	,4150**	,2966**	,0255**

*p < 0,05, **p < .01 PQM: Process Quality Management

Whether ET factors have a mediator effect on the existing relationship between Firm Innovation-Firm Performance has also been examined. Findings are presented in Table 9.

Table 9: Firm Innovation-Firm Performance Mediator Analysis

Panel A: Key Impact			
	Coeff	**R^2**	**F-Value**
FI	0,2478**	,1157**	34,8032**

Panel B: Mediator Effect				
	Model 1	**Model 2**	**Model 3**	**Model 4**
Firm Innovation	,2162**	,2271**	,2474**	,2245**
Environmental Turbulence	,0853**			
Market Turbulence		,0405**		
Technological Turbulence			,0011**	
Competitive Intensity				,0863**
Observations				
F-Value	17.8910**	17,5790**	17,3364**	18,3954**
R^2	,1190**	,1171**	,1157**	,1219**

*p < 0,05, **p < .01 FI: Firm Innovation

Findings indicate that the model was significant (R^2:0.2478; p<0.01). According to the findings, ET (β:0.0853; p<0.01), market turbulence (β:0.0405; p<0.01), technological turbulence (β:0.0011; p<0.01), and competitive intensity (β:0.0863; p<0.01) had a partial mediator effect on the relationship between Firm Innovation-Firm Performance. Thus, H_{16}, H_{17}, H_{18}, and H_{19} were accepted.

4. FINDINGS

This study aims to analyze the ambiguous effect of ET on firm performance and innovation. Besides, the effects of PQM on firm innovation and performance were also examined. The findings provide empirical evidence for the direct impact of PQM on firm performance and innovation. Then, it is analyzed how ET factors affect the relationship between PQM-Firm Innovation and PQM -Firm Performance. ET factors' moderator and mediator effects on relations were examined in this context.

The findings show that ET factors are a moderator and a partial mediator in the relationship between PQM-Firm Innovation. The effects of ET intensities on the existing relationships were also analyzed, and the findings are as follows. (1) As the intensity of MT increases, the strength of the existing relationship decreases but persists. (2) As the intensity of TT increases, the existing relationship becomes insignificant. (3) As CI increases, the strength of the existing relationship decreases, but the relationship persists. (4) When all the ET factors are together, the current relationship becomes insignificant as the density increases.

To summarize these results, in sectors where MT and CI are experienced, firms can gain sustainable competitive advantage with the PQM application until the turbulence factors reach the highest level. Firms in sectors where these uncertainties are experienced will gain sustainable competitive advantage by improving their innovation capacities by PQM. The positive effects of PQM on firm innovation might only behelpfulwith the intensity of MT and CI. PQM implementation does not affect firm innovation under the pressure of TT.

Furthermore, the relationship between firm innovation and firm performance under the effect of ET is also examined. The findings show that ET factors act as both a moderator and a partial mediator in the relationship between firm innovation and performance. According to the analysis, innovation's positive effect on performance increases when the sector's uncertainty increases. In addition, when the uncertainty in the external environment increases, the firm's innovative capacity and performance are strengthened positively.

Acknowledging that being innovative is the primary key to success underthe pressure of uncertainty. Firm performance in such environments depends entirely on their innovative capacity. Therefore, (1) firms should focus on innovation and consider innovative solutions when environmental uncertainties increase. (2) Regardless of the type and level of uncertainty experienced in the sector, firms should develop innovation capacities for sustainable success. (3) MT and CI uncertainty might be considered supportive pressure for innovation. (4) Focusing on PQM might contribute to increasing innovation capacity.

5. DISCUSSION AND IMPLICATIONS

The market conditions in which firms operate today are not stable or predictable. Each sector has its own internal and external dynamics. In addition, due to technological advances, local markets have been replaced by a single global market. All sectors in the global market interact with each other. Although the uncertainties within the firm might be kept under control, it is nearly impossible to predict them in the external environment. Thus, environmental turbulence might be considered a risk factor for firms. If firms cannot manage ET factors, their product/service success will decrease, and they will lose their competitive advantage. Predicting ET factors might enable effective strategies for companies.

Firms that want to overcome the difficulties of turbulence should constantly collect information about their external environment and prepare alternative plans for future situations and conditions. However, firms cannot manage changes by using traditional methods

and structures in an environment where environmental factors constantly change. Thereby, ET should be measured, and firms should prepare strategic plans according to their ET intensities. The enterprise's external environment should be comprehensively analyzed by measuring ET factors. PQM is a management philosophy encompassing all processes involved in delivering services. PQM might increase innovation capacity and firm performance (Ooi et al., 2012; Bhasin and Parrey, 2013). However, the literature has not investigated whether PQM will positively affect firm performance under environmental turbulence conditions.

The study's findings differ from those of Tsai and Yang (2013). In their study, Tsai and Yang (2013) found that market turbulence increases the intensity of competition and that increased competition intensity weakens the relationship between firm innovation and firm performance. This study found that ET factors strengthen the relationship between firm innovativeness and performance. In addition, ET factors have been found to have moderators and mediator effects between PQM-Firm Innovation and PQM-Firm Performance. Nevertheless, these effects are not valid under high ET conditions. PQM implementation positively affects firm innovation in sectors where turbulence is not intense. However, the power of PQM on firm innovation decreases under the pressure of technological turbulence. In this regard, alternative strategies will improve the firm's innovation capacity instead of PQM in sectors facing intense uncertainty.

There are some limitations in our study. Firstly, we did not consider the sub-dimensions of innovation. Which types of innovation are more critical in uncertain situations might be examined in future studies. Another limitation is that ET factors are included in the analysis as a single type of uncertainty. Considering the dynamic structure of firms, sub-environmental factors affecting each sector might have different intensities. We consider it useful for researchers to concentrate on these effects in future studies. In addition, the characteristic features of the firms were not included in the analysis. The research models might be extended by including characteristic features as control variables in future studies.

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