The Impact of Supply Chain Integration on New Product Development Performance: Evidence from Turkish Manufacturing Industry

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***Abstract*— This study researches the relation between supply chain integration and new product development. Supply chain integration has been included in the study under three sub-dimensions: customer integration, supplier integration and internal integration. The relation between supplier integration, customer integration and internal integration and new product development has been examined separately. Gathered data received from 390 mid-sized and macro firms engaged in manufacturing industry in Ankara and Istanbul, reliability analysis and construct validity tests, content, convergent, discriminant, nomological validity and confirmatory factor analysis test results have been presented. Finally, the research model was tested through using structural equation modeling. Study findings suggest that customer integration, supplier integration and internal integration has a positive impact on new product development. This study enriches the literature on supply chain integration by examining the impact of supply chain integration on new product development for the first time in Turkish manufacturing sector.**

***Keywords*—** *Supply Chain Integration, Supplier Integration, Customer Integration, Internal Integration, New Product Development Performance*

Introduction

Increasing progress of technology and rapidly changing customer demands intensify the challenging competition circumstances for firms. They should focus on innovation to survive in this fierce competitive condition in the marketplace, to increase their profitability and to reach their targeted growth rate. There are several types of innovation; however, this study will focus on "new product" as it is the most widely used innovation type in the manufacturing industry. New product refers to the output created in the new product development process. In this respect, new product development is a process that should be carefully considered by the firms. Otherwise, failed new product development projects lead to waste of time and financial resources for them. In addition, unsuccessful new products lead to customer dissatisfaction and thereby customer churn since they cannot meet customer expectations. Therefore, firms would like to include the stakeholders along the supply chain to new product development process not to experience above mentioned drawbacks.

Today, it is not sufficient to only optimize internal functions and infrastructure based on business strategy. Due to the fact that, successful manufacturers in this regard are the ones that connect their internal processes with the suppliers and customers [1]. The concept of supply chain and supply chain management become significant at this point. Because, understanding the need for establishing a relation between supply chain members provides an important competitive advantage for the firm [2]. The concept of supply chain integration developed in this respect is defined as a process that connects and redefines firms through sharing or coordinating information and resources [3].

Although the definition of supply chain management [4], [5] conceptually includes supply chain integration, there are deficiencies regarding the effects of integration in the literature [6]. In this respect, the scope of supply chain integration

have been stated by various authors [7], [8]. In general; supply chain integration is reviewed under three main dimensions: customer (C), supplier (S) and internal integration (I) [9]. Customer integration refers to collaboration and information sharing practices used between critical customers and the firm to be more agile towards customer needs and requirements [10]. Supplier integration refers to the synchronization between the firm's supplier and its procurement and production functions [11]. On the other hand, internal integration, which is also called as cross-functional integration, refers to the size of interaction and communication among functions, the level of information sharing, coordination level and participation level [12]. This study, in which the impact of supply chain integration dimensions on new product development performance is individually reviewed through resource-based approach and relational view theory, intends to widen the extent of literature on supply chain integration.

Within the second section of the study, hypotheses are developed between supply chain integration dimensions and new product development performance based on the studies in the literature. In the third section, introductory information is given regarding the population and sample on which implementation phase was performed. In the fourth section, reliability and validity analysis results are shared and hypotheses are tested by structural equation modeling. In the fifth section, study's results are interpreted and study restrictions are provided.

1. Literature and Hypotheses Development

Resource-based approach suggests that the firm will have a competitive advantage against other firms if firm's capabilities and competencies are exceptional, valuable, non-substitutable and inimitable. Furthermore, this approach states that if competitor firms have the standard inputs, the firm cannot have a competitive advantage [13]. For this reason, firm's critical resources may extend beyond the firm. At this point, the relations between firms come into prominence. Firms may have low transaction costs, learning opportunity and resource repository with the help of these relations [14]. In this respect, relational view theory that asserts the significance of the relations between firms is a strategic management approach which rises from the basics of resource-based approach and suggests that competitive advantage is built in the relations between firms by going beyond the firm borders [15]. Relational view theory points out that as the source of competitive advantage, investing in relations, establishing information sharing routines, developing supplementary capabilities and competencies and effective management [14].

In addition, nowadays, modern firms chose outsourcing option for their operations excluded by their main competencies. Because, firms can gain cost advantage and technical know-how in this way. It is not possible for the firms to own and manage all technologies needed to meet customer demands. So, firms share their new product development processes with their shareholders along the supply chain [16]. In competitive markets, suppliers are considered to be a resource that is more and more significant for manufacturers [17]. Manufacturing firms give the suppliers responsibilities regarding new product design, development and engineering in many industries [18]. Studies in the literature shows that supplier integration improves production and development costs, reduces production and development time, and increases quality [19]. Considering these information, the following hypothesis has been developed regarding the relation between supplier integration and new product development:

H_1: Supplier integration has a positive impact on new product development.

Reaching external information is getting more and more important for successful new product development projects. Researchers and practitioners working on this subject consider the customers as a critical source of information and would prefer that customers are more included in the new product development works [20]. The success of new product development depends on thoroughly understanding customer demands, needs and circumstances. This requires an active interaction with the customers [21]. Empirical studies show that customer integration from dimensions of supply chain integration has a positive impact on new product development [22], [23], [24]. In the light of these information, the relation between customer integration and new product development is stated as follows with the H2 hypothesis.

H_2: Customer integration has a positive impact on new product development.

Internal integration enhances for the firms the ability to utilize and coordinate internal resources [25]. Firms can access operational data more easily by leveraging from integrated databases [26]. In addition, internal integration removes functional barriers and promotes cooperation between internal functions. [27]. Internal integration provides the opportunity to exchange information between different

departments such as marketing, R&D and production. This ensures that processes that do not deliver benefits are eliminated by focusing on the same intention [28]. Thus, firms can increase the value and quality of product they offer to their customers, reduce time to market and decrease its costs with internal integration [27], [29]. It is stated in previous studies that there is a positive relation between internal integration and new product development [25], [27], [29]. The following hypothesis has been developed in the light of these information.

H_3: Internal integration has a positive impact on new product development.

The model developed considering above-mentioned hypotheses and used in this study is depicted in Figure 1 below.

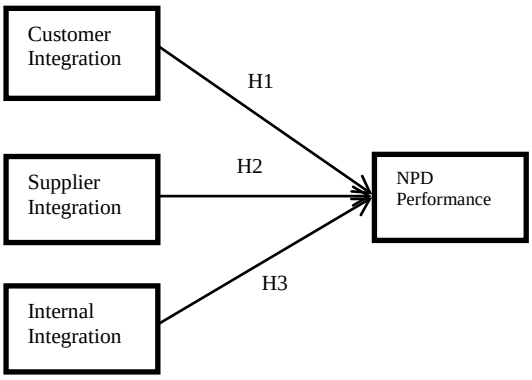

Figure 1. Research Model

2. Methodology

2.1 Sampling

The population of this study consists of mid-sized and macro firms operating in Istanbul and Ankara where the manufacturing industry is concentrated. Micro firms are not included in the scope of this research due to the fact that the majority of micro firms do not have new product development and research units as shown by preliminary research results. Provincial directorates of Ankara and Istanbul from the Ministry of Science, Industry and Technology were contacted to determine the size of the research environment. According to the obtained data, the number of mid-sized and macro firms operating in the manufacturing industry are 658 firms in Ankara and 1305 firms in Istanbul in 2016. Considering this information, the population of this study includes 1963 firms. It can be said that conducting the study with 390 samples is sufficient for the sampling calculation based on the population at 95% confidence level as suggested by Ref [30].

Table 1. Descriptive Analysis Results

	Frequency	Ratio (%)
Product type of firm		
Industrial Goods	170	43.6
Consumer Goods	128	32.8
Both	92	23.6
City		
Istanbul	263	67.4
Ankara	127	32.6
Your Title		
General Manager	43	11.1
Vice General Manager	37	9.5
Production Manager	138	35.5
New Product Development Manager	45	11.3
R&D Manager	127	32.6
Operating field of firm		
Textile	78	20
Food	64	16.4
Construction	46	11.7
Metal	36	9.2
Machinery	24	6.1
Automotive	23	5.8
Mining	19	4.8
Ship equipment	17	4.3
Pharmaceutical	16	4.1
Computer	13	3.3
Plastic	12	3.07
Jewelry	11	2.8
Steel	10	2.5
Shoe making	8	2.05
Petrochemical	6	1.5
Gun	4	1.02
Printing-Publishing	3	0.7

The scale was applied to firms in manufacturing industry. There is no sub-industry limitation and no scale was applied to firms that do not perform new product development activities. Simple random sampling method used in this study refers to a sampling method in which each unit in the population has an equal chance of being selected. Also, it is suggested that simple random sampling method is the shortest way to be followed in cases where there is a list of population [31]. Due to the fact that, simple random sampling method is used in the study.

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2.2 Research Variables and Measurements

In the study, survey method is used as data collection method. A detailed literature scanning work has been conducted to identify the tools to be used in measurement of structures included in research model. In review of literature, studies including structures like the ones in this study have been examined, and the source in which they were published, reliability and validity results of the scales used and whether they were used in other studies have been carefully reviewed. So, these four scales are used in this study: supplier integration, customer integration, internal integration and new product development.

The survey form used in the study consists of descriptive questions regarding the firm and items to realize research purposes. Items used for research purposes are customer integration, supplier integration, internal integration [9] and new product development [19] scales.

Table 2. Research Scales and Items

Customer Integration	The level of connection with our main customers through knowledge networks The level of automation used by our main customers in their orders The level of sharing market info by main customers Communication level with our main customers Set-up level of quick ordering system with our main customers The level of tracking our main customers to get their feedback Frequency of contact with our main customers
Supplier Integration	Set-up level of quick ordering system with our main suppliers Strategic partnership level with our main suppliers The level of consistent procurement from our main suppliers through network Participation level of our main suppliers in procurement and production process Participation level of our main suppliers in design process The level of sharing production schedules with us by our main suppliers
Internal Integration	Data integration level between internal departments Corporate application integration level between internal departments The level of integrated stock management The level of learning stock status real-time The level of learning operational data on logistics real time The level of leveraging from periodic meetings between internal departments Real-time integration and communication level of all internal departments from raw material management to shipment and sales
New Product Development	Meets customer requirements. Technical performance increases. Time to market decreases. Unit production costs decreases. Product quality increases.

3. Data Analysis

Cronbach alpha internal consistency coefficient of supplier integration sub-dimension is 0.78, Cronbach alpha internal consistency coefficient of customer integration sub-dimension is 0.81, Cronbach alpha internal consistency coefficient of internal integration sub-dimension is 0,84 and Cronbach alpha internal consistency coefficient of new product development sub-dimension is 0.72 and these values refers to the fact that the scale is reliable. Validity pertains to the relevance of research components [32]. Validity explains to what extent one can legitimately rely on test results interpreted for a specified purpose [33]. As part of the study, content validity and construct validity tests have been performed as validity analyses. Convergent validity, discriminant validity, nomological validity and confirmatory factor analysis tests have been conducted to test construct validity.

3.1. Content Validity

Experimental studies on people with various cultural characteristics yield different results. This is due to the fact that groups in experimental studies use different languages and have different administrative understanding. That is why the method suggested by Ref. [34]. was used for the adaptation of scale in this study. This method consists of five steps: translation from original language to target language, evaluation on the translation, re-translation into source language, evaluation on re-translation into source language and taking expert opinions.

As the first step, English (source) to Turkish (target) translation was made by two academics one of whom is an author. Then, translated statements were compared to find the correct Turkish equivalents of the statements in English. And then, Turkish statements were translated into English by another academic who has the relevant language proficiency. After translation into source language, comparisons were made with the original scale and it was observed that there was no significant difference between them. As the last step, expert opinion was received from three academic members whose area of study

is close to Turkish scale. Also, the managers of 27 mid-sized and macro firms were subjected to these statements to see whether the statements were understood and to evaluate incomprehensible statements.

According to Ref. [35] technique suggests that content validity index should be above 0.8 to ensure content validity. In the preliminary test conducted on 30 people, 27 of whom are firm managers, content validity index has different values from 0.8 to 1. Considering these values, it can be said that the construct ensures content validity.

3.2. Confirmatory Factor Analysis

Confirmatory factor analysis is a theory-based approach [36]. Confirmatory factor analysis is a kind of structural equation modeling in which the relations between latent variables and observed variables are reviewed through measurement models [37]. Confirmatory factor analysis, convergent validity, discriminant validity and nomological validity have been analyzed with LISREL program in the study. Solution results standardized for confirmatory factor analysis suggest that item factor loadings must be above 0.5 [38]. It is stated that factor loadings of all observed variables regarding customer integration scale are relevant above 0.5 and at $p<0.05$ level. It is stated that factor loads of all observed variables regarding supplier integration scale are relevant above 0.50 and at $p<0.05$ level. It is stated that factor loads of all observed variables regarding internal integration scale are relevant above 0.50 and at $p<0.05$ level.

When new product development scale was evaluated, the item was ruled out as Y4 item load was below 0.5 as a result of confirmatory factor analysis and then confirmatory factor analysis was repeated. At this stage, the item was ruled out as Y3 item load was below 0.5. Thus, the variables observed regarding development time and development cost among new product development performance criteria was removed from the study. Due to these removed variables, new product development performance was analyzed through variables observed regarding the level of meeting customer expectations, quality and technical performance.

Table 3. Fit Indices for Measurement Model

Overall Fit Measure								
x^2 Value	*df*	*RMSEA*	*SRMR*	*NFI*	*NNFI*	*CFI*	*GFI*	*AGFI*
562	221	.063	.061	.93	.95	.95	.88	.85

When acquired fit indices are reviewed, relative chi-square value 2.54 is within acceptable fit limits as shown in Table 3. In addition, it can be said that root-mean-square (RMSEA) value 0.063 of the approximation most frequently used in confirmatory factor analyses is within acceptable limits. Standardized root-mean-square residual (SRMR) value 0.061 has an acceptable fit as shown in Table 3. In the measurement model, NFI value 0.93, NNFI value 0.95 and AGFI value 0.85 are within acceptable fit limits.

Table 4. Confirmatory Factor Analysis Values

Factors and Items	*Standard Value*	*R^2 Values*	*Error Variance*	*T Values*
Customer Integration				
C1	0.56	0.32	0.68	11.28
C2	0.59	0.35	0.65	11.96
C3	0.53	0.28	0.72	10.44
C4	0.74	0.54	0.46	15.83
C5	0.75	0.57	0.43	16.35
C6	0.75	0.57	0.43	16.32
C7	0.59	0.34	0.66	11.83
Supplier Integration				
S1	0.53	0.28	0.72	10.35
S2	0.59	0.35	0.65	11.88
S3	0.66	0.44	0.56	13.70
S4	0.81	0.66	0.34	17.95
S5	0.78	0.61	0.39	16.99
S6	0.62	0.39	0.61	12.65
Internal Integration				
I1	0.64	0.41	0.59	13.05
I2	0.69	0.48	0.52	14.38
I3	0.62	0.38	0.62	12.47
I4	0.63	0.40	0.60	12.77
I5	0.70	0.49	0.51	14.62
I6	0.69	0.47	0.53	14.25
I7	0.68	0.46	0.54	14.09
NPD Performance				
N1	0.65	0.43	0.57	11.67
N2	0.64	0.41	0.59	11.45
N5	0.61	0.37	0.63	10.83

Standardized factor loading values obtained as a result of confirmatory factor analysis, R^2 values that show the variance level indicating the factor in which each variable resides, standard errors and t-values are shown in Table 4. Variability in customer integration factor is explained by maximum M5 ($R^2 = 0.57$) and M4 ($R^2 = 0.57$) observed variables, variability in supplier integration factor is explained by maximum T4 (R^2

= 0.66) observed variable, variability in internal integration factor is explained by maximum I5 (R^2 = 0.49) observed variable, and the variability in the new product development factor is explained by maximum Y1 (R2 = 0.49) observed variable. In other words, these observed variables are the ones that best explain the variance in the factors (latent constructs) to which they are related. Also, Table 4 shows that all standard values of the observed variables included in the scales are above 0.5, which is the sufficient value, and t values are above 1.96 at 95% confidence level.

3.3. Convergent Validity

Convergent validity is tested by the correlation between the statements, average variance explained (AVE) and combination reliability (CR) in this study. Average variance explained refers to the variance explained by the variables regarding the factors whereas combination reliability shows internal consistency [38].

Table 5. Results about Measurement Model

		Item Loading	*Cronbach Alpha*	*AVE*	*CR*
Customer Integration	C1	0.56	0.82	0.42	0.83
	C2	0.59			
	C3	0.53			
	C4	0.74			
	C5	0.75			
	C6	0.75			
	C7	0.59			
Supplier Integration	S1	0.53	0.83	0.45	0.82
	S2	0.59			
	S3	0.66			
	S4	0.81			
	S5	0.78			
	S6	0.62			
Internal Integration	I1	0.74	0.86	0.44	0.84
	I2	0.78			
	I3	0.65			
	I4	0.62			
	I5	0.65			
	I6	0.64			
	I7	0.64			
NPD Performance	N1	0.66	0.66	0.40	0.66
	N2	0.64			
	N5	0.60			

Average variance explained is accepted to be above 0.5, and 0.4 value is considered to be sufficient for convergent validity [39]. According to Ref. [40], if AVE value is below 0.5, but CR value is above 0.6, convergent validity of the construct is sufficient. Obtained results imply that the construct has convergent validity.

3.4. Discriminant Validity and Nomological Validity

Standardized correlation matrix of the constructs in the measurement model must be reviewed to test nomological validity and discriminant validity that represent other two basic indicators of construct validity [41]. Square root of average variance explained should be above inter-dimensional correlation values to ensure discriminant validity of constructs [42].

Table 6. Inter-Constructs Correlation and Discriminant Validity

	Customer Integration	*Supplier Integration*	*Internal Integration*	*NPD Performance*	*√AVE*
Customer Integration	1				0.64
Supplier Integration	0.41*	1			0.67
Internal Integration	0.52*	0.55*	1		0.67
NPD Performance	0.46*	0.29*	0.54*	1	0.63

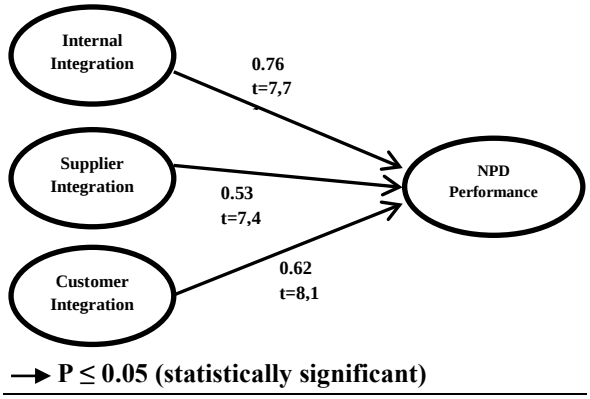
Table 6. shows that all relations between the constructs are relevant ($p<0.01$) and square root of average variance explained is bigger than inter-dimensional correlation. This refers to the fact that scales have discriminant validity and nomological validity. Also, Table 6 shows that correlation coefficients' not exceeding 0.80 means that variables do not show multicollinearity and interpretation of results rests upon a sound basis [43].

3.5. The Interpretation of Results

Coefficients and the model regarding structural equations were tested in the LISREL

program based on the relations in the study model. As is the case for measurement model, model goodness of fit tests that is frequently used in the literature were used as well in the evaluation of structural equation model. Testing the measurement model with the same variables and samples before testing structural equation model provides the opportunity to make a comparison between structural equation model and measurement model. Even if structural model never has better fit values than the measurement model, the fact that it has much worse values than the measurement model means that the structural model theory is far from valid. Model-related goodness of fit results are shown in Table 6.

It is observed that model goodness of fit results regarding structural equation model are within the acceptable goodness of fit results shown in Table 6. The fact that there is not a significant difference between obtained results and measurement model results also supports the structural equation model theory. Besides, the fact that the standard factor loads calculated by the structural equation model do not deviate from the standard factor loads calculated by the measurement model (> 0,05) suggests that there is no complexity of interpretation in the structural equation model.



Overall Fit Measure

X^2 *Value*	*df*	*RMSEA*	*SRMR*	*NFI*	*NNFI*	*CFI*	*GFI*	*AGFI*
629	224	.068	.075	.93	.95	.95	.88	.85

Figure 2. Causal relationship between latent variables in structural equation model

During review of research hypotheses upon structural equation model, 95% reliability level was considered and the relations for which t value is higher than 1.96, among latent variables (factors) were found to be relevant. Since the standard coefficient is 0.62 and t value is 8.11 (> 2.56) for the path between customer integration and new product development, there is a positive relationship between these two variables. It is observed that the results obtained in this respect are in line with the studies that test the relation between customer integration and new product development performance in the literature [20], [21], [44]. Since the standard coefficient is 0.53 and t value is 7.42 (> 2.56) for the path between supplier integration and new product development, there is a positive relationship between these two variables. It is observed that the results obtained in this respect are in line with the studies that test the relation between supplier integration and new product development performance in the literature [45], [46], [47] Since the standard coefficient is 0.76 and t value is 7.71 (> 2.56) for the path between internal integration and new product development, there is a positive relationship between these two variables. It is observed that the results obtained in this respect are in line with the studies that test the relation between internal integration and new product development performance in the literature [25], [29].

4. Conclusion

Studies conducted on new product development suggest that a lot of factors are important in developing new products. These include a new internal design model for production and quality from a firm-oriented point of view whereas they include supply chain design from a non-firm-oriented point of view [17]. In this study, along with this information, the impact of internal integration and external integration on new product development has been evaluated along the supply chain. This study enriches the literature on supply chain integration by examining the impact of supply chain integration on new product development for the first time in Turkish manufacturing sector. External integration has been examined under two sub-sections: customer integration and supplier integration. Thus, the impact of internal integration, customer integration and supplier integration on new product development has been examined separately in this study. Ref. [25] examine customer and supplier integration under one dimension as external integration in their study where they inquire about the impact of external integration on product innovation. As the differences between supplier integration and customer integration could not be identified in research results, it was suggested to separately evaluate these dimensions in the future studies. In this respect, the impact of three dimensions of supply chain integration on the new product development has been separately reviewed

through source-based approach and relational view theory to make contribution to literature.

Internal integration develops a holistic point of view between different departments [48]. The models developed by authors such as [25], [29] suggest that there is a direct and positive relation between internal integration and new product development. Also, the impact of internal integration on new product development has been tested as one of three sub-dimensions of supply chain integration as part of this study. Obtained results show that the strongest relation between supply chain integration dimensions and new product development is between internal integration and new product development. Customer integration is particularly crucial for product innovation in a highly ambiguous competition environment. Customer integration ensures accessing information about customer demands and helps with developing a mutual understanding [29]. These results in the success of the new products released to the market. Besides, it is also confirmed that there is a direct relation between customer integration and meeting customer expectations, which is one of new product development performance criteria.

Modern firms focus on main competencies and tend to use outsourcing for other competencies. This provides firms with cost advantage and expert knowledge. More advanced technologies required by a new product require closer collaboration between firms and suppliers. This is because it is impossible to have and coordinate all technologies required to meet customer demands [47]. It is observed that firms that focus on supplier integration reduce product development time, add more innovative features to the product, and utilize fewer engineers. Structural equation modeling results also demonstrate that supplier integration improves quality and technical performance, which are among new product development performance criteria. In the future studies, using different new product development performance criteria may contribute to literature. Also, the study was conducted in the two largest cities of Turkey, Istanbul and Ankara, considering the concentration of manufacturing industry; however, this poses a limitation for generalizing the results of the study as it could not be conducted in all of the regions of Turkey.

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