Risk analysis and prioritization of irregular order arrivals

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Abstract

Production is at the top of the functions that will ensure the continuity of the company. Hence, irregular orders are a major problem for companies. In this study, the main reasons for the irregular order arrivals for a production company are determined; risks that might possibly arise from those reasons are analyzed with Failure Mode and Effects Analysis (FMEA) and same risks are prioritized with Analytical Hierarchy Process (AHP) to compare and validate results. As a result of the study, the type of error / factor which is the risk priority for the operation has been determined and preventive activities are determined. As a result of the AHP, parameters that have same risk scores are separated and determined that market transactions, customer satisfaction and job shop production are the most important parameters that effect irregularity.

Keywords: AHP, Irregular Order Arrivals, FMEA

Düzensiz sipariş gelişlerinin risk analizi ve önceliklendirilmesi

Özet

Şirketin sürekliliğini sağlayacak fonksiyonların başında üretim gelir. Bu yüzden düzensiz siparişler şirketler tarafından büyük bir sorun olarak karşılanmaktadır. Bu çalışmada düzensiz siparişlerin geliş sebepleri tespit edilmiş ve bu sebepler için risk analiz yöntemlerinden Hata Türü Ve Etkileri Analizi (HTEA), ardından öncelik sırasını belirlemek adına Analitik Hiyerarşi Prosesi (AHP) yöntemi uygulanmıştır. Çalışma sonucunda işletmede risk önceliği olan hata/faktör türü tespit edilmiştir ve önleyici faaliyetlerde bulunulmuştur. Aynı risk skoruna sahip olan parametreler arasında yapılan ikili karşılamalarda Pazar hareketlerinin, müşteri tatmininin ve atölye tipi üretimlerin sipariş düzensizliklerine neden olduğu gözlemlenmiştir.

Anahtar Kelimeler: AHP, Düzensiz Siparişler, HTEA

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1. Introduction

It is very important to ensure regularity of production and to receive regular orders in order to survive in any industry. To sustain the same level of production is one of the key elements for companies to be successful. Especially companies who adopt *"make to order"* type of production need to have less variation in their production line in terms of order arrivals. Lack of regular order arrivals can cause many major problems among companies such as cost, time and labor. Hence, Irregular order arrivals must be reduced as far as possible to take possible correct preventions. Determination of factors that affect orders arrival is one of the most important pre-action for companies to take precautions. Factors affecting the order's development may vary from product to product or from environmental factors such as seasonality. By working on the right factors and finding the right solution, unnecessary cost can be reduced which will provide the continuity of production in operation, and will regulate customer satisfaction.

Preventing irregular order arrivals in order to work efficiently and meet customer expectations at the highest level are the main objective for companies to survive. The determination of irregularities has emerged as a long-term research outcome. Irregular order arrivals can cause from many factors such as; product satisfaction, seasonal factors, price, market transactions, competitor policy, legal regulations, company policies, quality, relations with customer, lead time, raw material variety, job shop production, product overview, customer tracking, planning error, technology tracking, customer contracts and competitor firms.

Factors that affect order arrivals may vary among companies and industries. Determining the most important factors can help companies to solve and focus on the problems that arise from those factors. Hence, prioritization of irregular order arrival factors becomes significantly important. Correspondingly, this study concerns the prioritization of the factors affecting order arrival in a medium sized plastic packaging and textile factory in the industrial zone of Adana. First part of the study includes the factors affecting the order arrival were determined and the FMEA method was applied to create an action plan for the company to prioritize the risks that causes from the determined factors. Second part of the study deals with the prioritization of the factors which have the same risk priority number (RPN) with AHP method to differentiate all the factors. FMEA and AHP methods are the methods that are generally used in previously conducted studies in many areas to prioritization purpose. For instance;

Aguiar et. al [1] evaluated using AHP, several proposals for the application of Process FMEA. The scientific contribution of this paper is to provide a way to select a reference table, available in the FMEA literature, for the application of the FMEA process. This paper has first presented different scoring criteria for Detection, Occurrence, and Severity in the context of FMEA application in different situations identified in publications about this topic. The use of AHP has provided a simple way to choose only one criterion for Detection, one for Occurrence, and another one for Severity. It was done by comparing different proposals and prioritizing them within three hierarchies. Abdelgawad and Fayek [2], extended the application of FMEA to risk management in the construction industry. Fuzzy logic and fuzzy analytical hierarchy process AHP are used to address the limitations of traditional FMEA. The use of this approach can support the project management team to establish corrective actions in a timely manner. The model presented in this paper offers the contribution of combining fuzzy logic with both FMEA and AHP in a comprehensive framework that provides a practical and thorough approach for assessing the level of criticality of risk events in the construction domain. The combination of fuzzy FMEA with fuzzy AHP and their integrated application to risk criticality assessment in construction are unique. The model is currently in use by the company as a

risk monitoring and control tool to support its top management to identify critical risk events in a timely manner so that corrective actions can be established more effectively. The use of the model over time will help in validating its applicability and usefulness in practice. Öztürk et. al, [3], used AHP to solve the supplier selection problem of a textile company. Sofyalıoğlu and Öztürk [4], compared three different methods for prioritizing failure modes in a design FMBA study. These methods are traditional approach. Grey Relational Analysis (GRA- under the assumption of risk factors having equal weights) and integration of Grey Relational Analysis and Fuzzy Analytic Hierarchy Process (FAHP). Özyazgan and Engin [5], calculated the errors, error probabilities, severity values and discoverability values of a knitted operation in their work with error detection effect analysis methods (FMEA). At the end of the study, mistakes were seen to decrease and widely usage of that analysis in sector should be increases customer satisfaction due to increasing of quality, reliability and competitiveness. For this reason representatives of the sector should be informed. Özyazgan [6], calculated error probabilities, severity values and discoverable values with the Process FMEA study of the faults in the textile operation which produces a woven fabric in his study. Corrective measures are specified according to the types of errors that occur. It has been determined that these errors are caused by the weaving machine and personnel. In addition, the improvement of workers' education and working conditions are identified as critical factors in the prevention of errors. Türedi and Bircan [7], analyzed the errors in industrial robotics automation systems using the FMEA method. By analyzing the error modes obtained as a result of the studies, the error mode and the other error modes that constitute the high criticality level are revealed. These conclusions may also contribute to, or make comparisons in, error analysis of equipment in industrial enterprises where similar equipment is available. Cakir [8], provided students who wanted to work part-time in their study identified through the AHP method. It was emphasized that this model will also lead to the evaluation of the suppliers in which the firm is working or to the decisions of the suppliers which offer different product varieties. Kecek and Yüksel [9], investigated the preference order of alternatives available in the smart mobile sector by young people aged 18-25 years. Analytic hierarchy process (AHP) and PROMETHEE, which are multi-criteria decision making techniques, were used in the study. Criterion weights are calculated with AHP. Dündar and Ecer [10], determined the order of preference of GSM operators in mobile phone purchases of university students by analytic hierarchy process in their studies. The students made binary comparisons of the decision criteria and the GSM operators according to each decision criterion at the level of importance of the analytical hierarchy process method

2. Material and Method

2.1. Material

In this study, prioritizations of irregular order arrival factors are determined in a medium sized plastic packaging and textile factory in the industrial zone of Adana. Selected factors and their effects are explained as follow;

- ✓ *Product Satisfaction:* Lower customer satisfactions can lead re-orders.
- ✓ *Seasonal Factors:* Seasonal changes cause differentiation of the quantity of products ordered.
- ✓ *Price:* The price can affect favorably the order as it will affect the adverse effect of the or
- ✓ *Market Transactions:* Since the raw materials are supplied from abroad, changes in the market are reflected in the price of the product. That can influence the order arrivals.
- ✓ *Competitor Policy:* Losing the rucksacks causes a loss of customers which leads irregularity of orders.
- ✓ *Legal Regulations:* The delivery of the used materials from abroad may result in loss of customer and irregularity of order due to the attachment to legal regulations such as customs.
- ✓ *Company Policies:* Strategies that the company will pursue within itself ensure that they stay on the market and make their customers permanent. Company policy regulations affect customer and order arrivals.

- ✓ *Quality:* Loss of customer because of quality problems causes irregularities in orders.
- ✓ *Relations with Customer:* Customer continuity is ensured through the correct communication with the customer. Thus, the regularity of order arrivals is valid.
- ✓ *Lead Time:* The delay of the customer's desired date causes the loss of the customer. This is the main reason for your irregularity.
- ✓ *Raw Material Variety:* Variations among products can lead irregularities in orders.
- ✓ *Job Shop Production:* The customer does not want to reorder when there is no suitable production for the order. This also causes irregularity in the order.
- ✓ *Product Overview:* Marketing affect can cause irregularities.
- ✓ *Customer Tracking:* Correct after sale follow up can lead regular or irregular order arrivals.
- ✓ *Planning Error:* Customer satisfaction may not be achieved because the mistake made in the plan will cause late delivery of the product or other problems.
- ✓ *Technology Tracking:* Staying behind technology will not be able to meet customer expectations.
- ✓ *Customer Contracts:* The rules that should be in the contracts made with the customer must be clearly explained to the customer and informed. Otherwise, any later inconveniences will cause loss of customers.
- ✓ *Competitor Firms:* Trials of staying in market can cause irregularities.

2.2. Method

AHP method is one of the multi criteria decision methods (MCDM) which was originally developed by Thomas Saaty from the University of Pittsburgh [11].

Steps taken in the AHP method are as follows [11]

1. Definition of decision making problem and determination of its purpose,
2. Determination of decision criteria to reach the purpose,
3. Identification of possible alternatives,
4. Establishing the hierarchical structure of the decision problem
5. Binary comparison of the criteria for each level of the hierarchy and determination of the importance levels of the criteria according to Table 1.
6. Binary comparison of alternatives according to the criteria and calculation of priorities in alternatives,
7. Calculation of the consistency rate,
8. Sort alternatives according to their relative priority values and select the alternative with the highest priority value.

Table 1. Pairwise Comparison Table [11]

Rating	Description
1	Equal importance
3	Moderate importance of one over another
5	Strong importance of one over another
7	Very strong importance of one over another
9	Extreme importance of one over another

2, 4, 6, 8	Intermediate values
Reciprocals	Reciprocals for inverse comparison

The FMEA was first developed by the American army and was used by NASA to determine system and hardware faults and their effects. The FMEA multiplies the Risk Priority Number (RPN) by three significant components. These components are occurance (O), severity (S) and detectability (D), respectively. All three components have 1-10 scale. Scales of FMEA method are obtained from literature [12]

3. Findings

After examining the order quantities between 2010 to 2018 (till April); it has been determined that irregular order arrivals obviously affects the company. Application of FMEA method and its results are illustrated in Table 2 at below.

Table 2. FMEA Results

Risk No	Factor	S	O	D	RPN	Actions to be taken
1	Product Satisfaction	7	4	1	28	"Customer surveys should be made and taken into account"
2	Seasonal Factors	2	2	5	20	"Seasonal estimates should be taken into consideration and planning should be done according to the situation"
3	Price	4	2	4	32	"Market values should be well analyzed, values should not be over or under"
4	Market Transactions	4	3	2	24	"Be careful when analyzing changes in the market"
5	Competitor Policy	4	4	3	48	"Innovations made by rival companies should be closely monitored and new strategies appropriate for them should be identified"
6	Legal Regulations	4	3	1	12	"New strategies should be set against changing legal regulations"
7	Company Policies	3	4	3	36	"Company policies must be constantly

					"renewed according to the market and the situation of competitors"
8	Quality	6	6	3	108	"Quality standards for products must be established and this standard must be permanent"
9	Relations with Customer	4	2	3	24	"Experienced staff must be selected and vocational training should be given in the field"
10	Lead Time	3	3	8	72	"Be more careful when planning for on-time delivery"
11	Raw Material Variety	1	2	8	16	"Raw materials must be supplied in various forms at the request of the customer"
12	Job Shop Production	2	2	8	32	"Expanded product range"
13	Product Overview	5	2	2	20	"More product announcements must be made, customers should be informed about the products"
14	Customer Tracking	7	1	4	28	"After the product delivery, the customer's opinions should be taken and necessary studies should be done"
15	Planning Error	8	3	4	96	"Be more careful when planning"
16	Technology Tracking	7	2	2	28	"Altering needs with changing technology"
17	Customer Contracts	4	3	2	24	"The interests of the company must be taken into account in the agreements signed between the client and the company"

18	Competitor Firms	4	5	4	80	"Competitors should be followed closely"

According to Table 2 for the factors of ; Seasonal Factors, Legal Regulations, Raw Material Variety; Product Overview do not need any actions to take since the RPN values are less than 20. For the factors of Product Satisfaction, Price, Market Transactions, Company Policy, Relationships with Customer, Job Shop Production, Customer Tracking, Technology Tracking, Customer Contracts; since the RPN values are between 20 to 40; precautions need to include more control and more training of the staff. For the factors of competitor policy, lead time, planning error and competitor firms control systems have to be examined immediately to detect the faults since the RPN values are between 40 to 100. On the other hand, quality factor is the most important factor that lead irregular order arrivals for the selected company since the RPN value is between 100 to 250.

Another striking result from Table 2 is; there are some factors which have the same RPN value. Having the same RPN value can cause confusion for the company because it can lead practitioners to take precautions in a wrong order. Since there is no prioritization made according to FMEA results among some factors; AHP method is needed to prioritize those factors as well. To create the hierarchical structure; all factors are divided under three main criteria as Competitive Firms, Legal Regulations and Product Satisfaction. AHP results for main criteria are as follows.

Table 3. Main criteria AHP Results

Competitive Firms	0,6491
Product Satisfaction	0,2789
Legal Regulations	0,0719

According to Table 3, the most influential factor in order arrivals is "competitors" with about 65%. Approximately 28% "product satisfaction" in the second place and "legal regulations" in the third place with 7%. Competitive firms have a higher priority than the other main parameters in the pairwise comparison of the main importance of having the main parameter in the first place. The impact of competitors' order arrivals is rather high. This causes the order to be regular or uneven. Having strong competitor, it leads to the danger of customer loss anytime. In Table 4, AHP results for sub-criteria are given.

Table 4. AHP Results for sub-criteria

SUB-CRITERIA	VALUE	SUB-CRITERIA	VALUE
Quality	0,5380	Price	0,1564
Competitors Policy	0,3439	Technology Tracking	0,1194
Company Policy	0,2913	Customer Tracking	0,1081
Job Shop Production	0,28162	Customer Contracts	0,0964
Market Transactions	0,2683	Product Overview	0,0837

Planning Error	0,2299	Seasonal Factors	0,0694
Relationships with Customer	0,1987	Raw Material Variety	0,0518
Lead Time	0,1625		

As it is illustrated in Table 4, Quality is the most important factor that affects company to have irregular order arrival. Therefore, it is a factor that should be paid attention primarily. Second important factor is the competitor policy. The policies implemented by the competitors in order to avoid the loss of customers should be followed closely and appropriate solutions should be produced. The third important factor is company policy. In order not to be behind competitors, the company should set appropriate policies and strategies.

After the application of FMEA, it has been mentioned that some factors have the same RPN value which can cause confusion for company to prioritize factors and take precautions. The AHP method is used to determine the priorities of the criteria with the same RPN values. Thus, priority order of the criteria was determined by binary comparison.

Table 5. Factors with Same RPN Value

RPN=24	RPN=28	RPN=32
Relations with Customer	Product Satisfaction	Price
Customer Contract	Customer Tracking	Job Shop Production
Market Transactions	Technology Tracking	

After performing AHP for the factors that have the same RPN value, results are illustrated in Table 6.

Table 6. Prioritization of Factors with Same RPN

Relations with Customer - 20% (Subcriterian of Competitor Companies)	**Product Satisfaction - 28%** (Main Criterian)	**Price - 16%** (Subcriterian of Competitor Companies)
Customer Contract - 10% (Subcriterian of Legislative Regulations)	**Customer Tracking - 11%** (Subcriterian of Competitor Companies)	**Job Shop Production - 28%** (Subcriterian of Competitor Companies)
Market Transactions - 27% (Subcriterian of Legislative Regulations)	**Technology Tracking - 12%** (Subcriterian of Competitor Companies)	

After applying AHP, priority orders of sub criteria emerged. With the prioritization of the factors that have the same RPN value, it helps the company to take precautions in a right order and clear the confusion of rankings in action plans.

4. Results

This study concerns the prioritization of the factors affecting order arrival in a medium sized plastic packaging and textiles factory in the industrial zone of Adana. The study consists of two methods. Among the risk analysis methods, FMEA and AHP have been used as a multi-criteria decision making method. After the determination of the factors that can cause irregular order arrivals;

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FMEA method is applied and actions to be taken for possible risks have been identified. According to FMEA results "Quality" is the most important factor that can cause irregular order arrival for the selected company. In addition to that, FMEA results show some repetitive results such as some factors having same RPN value. To clear the confusion and validate the results; AHP method is applied for the same factors and again "Quality" is resulted as the most important factor that cause the irregularities. Also AHP method clears the confusion among factors which have the same RPN value and those factors are ranked as well. Objecting to reduce order irregularities will facilitate the company's market expansion. In practice, a set of FMEA can be established and the method can be reapplied and new methods can be produced with different perspectives.

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