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VULNERABILITY OF AUTOMOTIVE SUPPLY CHAINS AS A RESULT OF IMPLEMENTING THE JUST-IN-SEQUENCE STRATEGY

Ranjivost automobilskih lanaca snabdevanja kao rezultat implementacije Just-in-Sequence strategije

Abstract

Supply chains in the automotive industry, due to their global nature, are constantly exposed to disruptions and interruptions caused by risk events. By utilizing various tools and modifying supply and distribution structures, supply chains in the automotive industry aim to mitigate the consequences of these risk events as efficiently as possible. The Just-in-Sequence strategy is one of the tools used by supply chains to address the challenges of the global environment. However, implementing this strategy increases exposure to risk events. In this context, the aim of the study is to examine the exposure of automotive industry supply chains to risk events resulting from the application of the Just-in-Sequence strategy. Achieving this goal will help determine the viability of applying this strategy under uncertain conditions. This paper presents the results of a study conducted in a company from the automotive industry with experience in implementing the aforementioned strategy. The perspectives of employees from the logistics, production, and sale sectors were examined, as they are directly involved in the implementation of the analyzed strategy. The results show that employees recognize a higher exposure to risk events when using the Just-in-Sequence strategy. However, it is concerning that there is a discrepancy in the views of employees from different sectors involved in the implementation of this strategy.

Keywords: *risks, supply chain, automotive industry, just-in-time, just-in-sequence.*

Sažetak

Lanci snabdevanja u automobilskoj industriji, zbog svoje globalne prirode, konstantno su izloženi poremećajima i prekidima izazvani rizičnim događajima. Korišćenjem različitih alata i modifikovanjem struktura snabdevanja i distribucije, lanci snabdevanja u automobilskoj industriji teže ka tome da ublaže posledice ovih rizičnih događaja što efikasnije. Just-in-Sequence strategija predstavlja jedan od alata koje lanci snabdevanja koriste kako bi odgovorili na izazove globalnog okruženja. Međutim, primena ove strategije povećava izloženost rizičnim događajima. U tom kontekstu, cilj istraživanja je da ispita izloženost lanaca snabdevanja u automobilskoj industriji rizičnim događajima koji nastaju kao posledica primene Just-in-Sequence strategije. Ostvarenje ovog cilja pomoći će u oceni opravdanosti primene ove strategije u uslovima neizvesnosti. U radu su prikazani rezultati istraživanja sprovedenog u preduzeću iz oblasti automobilske industrije koje ima iskustvo u primeni pomenute strategije. Ispitani su stavovi zaposlenih iz sektora logistike, proizvodnje i prodaje, jer su oni direktno uključeni u implementaciju analizirane strategije. Rezultati pokazuju da zaposleni prepoznaju veću izloženost rizičnim događajima pri korišćenju Just-in-Sequence strategije. Međutim, zabrinjavajuće je to što postoji neslaganje u stavovima zaposlenih iz različitih sektora koji učestvuju u primeni ove strategije.

Ključne reči: *rizici, lanac snabdevanja, automobilska industrija, just-in-time, just-in-sequence*

Introduction

The automotive industry today faces numerous challenges arising from its complex structure, as evidenced by the large number of participants and connections that need to be managed, as well as the variety of parts involved in the final product. Supply chains in the automotive industry are characterized by a logistics approach with strong inbound flows. This means that the supply side, or the upstream segment of the supply chain, is much more complex in terms of the number of suppliers and the various parts produced, which will then be assembled into the final product. In contrast, coordination in the downstream segment of the supply chain is easier to ensure, as the automotive market increasingly communicates directly with customers or through a single level of intermediaries. However, despite the downstream segment being less extensive than the upstream one, its complexity is influenced by market demands for numerous product variants. Automotive manufacturers aim to meet the individual needs of their customers through customized models and variants.

To maintain their position in the market, automotive manufacturers must be reactive, meaning they need to develop, produce, and distribute products more quickly. They are also expected to offer a diverse range of products at competitive prices. In this regard, they often face the dilemma of maintaining higher inventory levels to respond promptly to market demands or saving costs by keeping inventory levels lower to ensure cost efficiency. These two demands seem difficult to reconcile. However, the application of inventory management strategies, such as Just-in-Time (JIT), has enabled companies and global supply chains to secure a stable supply of raw materials and maintain stable inventory levels while achieving cost savings.

Given that customers today demand a wider range of products and component variations, this creates greater challenges for production systems based on the JIT strategy. Under such conditions, JIT leads to the need for more space [26], higher inventory levels, and increased material handling costs [1]. In this new environment, JIT is no longer the ideal solution for the automotive industry and mass customization.

Automotive manufacturers recognize that a higher degree of customization and responsiveness to specific customer requirements [29] can be achieved by increasing flexibility and reducing lead times, which can be accomplished through sequential delivery. As a result, companies in the automotive industry are facing new demands regarding changes in inventory management strategies and the adoption of a new approach known as Just-in-Sequence (JIS) [7][9].

JIS is an evolutionary advancement of the JIT concept [2]. Authors Werner, Kellner, Schenk, and Weigert (2003) explain that "Just-in-Sequence can be viewed as an enhancement of the Just-in-Time concept because, in addition to delivering parts at the right time, to the right place, in the right quantity, and in the right condition in terms of quality, it seeks to ensure that parts are delivered according to the right sequence" [7]. Thus, JIS adopts the basic procedure of JIT and adds the sequencing aspect [30]. The primary goal of JIS is to eliminate waste, reduce work-in-progress inventory levels, minimize storage space requirements, and shorten delivery times by implementing flexible and lean production [30]. By applying the JIS strategy, automotive manufacturing becomes much leaner than with the JIT strategy, ensuring higher efficiency [17]. However, a particular challenge is eliminating all factors that could serve as buffers in the event of a risk occurrence [31, p. 164]. In this context, buffers are a type of risk protection, such as excess inventory, additional supply sources, extra production capacities, and the like, which are used in conditions of unforeseen events in order to absorb disruptions. In this regard, it is necessary to examine the vulnerability of supply chains when applying the JIS strategy [19] [6] [11, p. 29] and the severity of the consequences in the event of a risk.

Literature review

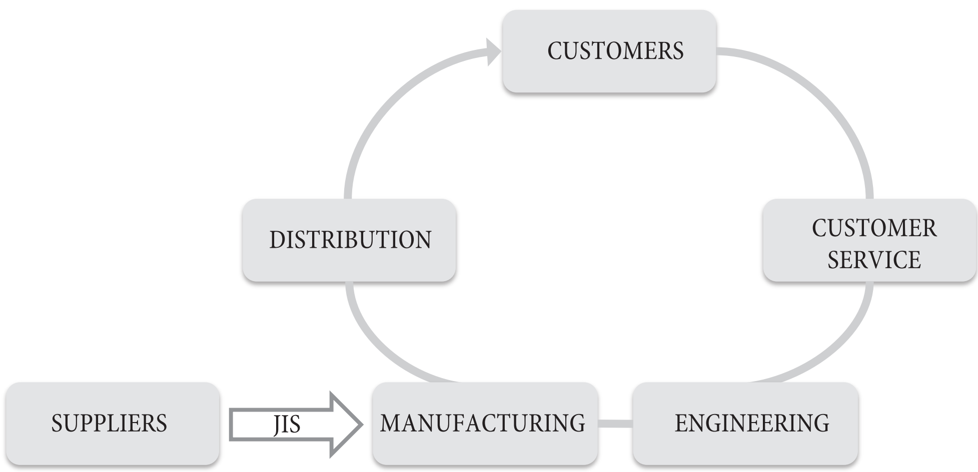
JIS represents an innovative approach that enables companies and supply chains to manage product and process complexity while responding more effectively to the demand for mass customization—something that JIT could not address. While JIT is defined as a method for delivering the right parts, in the right quantity, at the right time to the production line, JIS can be seen as its upgrade [2]. The JIS strategy involves receiving raw materials and other components at the right time, but in a precisely determined sequence [5] [3]. JIS is particularly characteristic of engineer-to-order products, where product specifications require a unique engineering design or significant customization. Each customer order necessitates cost evaluation and the determination of a special price. Orders are based on a unique set of components and a customized production route. Figure 1 illustrates a typical production process in a supply chain with the implementation of the JIS strategy. This represents a closed-loop supply chain.

In the automotive industry, the JIS strategy has become an increasingly common approach for inventory management. One of the earliest examples of the JIS strategy comes from Toyota Motor Manufacturing. This business case demonstrates how a seat supplier developed the capability to produce and deliver this component according to the required schedule. Initially, Toyota suggested that the seat supplier produce for stock and deliver according to the JIS strategy. However, the seat supplier argued that the production and transport time for the seats were short enough that, after the car painting process (the point at which the sequence is established due to variability in the painting process), the seats would be delivered to the factory on time for installation in the car. Moreover, the number of seat variants was large enough to require significant storage space, and this number continued to grow over time. The supplier was located just 30 minutes away from Toyota's factory, which also facilitated the implementation of the JIS strategy [13]. In addition to the automotive industry, this strategy is increasingly valued and adopted in industries known for mass customization, such as the production of electrical and electronic products, heavy machinery, furniture, and similar sectors.

Advantages of the JIS Strategy Over JIT

Key advantages of the JIS strategy compared to JIT include greater flexibility and responsiveness, shorter production cycles, lower inventory levels, and reduced space requirements [3], leading to enhanced competitiveness. With JIS, it is possible to completely eliminate the receiving area for raw materials or parts. Parts are delivered directly to the point of use—i.e., directly to assembly—according to a predefined sequence. This reduces the space required for final assembly and eliminates the need for storage space for different variants [16] [26]. JIS can also significantly reduce capital blockage by lowering inventory levels at both the manufacturer and the supplier [30]. Additionally, JIS ensures quick response times and effective cost control. One of the key competitive advantages of JIS is that this supply system is difficult to replicate. However, suppliers will need to reorganize their production processes, which may create an entry barrier for new suppliers. Building strong partnerships and fostering trust are essential to influencing the supplier's willingness to adjust their operations to meet the manufacturer's needs.

Figure 1: JIS strategy in supply chain



Source: [4]

Risks of the JIS Strategy Compared to JIT

While the advantages and disadvantages of the JIS strategy share similarities with those of the JIT strategy, JIS is generally riskier due to its increased sensitivity to potential disruptions in the production process [16] [19] [25]. These disruptions can often lead to a complete halt in production. As a result, the risks associated with JIS—such as delays, quality issues, information system failures, and transport damage—are similar to those of JIT. However, the negative consequences of risk events are typically more severe under JIS implementation [9] [8] [2] [6]. Table 1 provides an overview of potential risks that could lead to disruptions or interruptions in production under JIS implementation.

Table 1: Risks that can lead to disruptions and/or interruptions in the context of JIS strategy implementation

Category	Risks
Information technology	• Failure of the electronic data processing system • Inaccurate data • Delay in data transmission
Suppliers	• Incorrectly ordered quantities • Production disruptions due to machine breakdowns, issues with the delivery of own suppliers • Inaccurate labeling of parts (components) • Quality issues
Transport	• Extension of transport time due to congestion, weather conditions, obstacles, accidents • Damage to parts due to poor packaging
Customers	• Damage during assembly • Severe disruptions in production • Short-term changes in the production schedule

Source: [30]

The introduction of the JIS strategy has heightened sensitivity [6, p. 24] [25] to disruptions in the production process due to shortages, defective or incorrect parts, delays in delivery, or quality issues. Short-term disruptions, such as quality problems or missing parts, can jeopardize the production sequence. For instance, if a risk event occurs in the automotive industry, the affected vehicle is removed from the sequence, and the resulting gap is filled by moving subsequent vehicles forward. However, such changes in the sequence can lead to fluctuations in workload and potential overloads at assembly stations [12]. Disruptions often result in a complete shutdown of the assembly line, mainly because failures cannot be compensated by replacement parts, as these parts are specially manufactured according to a predefined schedule. Additionally, quality issues are difficult to resolve. Therefore, supplier guarantees are essential to ensure compliance with defined quality standards, while the value delivered to customers depends on their capabilities and potential [27, p. 181]. Sensitivity to disruptions in JIS also arises from its high level of complexity, as it requires a precise sequence of parts to be delivered just before assembly. Problems with information systems can result in incorrect or delayed deliveries. The transfer of information in JIS is more complex than in JIT, as it requires the transmission of details about specific variants to be delivered, while JIT only requires information about the component's serial number. Furthermore, there is a risk of dependency among supply chain participants. On one hand, the supplier must make significant investments to meet the manufacturer's requirements, while on the other hand, the manufacturer must rely on the supplier's reliability [30].

Due to the fact that the JIS strategy is leaner than the JIT strategy and has far fewer "buffers" available to mitigate risk events, the authors define the following hypothesis:

H1: *The risk of disruption in the supply chain is greater when a risky event occurs while applying the JIS strategy, compared to the JIT strategy.*

Additionally, due to the potential for a "ripple" effect in the event of a risk occurrence [33] [28] [14, p. 14] [22], it is necessary to examine the degree of correlation among these factors, leading to the following hypothesis:

H2: *There is a high degree of correlation between the independent variables (risk factors).*

Research Methodology – Defining Hypotheses, Sample, and Variables

Sharp competition, on one hand, and growing customer demands, on the other, have led to the shortening of product life cycles and increased demand volatility, which is becoming more uncertain and difficult to predict. In such conditions, the implementation of the JIS strategy can positively impact the efficiency of supply chains in the automotive industry, but it can also increase vulnerability. Given the characteristics of the JIS strategy in comparison to the JIT strategy, it is assumed that its implementation may further jeopardize the sustainability of supply chains in the event of a risk occurrence.

The research involves employees from sectors directly linked to the implementation of the JIS strategy, including logistics, production, and sale. Additionally, the sample consists of employees in managerial and leadership roles within these sectors, as well as material and sales analysts. These employees have the authority to make decisions regarding the implementation of the JIS system, making their opinions crucial for understanding the environment necessary for its successful implementation (see Table 2).

Table 2: Sample Structure

Position in the company	Manager	Team Leader	Shift Leader and Analyst	Total	%
Production	1	2	12	15	42
Logistics	1	2	8	11	31
Sale	1	1	8	10	28
Total	3	5	28	36	100
	8%	14%	78%		
Work Experience (in years)	8.67	4.80	2.61		
Education Level	College/ University	Community College	Secondary School		
	21	12	3		
	58.33%	33.33%	8.33%		

Source: Authors

By selecting a company from the automotive industry that acts as a supplier within its supply chain and applies the JIS strategy for delivering finished products to original equipment customers, the authors aim to assess the degree of exposure to risks. To maintain the company's anonymity in further research, the reasons for selecting this particular company are as follows:

- The company belongs to the automotive industry and is recognized as a model for implementing the JIS strategy [30] [32] [10] [15] [4] [21] [20].
- The company applies the JIS strategy in delivering its final product to customers.
- The company also uses the JIT strategy in both production and delivery processes, enabling employees to understand the benefits of both strategies and easily compare them.

Employees evaluated the variables related to risk factors based on their potential consequences, considering and comparing them with the experience gained during the implementation of the JIT strategy. The following variables were assessed: lack of quality raw materials (R1), diversification of the supplier network (R2), machine breakdowns in production (R3), delivery delays (R4), insufficiently trained workers (R5), lack of employee commitment (R6), changes in customer requirements (R7), changes in customer demand levels (R8), low flexibility (R9), and communication and coordination errors with suppliers/customers (R10). A Likert scale ranging from 1 to 5 was used for evaluation (with 1 representing the lowest rating and 5 the highest). The independent variables used in the analysis were work experience, education level, position, and sector (production, logistics, sale).

Results of the Analysis

Employees who participated in the study rated the risk of machine failure with a score above 4. This was also the only variable that received the lowest rating of 3. In fact, for 5 out of the 10 potential risk events, the minimum score assigned was 1. High ratings (above 3.00) for all risk events, except for R1 and R2, suggest that employees believe the consequences would be greater in the event of a risky occurrence when applying the JIS strategy, compared to the JIT strategy. However, considering that, in most cases, the risks analyzed by employees also received very low ratings (such as 1 or 2), it indicates that a certain number of employees disagree with the assumption presented in the cited literature. Therefore, cluster analysis was applied (see Table 3).

Table 3: Descriptive Statistics

	N	Min	Max	Mean	Std. Deviation
R1	36	1.00	5.00	2.7222	1.11127
R2	36	1.00	4.00	2.3056	.78629
R3	36	3.00	5.00	4.3333	.82808
R4	36	1.00	5.00	3.5000	1.05560
R5	36	1.00	5.00	3.5000	1.05560
R6	36	2.00	5.00	3.1389	.59295
R7	36	2.00	5.00	3.8611	.79831
R8	36	2.00	5.00	3.8056	.78629
R9	36	2.00	5.00	3.6111	1.02198
R10	36	1.00	5.00	3.7500	1.20416
Valid N (listwise)	36				

Source: Authors

By applying K-means cluster analysis, two clusters were identified based on the ratings given to the risk events and the severity of their consequences. The first cluster consisted of employees who assessed the risk events in a way that supports the confirmation of the first hypothesis. Notably, 70% of employees belonged to the first cluster, indicating their agreement with the defined assumption (see Tables 4 and 5).

Table 4: Final Cluster Centers

	Cluster	
	1	2
R1	3.12	1.82
R2	2.52	1.82
R3	4.64	3.64
R4	4.08	2.18
R5	4.08	2.18
R6	3.32	2.73
R7	4.28	2.91
R8	4.24	2.82
R9	4.20	2.27
R10	4.44	2.18

Source: Authors

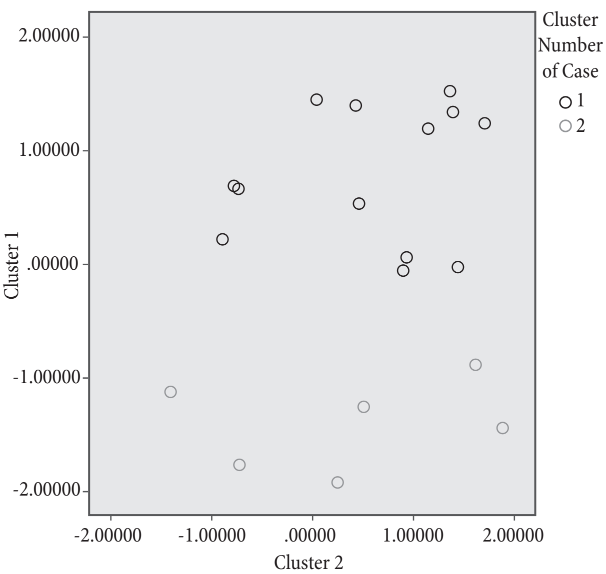
Table 5: Number of Cases in each Cluster

Cluster	1	25.000
	2	11.000
Valid		36.000
Missing		.000

Source: Authors

The visualization (Figure 2) shows the division of respondents into two clusters obtained through K-means cluster analysis. On the diagram, some respondent answers overlap at certain points, so not all 36 points can be visually distinguished. The visibly thickened points represent locations where multiple respondents gave identical ratings of the severity of risk events occurring under the conditions of JIS strategy application. In other words, the intensity of the point's color indicates the number of respondents who share the same rating for a particular risk.

Figure 2: Cluster visualization



Source: Authors

Further analysis focused on examining the correlation between membership in one of the two clusters and the independent variables. The authors aimed to determine whether perceptions of the severity and consequences of any of the analyzed risky events, in the case of applying the JIS strategy, were influenced by any of the independent variables (sector, position, experience, and education level). The correlation analysis between the dependent and independent variables indicated that further investigation into the impact of sector membership (production, logistics, sale) was warranted. A high degree of correlation, 0.626, was found in this case, with statistical significance of $p < 0.05$ (see Table 6).

Since it was determined that there is a correlation between sector membership and the ratings of the dependent variables, further cross-tabulation was performed. This analysis allows for the identification of the sectors from which employees assigned high ratings to the dependent variables. Table 7 shows that employees from the Production and Logistics sectors assessed the seriousness of the risk factors as much greater in the case of the JIS strategy, compared to employees from the Sales sector (see Table 7).

The Table 8 shows the level of agreement among employees regarding individual risk events. It is evident

Table 6: Paired Samples Correlations

		N	Corre-lation	Sig.
Pair 1	Sector & Cluster Number of Case	36	.626	.000
Pair 2	Position & Cluster Number of Case	36	.064	.709
Pair 3	Work Expirience & Cluster Number of Case	36	-.116	.499
Pair 4	Education Level & Cluster Number of Case	36	.089	.604

Source: Authors

Table 7: Crosstabulation: Cluster Number of Case * Sector

		Sector			Total
		Production	Logistics	Sell	
Cluster Number of Case	1	13	11	1	25
	2	2	0	9	11
Total		15	11	10	36

Source: Authors

that there is a high level of agreement between Production and Logistics, except in the cases of R1 and R10. Since the correlation analysis (Appendix 1) shows a high degree of correlation between R1 and the other dependent variables (except for R3), and R10 is correlated with the other dependent variables (except for R2), neglecting the importance of either of these two risk events could indirectly lead to the occurrence of other analyzed risk events. Production and Sales are aligned only in the cases of R1, R2, and R6, while Logistics and Sales are aligned only in the cases of R2 and R6.

What is particularly concerning about these results is that all three sectors agree on the seriousness of the consequences resulting from R2, yet there is no agreement regarding the importance of variables related to supplier management, especially variable R10. Additionally, the awareness of the seriousness of R6 across all three sectors is not reflected in the ratings of the significance of variables related to human resource management, as seen with variable R5.

According to Appendix 1, the correlation between R3 and R1 and R2 was not confirmed, which is somewhat expected, given that R3 relates to internal processes, while R1 and R2 concern supplier processes and relationships. However, what is concerning is that the correlation between R3 and R6 was not confirmed, especially because R6 is one of the few factors where employees recognized significant severity and consequences for the system if it occurs under the JIS strategy implementation conditions. Furthermore, employees do not recognize the correlation between R2 and R10, despite the fact that both variables fall under the domain of supplier management. Aside from the cases mentioned, there is a high degree of correlation among the analyzed variables. This points to the possibility of a "ripple" effect, meaning that the occurrence of one risk event under JIS strategy implementation conditions can lead to others.

Conclusion Remarks

In global competition, automobile manufacturers and their suppliers face the demand to produce faster and cheaper, especially according to individual requirements. Manufacturers in the automotive industry must offer a wide range of products and numerous variants. Additionally, the automotive industry is under pressure to shorten delivery times to customers. The inevitable consequence of these demands is an increasing complexity of products and processes. Therefore, the primary goal of new production and logistics concepts developed in the automotive industry

Table 8: Test Statistics

Production/Logistics	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10
Mann-Whitney U	2.000	55.000	63.500	55.000	55.000	58.500	50.000	68.500	68.500	29.500
Wilcoxon W	122.000	175.000	183.500	175.000	175.000	178.500	170.000	188.500	188.500	149.500
Z	-4.349	-1.601	-1.340	-1.693	-1.693	-1.531	-1.912	-.897	-.897	-3.068
Asymp. Sig. (2-tailed)	.000	.109	.180	.090	.090	.126	.056	.370	.370	.002
Exact Sig. [2*(1-tailed Sig.)]	.000[b]	.164[b]	.330[b]	.164[b]	.164[b]	.217[b]	.097[b]	.474[b]	.474[b]	.004[b]
Production/Sale	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10
Mann-Whitney U	73.500	73.500	30.000	4.000	4.000	74.500	15.500	14.000	2.000	2.000
Wilcoxon W	128.500	128.500	85.000	59.000	59.000	129.500	70.500	69.000	57.000	57.000
Z	-.093	-.093	-2.657	-4.109	-4.109	-.037	-3.631	-3.633	-4.271	-4.246
Asymp. Sig. (2-tailed)	.926	.926	.008	.000	.000	.970	.000	.000	.000	.000
Exact Sig. [2*(1-tailed Sig.)]	.935[b]	.935[b]	.012[b]	.000[b]	.000[b]	.978[b]	.000[b]	.000[b]	.000[b]	.000[b]
Logistics/Sale	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10
Mann-Whitney U	1.500	36.000	8.000	.000	.000	37.000	7.000	4.000	.000	.000
Wilcoxon W	56.500	91.000	63.000	55.000	55.000	92.000	62.000	59.000	55.000	55.000
Z	-3.918	-1.459	-3.575	-4.069	-4.069	-1.605	-3.590	-3.823	-4.111	-4.118
Asymp. Sig. (2-tailed)	.000	.145	.000	.000	.000	.108	.000	.000	.000	.000
Exact Sig. [2*(1-tailed Sig.)]	.000[b]	.197[b]	.000[b]	.000[b]	.000[b]	.223[b]	.000[b]	.000[b]	.000[b]	.000[b]

a. Grouping Variable: Sector
b. Not corrected for ties.
Source: Authors

is to enable mass production of highly customized products while ensuring maximum efficiency of the production system, i.e., transitioning from mass production to mass customization [18].

Despite the potential of JIT to improve the delivery process of standard products by reducing inventory levels, it fails to offer solutions for products with numerous variants. As a result, the JIS strategy found its application in the automotive industry. However, like the JIT strategy, the JIS strategy also faces certain limitations. One of the key issues is the increased exposure of the supply chain to risk events and the reduced resilience of the system.

The results presented in this paper confirm that employees in the company under investigation recognize the dangers associated with the implementation of the JIS strategy. The elimination of buffers that could mitigate the consequences of a risk occurrence is a critical issue for this strategy [31]. Considering the estimated severity of the consequences associated with certain risk events, it can be concluded that employees are aware of the problems inherent in the JIS strategy [6, p. 24] [25].

However, it is concerning that employees from different sectors seem to perceive things differently, especially since previous research indicates that decentralization and coordination can directly affect performance, particularly delivery lead times [24]. This could be particularly problematic in cases where a risk event occurs, due to potential disagreements regarding the measures and steps to be taken to eliminate or mitigate the consequences. Furthermore, the high degree of correlation among the analyzed risk events emphasizes the need for alignment among employees in sectors directly involved in the implementation of the JIS strategy. The strong correlation points to the possibility of a ripple effect, where the occurrence of one risk event could trigger others that are correlated with it [33] [28] [14, p. 14] [22].

Managerial Implications

Undoubtedly, the JIS strategy brings numerous benefits. Therefore, it is unrealistic to expect the strategy to be eliminated due to the anticipated increase in supply chain vulnerability. However, certain steps and actions can be taken to mitigate the negative effects of the JIS strategy.

The direct transmission of delivery schedule information is particularly important for continuous supply and production. Without such information, problems would immediately arise on the manufacturer's production line. Therefore, information systems must be reliable and efficient [8] [25] and guarantee smooth information flow [10].

Additionally, the limitations of the JIS strategy can be mitigated by signing contracts among supply chain participants [8] [3]. It is necessary to integrate suppliers based on building and maintaining long-term relationships through shared risk, cost, and information management [5] [25]. Supplier reliability must be extremely high to avoid disruptions and rework due to quality issues [23], and employees must be well-trained and qualified.

There are also proposals for adopting hybrid models, that is, combinations of JIS and JIT elements aimed at exploiting the advantages of both models and minimizing risks, which include elements of the JIS strategy along with buffer stock [31, p. 168]. These hybrid models may be a suitable solution, especially considering that many companies in the automotive industry that previously implemented the JIT strategy transitioned to a Just-in-Case strategy during the COVID-19 pandemic [11, p. 30].

Study Limitations

The conducted research may serve as a pilot study, given that it involved only one company and its internal employees. The fact that only employees directly involved in the implementation of the JIS strategy, and who also have experience with the JIT strategy, were surveyed, limits the generalizability of the findings. However, the results presented can be used as a basis for future research into system vulnerabilities under the JIS strategy.

This could include, for example, the involvement of upstream and downstream partners in the analysis, as the study demonstrated a high degree of correlation among the analyzed risks. Just as risks can spread among sectors within a company, they can also affect other partners in the supply chain. Moreover, since the results of this analysis show that the Sales sector stands out in comparison to Production and Logistics in terms of not recognizing the increased vulnerability associated with the JIS strategy, it raises questions about the level of engagement of the Sales sector in the implementation and execution of the JIS strategy.

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Appendix 1: Correlations between dependent variables

		R1	R2	R3	R4	R5	R6	R7	R8	R9	R10
R1	Pearson Correlation	1	,721**	,321	,560**	,560**	,581**	,664**	,590**	,506**	,587**
	Sig. (2-tailed)		,000	,056	,000	,000	,000	,000	,000	,002	,000
	N	36	36	36	36	36	36	36	36	36	36
R2	Pearson Correlation	,721**	1	,015	,465**	,465**	,764**	,343*	,561**	,365*	,294
	Sig. (2-tailed)	,000		,933	,004	,004	,000	,041	,000	,028	,082
	N	36	36	36	36	36	36	36	36	36	36
R3	Pearson Correlation	,321	,015	1	,621**	,621**	,136	,591**	,453**	,461**	,544**
	Sig. (2-tailed)	,056	,933		,000	,000	,430	,000	,005	,005	,001
	N	36	36	36	36	36	36	36	36	36	36
R4	Pearson Correlation	,560**	,465**	,621**	1	1,000**	,571**	,695**	,809**	,821**	,820**
	Sig. (2-tailed)	,000	,004	,000		,000	,000	,000	,000	,000	,000
	N	36	36	36	36	36	36	36	36	36	36
R5	Pearson Correlation	,560**	,465**	,621**	1,000**	1	,571**	,695**	,809**	,821**	,820**
	Sig. (2-tailed)	,000	,004	,000	,000		,000	,000	,000	,000	,000
	N	36	36	36	36	36	36	36	36	36	36
R6	Pearson Correlation	,581**	,764**	,136	,571**	,571**	1	,344*	,611**	,422*	,370*
	Sig. (2-tailed)	,000	,000	,430	,000	,000		,040	,000	,010	,026
	N	36	36	36	36	36	36	36	36	36	36
R7	Pearson Correlation	,664**	,343*	,591**	,695**	,695**	,344*	1	,775**	,737**	,825**
	Sig. (2-tailed)	,000	,041	,000	,000	,000	,040		,000	,000	,000
	N	36	36	36	36	36	36	36	36	36	36
R8	Pearson Correlation	,590**	,561**	,453**	,809**	,809**	,611**	,775**	1	,899**	,852**
	Sig. (2-tailed)	,000	,000	,005	,000	,000	,000	,000		,000	,000
	N	36	36	36	36	36	36	36	36	36	36
R9	Pearson Correlation	,506**	,365*	,461**	,821**	,821**	,422*	,737**	,899**	1	,940**
	Sig. (2-tailed)	,002	,028	,005	,000	,000	,010	,000	,000		,000
	N	36	36	36	36	36	36	36	36	36	36
R10	Pearson Correlation	,587**	,294	,544**	,820**	,820**	,370*	,825**	,852**	,940**	1
	Sig. (2-tailed)	,000	,082	,001	,000	,000	,026	,000	,000	,000	
	N	36	36	36	36	36	36	36	36	36	36

**. Correlation is significant at the 0.01 level (2-tailed).
*. Correlation is significant at the 0.05 level (2-tailed).
Source: Authors