

Influence Of Global Supply Chain Disruptions To Apparel Industry In North Macedonia: Secondary Data Evaluation From COVID-19 And Transport Shocks Time Base

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Jusuf Ajrula¹, Riste Temjanovski², Emilija Miteva-Kacarski³

¹ PhD Student, Goce Delcev University, Faculty of Economics, Krste Misirkov St.10 n- A, North Macedonia, e-mail: jusuf.30831@student.ugd.edu.mk

² Professor, Goce Delcev University, Faculty of Economics, Krste Misirkov St.10 n- A, North Macedonia, e-mail: riste.temjanovski@ugd.edu.mk

³ Professor, Goce Delcev University, Faculty of Economics, Krste Misirkov St.10 n- A, North Macedonia, e-mail: emilija.miteva@ugd.edu.mk

Abstract

This paper examines the impact of global supply chain disruptions on the apparel production of textile sector in North Macedonia, with particular emphasis on the COVID-19 period and the subsequent transport and logistics shocks. The study is based on a quantitative approach and uses secondary monthly data for the period 2019–2024. The apparel production index is used as the dependent variable, while oil prices, container transport costs, textile input inflows, and dummy variables for crisis and shock periods are included as independent variables. The analysis applies descriptive statistics, comparative analysis, one-way ANOVA, Pearson correlation analysis, and multiple linear regression. The findings indicate that the hypotheses for statistically significant differences in production performance between pre-crisis, crisis and post-crisis periods is being confirmed. The regression results show that textile input inflows have a positive and statistically significant effect on production, whereas the transport shock has a strong negative and statistically significant effect. Hypothesis based on individual effect of oil price change and price change of container transport for supply of input materials, gains partial support in descriptive statistics, graphical and correlational analysis, but they are not being confirmed completely at multiple regression model. The paper concludes that the apparel industry in North Macedonia is highly sensitive to disruptions in supply chain and transport, therefore for best performance of the apparel industry great accent needs to be stated on stability of the supply chain and ability to deal with transport shocks. For future endurance of this sector, we have to highlight the need for greater resilience, supplier diversification, better safety stock management and improved logistics risk management.

Keywords: Apparel industry in North Macedonia, COVID-19, Supply chain, Textile inputs, Transport shocks

1. Introduction

In conditions of deepening globalization, supply chains are one of the key mechanisms for the functioning of modern production and international trade. The efficiency of production sectors today largely depends on the timely supply of raw materials, stable transport flows and reliable international logistical connections. However, the last few years have shown that global supply chains are extremely sensitive to crisis disruptions, such as pandemics, energy shocks, transport restrictions and geopolitical tensions. These factors have caused delays in deliveries, rising transport costs and increased uncertainty in the provision of production inputs.

The textile and apparel sector in North Macedonia is particularly exposed to such external disruptions. Its functioning depends largely on the import of textile raw materials, as well as on the smooth running of international transport and logistics processes. In such conditions, any disruption in the global supply chain can directly affect production, exports, costs and the overall competitiveness of the sector. Particularly, in this research, pronounced consequences were observed during the COVID-19 pandemic and then during the period of transport and logistics shocks, when the prices of container transport and energy increased significantly.

Having in consideration the importance of this sector for the country economy, it is necessary to analyze in more depth the way in which global disruptions spill over into the textile and apparel production sector in North Macedonia. In this regard, this paper aims to examine the impact of selected global and logistical factors on apparel production, using secondary data for the period 2019–2024. In doing so, special attention is paid to the effects of oil prices, container transport prices, textile raw materials imports, and crisis-shock periods on the apparel production index.

The research is significant from a theoretical and practical perspective. From a theoretical perspective, it contributes to understanding the relationship between global supply chain disruptions and sectoral production performance. From a practical perspective, the results can provide useful insights for companies in the apparel industry, as well as for economic policymakers, in order to strengthen resilience, improve supply strategies and reduce the vulnerability of the sector in future crisis situations.

2. Literature review

A supply chain is a system of interconnected activities, participants, and flows through which raw materials, semi-finished products, information, and finished goods move from suppliers to end users (Seuring & Müller, 2008). In a globalized economy, supply chains are characterized by a high level of international connectivity, geographical dispersion, and dependence on transport and logistics networks. It is this interdependence that enables efficiency and cost optimization, but at the same time creates greater exposure to risks, as an interruption or disruption in one part of the chain can be transmitted to the entire production system (Pires Ribeiro & Barbosa-Povoa, 2018). The literature on supply chain resilience emphasizes that modern chains, especially those that rely on global supply and lean models, are more vulnerable to shocks, so in addition to efficiency, the issue of resilience and adaptability also is emphasized (Birkie, 2016).

In recent literature, supply chain resilience is most often understood as the ability of the chain to be prepared for disruptions, absorb their effects, adapt, and recover with minimal performance losses (Rahman et al., 2022). Systematic literature reviews show that key elements of resilience

are flexibility, visibility, collaboration, spare capacity, multiple supply and inventory management. Hence, in modern conditions, supply chain management is no longer just about reducing costs, but also about ensuring continuity and stability in conditions of uncertainty (Ma et al., 2025).

Global supply chain disruptions can derive from a variety of sources, such as pandemics, natural disasters, geopolitical conflicts, energy crises, transportation bottlenecks, and regulatory changes (Cagri Gurbuz et al., 2023). In such conditions, disruptions typically manifest themselves through delays in deliveries, limited availability of inputs, rising transportation costs, and price volatility. Contemporary literature increasingly emphasizes the shift from a classic, efficiently optimized supply chain to a more resilient model that includes alternative suppliers, better inventory management, and greater organizational preparedness for shocks (Nikookar et al., 2024).

Supply chain disruptions can occur due to significant natural disasters, severe weather conditions, wars and political instability, export/import restrictions, terrorism, economic downturns, delays in information and communications, and/or breakdowns in transportation infrastructure (Zhang et al., 2024). In addition, supply chain disruption encompasses vulnerability and disruption of the supply chain process caused by unknown events, resulting in negative effects on productivity, product quality, and delivery capacity of the entire supply chain (Song et al., 2024).

The COVID-19 pandemic represents one of the most significant global shocks to supply chains in recent economic history. Research shows that sectors that were more heavily exposed to imports of intermediate goods from China faced larger declines in production, imports, exports and employment, as well as increases in input and output prices (Meier & Pinto, 2024a).

While supply chain management (SCM) plays a key role in virtually every industry, its importance in the apparel sector is particularly pronounced. This is primarily due to the constant evolution of fast fashion trends and micro-seasons, which have a profound impact on the entire industry (Singh et al., 2024). The rapid rate at which customer preferences change forces fashion retailers to maintain a wide range of products to meet their demands. Consequently, the product life cycle in the industry is becoming extremely short. Even before new merchandise hits the shelves, the fashion industry is already producing new styles, ensuring that they stay ahead of the curve as current trends in stock go out of style. Moreover, before the involvement of wholesalers and retailers, the apparel industry's complex supply chain begins with manufacturers who make fibers, textiles, and finished garments. This highlights the need for a well-structured logistics management system within the industry to continuously move new products through the supply chain and effectively monitor the flow of inventory throughout the operation (Dawn Downes, 2021).

The fashion industry faces tremendous challenges in forecasting demand. With short product life cycles and rapidly changing trends, new season's products do not have sales history. This lack of data, such as sales figures from the previous year, makes it difficult for retailers to assess product performance. Trends are influenced by a variety of factors, including media, individual influencers, weather forecasts, and economic conditions, which are often unpredictable. Predicting whether a popular trend from the previous year will continue or fade from the market is no easy task. In addition, consumer preferences are constantly evolving, further complicating the forecasting process (Dawn Downes, 2021).

In the apparel industry, it is imperative for companies to navigate between shortages and overstocks, especially given the condensed fashion seasons. Shortages at critical times can profoundly impact seasonal sales, while excess inventory can erode profitability and waste valuable retail space. Effective supply chain management is key to maintaining a steady flow of products, arriving just in time to meet current demands. Without a robust SCM structure, apparel brands and retailers risk failing to meet consumer expectations.

UNCTAD (United Nations Trade and Development) emphasized that textile and apparel chains are highly integrated at a global level and that many developing countries are involved as production bases or as suppliers of lower-cost inputs. For this reason, the sector is particularly

vulnerable when logistical flows are disrupted, when demand declines, or when transport and energy costs rise sharply (Teodoro & Rodriguez, 2020).

One of the most important channels through which global disruptions affect production is transport. UNCTAD states that over 80% of world trade by volume is carried by sea, meaning that disruptions to key maritime routes and chokepoints have broad economic significance (REVIEW OF MARITIME TRANSPORT : Navigating Maritime Chokepoints, 2024). UNCTAD's maritime transport reports show that in 2024, extended routes, geopolitical tensions and disruptions in key sea straits put pressure on costs and supply chains and the maritime transport review also notes new peaks in container tariff indices (REVIEW OF MARITIME TRANSPORT : Navigating Maritime Chokepoints, 2024).

The price of oil is closely linked to transportation and logistics costs, as it affects the price of fuels, freight, and the movement of goods. The World Bank and the IMF regularly monitor global crude oil prices as a key macroeconomic and cost indicator (World Bank Group, n.d.).

The COVID-19 pandemic has significantly impacted countries around the world, both economically and socially. This global health crisis has disrupted the core work process of national and international economies, affecting business operations, trade, and social interactions (Fang, 2025). One of the most affected areas are the industrial and global supply chains, especially in the manufacturing sector, which includes the textile and apparel sector too. Following the outbreak of COVID-19, many manufacturing plants in North Macedonia faced a shortage of raw materials. Suppliers in various regions had to stop production due to lockdown measures, forcing factories that depend on these inputs to operate at reduced capacity or, in some cases, to stop production altogether. As a result, there was a significant drop in production. Manufacturers in North Macedonia, as in other countries in the region, quickly shifted from apparel production to the production of masks to protect against the virus during this period. Such production led to new investigations into materials, which again could not be reached and produced in a timely manner due to the pandemic, partly due to limited production and stockouts, partly due to closed transport channels and restrictions.

In this period of disrupted supplies and deliveries, some sort of institutional responses has emerged. Governments in some garment-producing countries have provided financial support and policy incentives to help the industry survive (Sarasi et al., 2023). In this tough period, e-commerce has played a key role. Many apparel retailers that previously relied mainly on physical stores have shifted their focus to online sales. Brands like H&M and Uniqlo have increased their investments in e-commerce platforms, improved their online shopping experiences, and improved their digital marketing strategies. This has helped them reach consumers who were unable or unwilling to visit physical stores during the pandemic (Sharma et al., 2024).

For the apparel industry, these strategies are particularly important due to the dependence on the timely availability of fabrics, yarns, accessories and other textile inputs. Even when there is demand in foreign markets, disruptions in supply and transportation can limit production and exports (Teodoro & Rodriguez, 2020). Hence, resilience should not only be understood as the ability to return to normal, but also as the ability to reorganize procurement, reorient logistics solutions and maintain production continuity in conditions of prolonged uncertainty.

Existing literature clearly confirms that global disruptions can strongly affect manufacturing and trade sectors, with the apparel industry being among the most sensitive due to its dependence on global value chains, imported inputs, and time-sensitive logistics (Meier & Pinto, 2024b). However, much of the study focuses on large global manufacturing centers or on firms in Asia and larger markets, while significantly less attention is paid to small, open economies and their sectoral production effects (Mostafiz et al., 2022). This is exactly where this paper positions itself: it focuses on the apparel industry in North Macedonia and, through secondary monthly data, analyzes how the price of oil, the price of container transport, the entry of textile raw materials, and crisis-shock periods are related to apparel production. Thus, the paper seeks to make an

empirical contribution to the understanding of supply chain disruption and resistance in the context of a small economy strongly connected to international supply and export flows.

3. Conceptual Model and Hypotheses

This research explores the impact of global supply chain disruptions on the performance of the textile and apparel manufacturing sector in North Macedonia. The aim of the research is to analyze how global supply chain crises, particularly COVID-19 and increasing transportation costs, have affected the performance of the textile and apparel manufacturing sector in North Macedonia.

The research covers the effects of several consecutive crisis periods: the COVID-19 pandemic in 2020–2021, the transport shock in 2021–2022, when container transport prices increased significantly, as well as new logistical disruptions in 2023–2024, related to disruptions in transport routes across the Red Sea.

This model observes effects on the performance of the textile sector for apparel production in North Macedonia caused by:

- Crude oil price
- Container transport price from the Far East (China)
- Total imports of textile materials and raw materials

In this model, apparel production is the dependent variable, while the price of crude oil, the price of container transport, and total imports of textile materials and raw materials are independent variables. Accordingly, the following hypotheses are set:

H1: The global increase in oil prices has a negative impact on apparel production in North Macedonia.

H2: Higher transportation costs have a negative impact on apparel production in North Macedonia.

H3: In the face of global supply chain disruptions, changes in total imports of textile materials and raw materials are significantly linked to changes in apparel production in North Macedonia.

H4: There are statistically significant differences in the performance of the apparel industry in North Macedonia between the pre-crisis, crisis and post-crisis periods.

4. Research Methodology

The research is based on secondary data collected from national and international relevant statistical sources. The data are taken from official institutions and databases that provide time series for economic, trade and logistics indicators related to the textile manufacturing industry and the factors affecting its functioning (Appendix 1 showing data sources).

The time frame of the research covers the period 2019–2024, in order to analyze the developments in the textile and apparel industry in North Macedonia before the crisis, during the crisis and in the post-crisis period. The choice of this time interval allows for a clear comparison between different economic phases and their effects on the sector. Monthly data are used, due to their greater analytical value in monitoring short-term disruptions.

For the purposes of the analysis, the dependent variable used in the research is the apparel production in North Macedonia, which will be operationally represented through an appropriate statistical indicator, i.e. the industrial production index for the apparel production sector.

The following factors are included as independent variables:

- Crude oil price.

- Container shipping cost from China/Far East.
- Total imports of materials and raw materials.

In addition to the basic independent variables, the analysis also includes control or auxiliary variables, such as:

- Dummy variable for the COVID-19 crisis, which takes the value 1 for the crisis period and 0 for the remaining periods;
- dummy variable for transport shock, which takes the value 1 for periods of pronounced transport disruptions and 0 in the remaining periods;

For the purposes of the research, at a first place a descriptive statistical analysis will be conducted, through which the basic characteristics of the data will be presented. In addition to the descriptive analysis, a comparative analysis will also be applied, through which the movements of the dependent variable and other key indicators between different time periods will be compared. The central analytical instrument in the research is regression analysis, through which the influence of the independent variables on the dependent variable will be examined. Through this method, it will be analyzed whether and to what extent changes in the price of crude oil, container transport costs and the level of material imports are related to changes in apparel production in North Macedonia.

In its simplest form, the analytical model can be represented as follows:

$$Y_t = \beta_0 + \beta_1 OIL_t + \beta_2 TRANS_t + \beta_3 IMPORT_t + \beta_4 COVID_t + \beta_5 SHOCK_t + \varepsilon_t$$

5. Results and Discussion

This chapter presents the results of the analysis of secondary data, where first a descriptive analysis of the basic variables is performed, which allows to identify the initial changes in clothing production, as well as to perceive the movements of the price of crude oil, container transport costs and the overall import of materials and raw materials. Then a comparative analysis is applied, which compares the performance of the clothing industry in three different time periods: the pre-crisis period, the crisis period and the post-crisis period. Such a division allows to determine whether the crises caused significant changes in production indicators. The main output is a regression analysis, in order to statistically examine the impact of the independent variables on the dependent variable, i.e. apparel production in North Macedonia.

5.1. Descriptive statistics

The descriptive analysis covered six key variables: the apparel production index, the price of crude oil, the price of container transport, the input of textile raw materials, the transport CPI and the export of clothing. The analysis was carried out on a total of 72 monthly observations, covering the period from January 2019 to December 2024.

Table 1 Descriptive data analysis

	N	Minimum	Maximum	Mean	Std. Deviation
Confectionary index	72	56,1	147,4	102,8042	19,65279
Crude oil price	72	19,23	114,38	68,6478	19,18375
Container transport price	72	716,37	5260,10	2131,0408	1417,11255
Textile raw materials input	72	20844,00	49336,00	36651,8750	5490,42287
Transport CPI	72	88,79	132,95	103,8471	9,84816

Apparel export	72	21257,00	46538,00	33121,2778	5605,39635
Valid N (listwise)	72				

The results show that the apparel production index has an average value of 102,80, with a minimum value of 56,10 and a maximum value of 147,40, while the standard deviation is 19,65. This indicates significant oscillations in production activity in the observed period, which is expected given the presence of multiple crisis and post-crisis phases.

The average crude oil price in the analyzed period is 68,65 USD, with a minimum value of 19,23 USD and a maximum value of 114,38 USD, with a standard deviation of 19,18. This range indicates high volatility of energy prices, which is relevant from the perspective of transportation and production costs.

For the price of container transport, the average value is 2.131,04, while the minimum and maximum values are 716,37 and 5.260,10, with a very high standard deviation of 1.417,11. This variable shows the most pronounced instability among the analyzed indicators, which indicates strong fluctuations in global transport costs, especially in periods of disruption of international logistics flows.

In terms of textile raw material inputs, the average monthly value is 36.651,88, with a minimum of 20.844,00 and a maximum of 49.336,00, with a standard deviation of 5.490,42. These values indicate relatively significant changes in the import supply of the textile input sector, which is an important factor for the production capacity of the clothing industry.

In general, the descriptive analysis shows that all analyzed variables show some dynamics in the observed period, but the most pronounced oscillations are observed in the price of container transport, the index of ready-made clothing production and clothing exports. This guides to the conclusion that the clothing industry in North Macedonia has operated under conditions of significant external instability, which creates a good basis for further comparative and regression analysis.

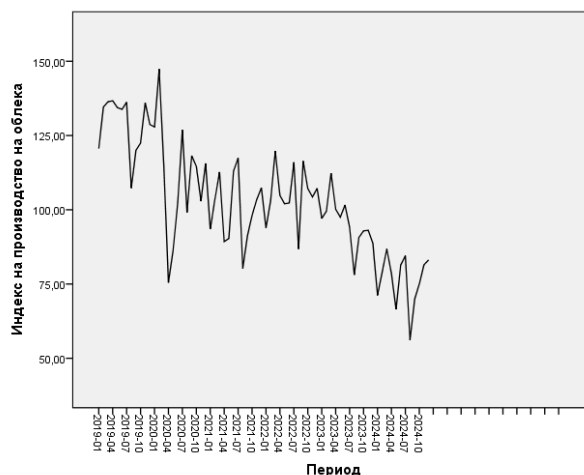


Figure 1 Movement in the clothing production index (2019-2024)

The apparel production index in North Macedonia for the period 2019–2024 (Figure 1) shows pronounced oscillations in production activity. In the pre-crisis period, relatively higher index values were observed, while in 2020 a significant decline was evident, which can be linked to the negative effects of the COVID-19 pandemic on industrial production and supply chains. In the following years, a partial recovery is present, but with frequent fluctuations, indicating continued instability in the sector. During 2024, a downward trend in the index is again observed, indicating that the apparel industry remained sensitive to external economic and logistical disruptions.

5.2. Comparative analysis of performance by periods

In order to see the differences in the movement of key indicators across different economic phases, a comparative analysis was conducted for three time periods: pre-crisis period (2019), crisis period (2020–2021) and post-crisis period (2022–2024). The analysis covered the apparel production index, crude oil price, container transport price, textile raw material imports and clothing exports.

Table 2 Results from Pearson correlation analysis

Group period		Index of confection	Crude Oil Price	Container transport price	Textile raw mat. input	Apparel export
1	Mean	128,9333	57,3100	819,7317	37434,9167	36231,1667
	N	12	12	12	12	12
	Std. Deviation	9,35748	3,31919	69,25649	5226,53063	4037,03712
	Minimum	107,30	53,49	716,37	28833,00	28635,00
	Maximum	136,70	63,83	942,57	45883,00	43347,0
2	Mean	105,4833	53,4050	2459,6242	33036,7083	29646,0000
	N	24	24	24	24	24
	Std. Deviation	16,51407	17,65746	1442,06532	5090,73559	4443,17215
	Minimum	75,50	19,23	855,92	20844,00	21257,00
	Maximum	147,40	83,50	4807,30	41297,00	41225,00
3	Mean	92,3083	82,5889	2349,0883	38800,9722	34401,5000
	N	36	36	36	36	36
	Std. Deviation	14,98184	11,61450	1411,81850	4648,93515	5688,57717
	Minimum	56,10	68,0	886,65	29390,00	21495,00
	Maximum	119,80	114,38	5260,10	49336,00	46538,00
Total	Mean	102,8042	68,6478	2131,0408	36651,8750	33121,2778
	N	72	72	72	72	72
	Std. Deviation	19,65279	19,18375	1417,11255	5490,42287	5605,39635
	Minimum	56,10	19,23	716,37	20844,00	21257,00
	Maximum	147,40	114,38	5260,10	49336,00	46538,00

The results in Table 2 shows that the average index of apparel production is highest in the pre-crisis period, when it is 128,93. In the crisis period, the average value decreases to 105,48, while in the post-crisis period it further drops to 92,31. These results indicate a clear deterioration in the production performance of the industry during the analyzed period, with no complete return to the pre-crisis level observed even in the post-crisis period.

In terms of crude oil prices, during the post-crisis period has seen a significant increase, with the average price reaching USD 82,59. This indicates increased energy pressure in the post-crisis years, which potentially affected the sector's transport and production costs.

The price of container transport shows even more pronounced differences between periods. In the pre-crisis period, the average value was 819,73, while in the crisis period it sharply increased to 2.459,62. In the post-crisis period, it remained at a high level and accounted to 2.349,09, which shows that despite a certain decrease, transport costs continued to be significantly higher than before the crisis.

The comparative analysis shows that the North Macedonian apparel industry was significantly affected by the crises during the analyzed period. These results provide strong initial empirical

support for the hypothesis that there are significant differences in sectoral performance between the pre-crisis, crisis and post-crisis periods.

In order to examine whether there are statistically significant differences in the apparel production index between the pre-crisis, crisis and post-crisis periods, a one-way analysis of variance (One-Way ANOVA) was applied. Before conducting the ANOVA, a Levene test was performed to check the homogeneity of variances. The results showed that the assumption of equality of variances was met, $F(2, 69) = 1,703$, $p = 0,190$.

Table 3 Results of one-way analysis of variance (ANOVA)

	Sum of Squares	df	Mean Square	F	Sig.
Between groups	12330,921	2	6165,461	28,189	,000
Within Groups	15091,567	69	218,718		
Total	27422,489	71			

The results of the one-way analysis of variance (table 3) showed that there are statistically significant differences in the apparel production index between the analyzed periods, $F(2, 69) = 28,189$, $p < 0,001$. This result confirms that the performance of the apparel industry in North Macedonia differed significantly between the pre-crisis, crisis and post-crisis periods.

Based on the results obtained, *hypothesis X4 is accepted*, i.e. it is confirmed that there are statistically significant differences in the performance of the apparel industry in North Macedonia between the pre-crisis, crisis and post-crisis periods.

5.3. Correlation analysis (Pearson correlation) and Multiple regression analysis by the impact of global disruptions on apparel production

In order to examine the interrelationships between the analyzed variables, Pearson correlation analysis was conducted. The results shown in table 7 show that the apparel production index has a statistically significant negative correlation with the price of oil ($r = -0,278$; $p = 0,018$) and with the price of container transport ($r = -0,272$; $p = 0,021$). These results indicate that higher energy and transport costs are associated with lower values of apparel production in North Macedonia.

Table 7 Pearson correlation analysis

		Confectionary Index	Crude Oil Price	Container Transport Price	Textile Raw Mat. Inputs	Transport CPI	Apparel export
Confectionary Index	Pearson correlation	1	-,278)*	-,272)*	,178	-,082)	,496**
	Sig. (2-tailed)		,018	,021	,136	,492	,000
	N	72	72	72	72	72	72
Crude Oil Price	Pearson correlation	-,278)*	1	,557**	,432**	,710**	,253*
	Sig. (2-tailed)	,018		,000	,000	,000	,032
	N	72	72	72	72	72	72
Container Transport Price	Pearson correlation	-,272)*	,557**	1	-,002)*	,657**	-,269)*
	Sig. (2-tailed)	,021	,000		,989	,000	,022
	N	72	72	72	72	72	72
Textile Raw Mat. Inputs	Pearson correlation	,178	,432**	-,002)*	1	,218	,373**
	Sig. (2-tailed)	,136	,000	,989		,066	,001
	N	72	72	72	72	72	72
Transport CPI	Pearson correlation	-,082)*	,710**	,657**	,218	1	,062
	Sig. (2-tailed)	,492	,000	,000	,066		,604

	N	72	72	72	72	72	72
Apparel export	Pearson correlation	,496**	,253*	-,269)*	,373**	,062	1
	Sig. (2-tailed)	,000	,032	,022	,001	,604	
	N	72	72	72	72	72	72

*correlation is significant at the 0.05 level (2-tailed)

**correlation is significant at the 0.01 level (2-tailed)

On the other hand, the correlation between the apparel production index and the input of textile raw materials is positive, but statistically insignificant ($r = 0,178$; $p = 0,136$). Similarly, the transport CPI does not show a statistically significant relationship with the apparel production index ($r = -0,082$; $p = 0,492$). Regarding clothing exports, there is a positive and statistically significant correlation with the apparel production index ($r = 0,496$; $p < 0,001$), indicating that a higher level of production is associated with higher export performance of the sector.

The correlation analysis also shows relatively high and statistically significant relationships between some of the independent variables, especially between the price of oil and the transport CPI ($r = 0,710$; $p < 0,001$), as well as between the price of oil and the price of container transport ($r = 0,557$; $p < 0,001$). These results indicate the possibility of the presence of multicollinearity in the regression models, which requires careful selection of the independent variables when forming the final model.

Table 8 Results from statistical significance of the overall model (Model Summary ^b)

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics					Durbin Watson
					R Square Change	F Change	df1	df2	Sig. F Change	
1	,698 ^a	,487	,448	14,59720	,487	12,539	5	66	,000	1,047

a. Predictors: (Constant), Shock Dummy, Textile raw mat. input, Container Transport Price, COVID Dummy, Crude Oil Price

b. Dependent Variable: Confectionary Index

The results from table 8 show that the multiple regression model has a coefficient of determination $R^2 = 0,487$, which means that 48,7% of the variation in the apparel production index can be explained by the included independent variables.

The ANOVA results (appendix 2) show that the regression model as a whole is statistically significant, $F(5, 66) = 12,539$, $p < 0,001$. This indicates that the selected independent variables, considered all together, have significant explanatory power with respect to the apparel production index.

Table 9 Results of multiple regression analysis

Model		Unstandardized coefficients		Stan. Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta (β)			Tolerance	VIF
1	(Constant)	53,511	16,256		3,292	,002		
	Crude Oil Price	,416	,222	,406	1,871	,066	,165	6,070
	Container Transport Price	-,001	,002	-,089	-,588	,558	,341	2,930
	Textile Raw Mat. Input	,001	,000	,331	3,184	,002	,717	1,394
	COVID Dummy	4,077	6,243	,098	,653	,516	,342	2,927
	Shock Dummy	-35,999	5,846	-,905	-6,158	,000	,360	2,778

a. Dependent Variable: Confectionary Index

In terms of individual effects, the results show that the input of textile raw materials has a positive and statistically significant impact on the index of apparel production ($B = 0,001$; $\beta = 0,331$; $t =$

3,184; $p = 0,002$). This means that increasing the availability of textile inputs is associated with a higher level of production in the apparel industry.

Additionally, the dummy variable for the transport shock shows a strong negative and statistically significant impact ($B = -35,999$; $\beta = -0,905$; $t = -6,158$; $p < 0,001$), indicating that periods of pronounced transport and logistics disruptions significantly reduce the apparel production index.

On the other hand, the oil price does not show a statistically significant effect at the 5% level ($B = 0,416$; $\beta = 0,406$; $t = 1,871$; $p = 0,066$), although it is close to the significance limit. The price of container transport also does not show a statistically significant impact in the model ($B = -0,001$; $\beta = -0,089$; $t = -0,588$; $p = 0,558$). Also, the COVID dummy variable is not statistically significant ($B = 4,077$; $\beta = 0,098$; $t = 0,653$; $p = 0,516$).

Regarding multicollinearity, the VIF values are generally within acceptable limits, although a higher value is observed for the oil price variable ($VIF = 6,070$), indicating the possibility of moderate overlap with other independent variables in the model. In addition, the Durbin-Watson statistic is 1,047, indicating a possible positive autocorrelation in the residuals, which should be considered as a limitation of the model.

Based on the results obtained, it can be concluded that:

- *Hypothesis X3 is confirmed*, since the input of textile raw materials has a statistically significant impact on apparel production.
- *Hypothesis X1 is not fully confirmed*, while *hypothesis X2 does not receive statistical confirmation* within the framework of the multiple regression model.

5.4. Practical Implications

The results of the research have important theoretical, practical and policy-oriented implications for the textile and apparel sector in North Macedonia. First of all, they confirm that the sector is highly sensitive to external shocks related to global supply chains, especially in the context of transport disruptions, instability in the supply of textile inputs and sudden changes in international logistical flows. In this sense, the results indicate that the stability of production in the apparel industry does not depend exclusively on domestic production capacities, but also on the security, continuity and cost sustainability of international supply.

One of the key practical implications stems from the finding that the input of textile raw materials is a statistically significant factor for the level of production. This indicates that the timely provision of textile inputs is a basic prerequisite for maintaining production continuity. Hence, companies in the apparel industry need to pay more attention to strategic procurement management, especially through better planning of material needs, monitoring delivery deadlines and establishing more flexible supply arrangements. Instead of relying on a linear and narrowly optimized supply model, a more resilient approach is needed that will allow for faster adaptation in conditions of disruption. On the other hand, a large percentage of the procurement of materials depends on the customers for the production of clothing in the textile production facilities in North Macedonia, therefore, the disruption of the chain does not always depend on timely purchases, but can often result from receiving work orders from customers, which then form the supply chain. In this context, if buyers reduce the level of orders, the supply of raw materials for production will automatically decrease.

The results also show that transport shocks have a strong negative impact on production, which has important implications for logistics management. In this regard, one of the most important recommendations is the diversification of transport and supply channels. Companies should not rely on a limited number of routes, intermediaries or transport models, but should develop alternative logistics solutions that could be activated in crisis conditions. It would also be useful for companies to establish longer-term contractual relationships with transport and forwarding

partners, in order to reduce exposure to sudden price shocks and unavailability of transport capacities.

Conclusion

The research showed that the textile and apparel sector in North Macedonia is sensitive to global disruptions and that its performance varied significantly over the analyzed period. The descriptive analysis and graphical presentation showed significant oscillations in the apparel production index, pronounced fluctuations in the price of container transport, as well as instability in the input of textile raw materials. These findings indicate that the sector operated under conditions of strong external uncertainty, with global shocks not being short-lived, but spilling over into the post-crisis period.

Comparative analysis and one-way analysis of variance (ANOVA) showed that there are statistically significant differences in the apparel production index between the pre-crisis, crisis and post-crisis periods. The highest level of production was observed in the pre-crisis period, followed by a significant decline in the crisis period and a further decrease in the post-crisis period. Post hoc analysis confirmed that each of the three periods is statistically significantly different from the others.

Correlation analysis showed that the apparel production index has a statistically significant negative relationship with the price of oil and the price of container transport, indicating that higher energy and transport costs are associated with weaker production performance

Multiple regression analysis provided deeper insight into the relative importance of the individual factors. The regression model as a whole proved to be statistically significant and explained a significant part of the variation in the apparel production index. Within the model, the input of textile raw materials proved to be a positive and statistically significant factor, which means that the availability of imported textile inputs is an important prerequisite for maintaining production. In addition, the dummy variable for the transport shock showed a strongly negative and statistically significant impact, indicating that periods of pronounced transport and logistics disruptions have a serious negative effect on the apparel industry. On the other hand, the price of oil and the price of container transport did not show a statistically significant independent effect in the final regression model, although in the correlation analysis their association with production was significant.

In terms of the hypotheses set, the research showed that the hypothesis of the existence of statistically significant differences between the pre-crisis, crisis and post-crisis periods is confirmed. The hypothesis that changes in total imports of textile materials and raw materials are significantly related to changes in apparel production is also confirmed. The hypotheses relating to the individual impact of oil prices and container transport prices receive partial support in the descriptive, graphical and correlation analysis, but are not fully confirmed in the multiple regression model.

The main conclusion of the research is that the apparel industry in North Macedonia is highly dependent on the stability of the supply chain and is particularly sensitive to transport and logistics disruptions. The continuity of supply of textile inputs and the ability to cope with transport shocks are shown to be key factors in maintaining production stability. Hence, the resilience of the sector in the future will depend on the ability of companies to diversify sources of supply, develop more flexible logistics solutions, plan safety stocks and introduce better supply risk management systems.

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Appendix

Table 1 Secondary data sources for every single variable

Variable	Type	Explanation	Source
Apparel production in North Macedonia	Dependent	Industrial production index for the apparel manufacturing sector	State Statistical Office (DZR)
Crude Oil price	Independent	Average monthly price	Macrotrends.net
Price of container transport from China / Far East	Independent	Index points	Trading Economics
Global import of materials and raw materials	Independent	Value of imports of textile materials	State Statistical Office (DZR)
COVID-19 crisis period	Dummy	1 = for the period of COVID-19 crisis 0 = for other periods	Author edits
Transport shock	Dummy	1 = for the period of transport shock 0 = for the other periods	Author edits

Table 2 ANOVA Results

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	13359,318	5	2671,864	12,539	,000 ^b
	Residual	14063,170	66	213,078		
	Total	27422,489	71			