

An analysis of the current state of digital transformation implementation in supply chain during the COVID-19 pandemic

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December 2021

Abstract

In 2019, the business environment faced a new disruption caused by COVID-19 pandemic. This pandemic has changed many things including customers' preferences and purchasing behavior. Addressing these changes in the supply chains require novel and innovative ways. Digital transformation as a new phenomenon can help supply chain managers. However, they first need to assess the current state of readiness for digital transformation implementation. This study aims to do a quantitative analysis on a sample of European firms to address this issue.

Keywords: Digital transformation, Supply chain management, COVID-19, Digital technologies

1. Introduction

COVID-19 pandemic has brought a new business environment with different and more demanding requirements. Customers' preferences and purchasing behavior have changed significantly. Therefore, organizations in general and supply chain managers in particular need to shift their attention toward more agility, adaptability, and alignment in their supply chains.

Digital transformation is one of the novel concepts that can help organizations to realize this goal. Generally speaking, it can be defined as using advanced digital technologies (such as cloud computing, artificial intelligence, robotics, and big data analytics) in order to transform business strategy and business model. In the context of supply chains, digital transformation can benefit such fields as logistics management, production and operation, and sales.

Given the importance of digital transformation, awareness of the current readiness level of the firm can be important to identify the weaknesses and gaps. Therefore, this study aims to answer this question: "What is the readiness level of firms to implement digital transformation in the supply chain, and what are the barriers to do so?". To this end, an quantitative analysis of the current status of implementing

digital transformation is undertaken on a comprehensive sample. The sample includes information about 3366 European firms (from Ireland, Belgium, Luxemburg, and the Netherland) in five different topics (such as the use of digital technologies for sales, procurement and supply chain management, operation planning, and production).

2. The Concept of digital transformation

With ongoing developments in information and communication technologies over the last decades, digital transformation has emerged as a novel solution for businesses. Despite its importance, however, there is no comprehensive and agreed-upon definition of digital transformation. This is mostly because there is still some confusion regarding the difference between three overlapping concepts of digitization, digitalization, and digital transformation. This difference can be elaborated using the hierarchy of tactical, operational, and strategic levels in an organization. At the operational level, digitization refers to the process of converting analog data (such as text, image, and video) into digital format [1]. Digitalization goes further than just digital conversion and it encompasses the utilization of digital tools and technologies to improve business operations[2]. At the highest level, digital transformation deals with both digitization and digitalization in a strategic manner. More precisely, it is about transforming a business strategy using digitally-enabled technologies. In recent years, many definitions of digital transformation have been proposed. A number of these definitions are summarized in Table 1.

Table 1. Definitions of digital transformation

NO.	Author(s)	Definition
1	Fitzgerald et al. (2014, p. 2) [3]	“The use of new digital technologies (social media, mobile, analytics or embedded devices) to enable major business improvements (such as enhancing customer experience, streamlining operations or creating new business models)”
2	Demirkan et al. (2016, p. 14) [4]	“Digital transformation is the profound and accelerating transformation of business activities, processes, competencies, and models to fully leverage the changes and opportunities brought by digital technologies and their impact across society in a strategic and prioritized way.”
3	Chanas, S. (2017, p. 1) [5]	“The extended use of advanced IT, such as analytics, mobile computing, social media, or smart embedded devices, and the improved use of traditional technologies, such as enterprise resource planning (ERP), to enable major business improvements”
4	Heilig et al. (2017, p. 2) [6]	“Transformations in organizations that are driven by new enabling IT/IS solutions and trends”
5	Reis et al. (2018, p. 412) [7]	“The use of technology to radically improve performance or reach of enterprises”
6	Nasiri et al. (2020, p. 2) [8]	“The transformation of business process, culture, and organizational aspects to meet market requirements, owing to digital technologies”

The transformation enabled by new digital technologies can influence various industries and supply chain management is no exception. Nowadays, many organizations are implementing such digital technologies as cloud computing, big data analytics, machine learning, robotic automation, artificial intelligence, blockchain to improve the performance of their supply chains. For instance, these advanced technologies can be applied to:

- Improve demand forecasting (e.g., using big data analytics and IoT)

- Enhance transportation management (e.g., using IoT, artificial intelligence, and machine learning)
- Increase product quality (e.g., using robotic automation and artificial intelligence)

3. A quantitative analysis of the current state of digital supply chains

In this section, a quantitative analysis will be provided to explore the status of implementing digital transformation in the supply chains of manufacturing and service firms amid the COVID-19 pandemic.

The data used for this analysis is obtained from the recent survey of the World Bank on enterprises across four European countries including the Netherland, Belgium, Ireland, and Luxemburg. It covers information about a wide range of business-related topics (such as infrastructure, finance, competition, workforce, and performance) among 3366 firms. One of the sections included in these datasets deals with the supply chain-related factors. This section of the survey describes the status of the individual firms in terms of production, operations, supply, and demand. Table 2 shows the sample distribution which is grouped by different countries, size, and sectors.

Table 2. Sample distribution

<i>Sector</i>	Ireland		Belgium		Luxemburg		Netherland		Total
	Obs.	Prop.	Obs.	Prop.	Obs.	Prop.	Obs.	Prop.	
Food	70	23.4%	69	23.1%	6	2.0%	154	51.5%	299
Tobacco	0	0.0%	0	0.0%	0	0.0%	2	100.0%	2
Textiles	12	40.0%	6	20.0%	0	0.0%	12	40.0%	30
Garments	0	0.0%	1	14.3%	0	0.0%	6	85.7%	7
Leather	0	0.0%	2	25.0%	0	0.0%	6	75.0%	8
Wood	6	10.2%	13	22.0%	0	0.0%	40	67.8%	59
Paper	10	29.4%	6	17.6%	0	0.0%	18	52.9%	34
Publishing, printing,	42	85.7%	3	6.1%	0	0.0%	4	8.2%	49
Refined petroleum pro	4	30.8%	1	7.7%	0	0.0%	8	61.5%	13
Chemicals	16	30.8%	12	23.1%	4	7.7%	20	38.5%	52
Plastics & rubber	20	32.8%	7	11.5%	2	3.3%	32	52.5%	61
Non-metallic mineral	4	22.2%	6	33.3%	2	11.1%	6	33.3%	18
Basic metals	12	26.1%	6	13.0%	4	8.7%	24	52.2%	46
Fabricated metal prod	30	17.1%	35	20.0%	8	4.6%	102	58.3%	175
Machinery and equipment	48	27.6%	20	11.5%	6	3.4%	100	57.5%	174
Electronics	18	27.3%	6	9.1%	2	3.0%	40	60.6%	66
Precision instruments	8	30.8%	4	15.4%	0	0.0%	14	53.8%	26
Transport machines	6	50.0%	2	16.7%	0	0.0%	4	33.3%	12
Furniture	26	52.0%	6	12.0%	0	0.0%	18	36.0%	50
Recycling	4	36.4%	1	9.1%	0	0.0%	6	54.5%	11
Construction Section	96	43.4%	35	15.8%	24	10.9%	66	29.9%	221
Services of motor veh	52	34.4%	23	15.2%	12	7.9%	64	42.4%	151
Wholesale	28	8.3%	67	19.8%	38	11.2%	206	60.8%	339
Retail	306	42.3%	121	16.7%	26	3.6%	270	37.3%	723

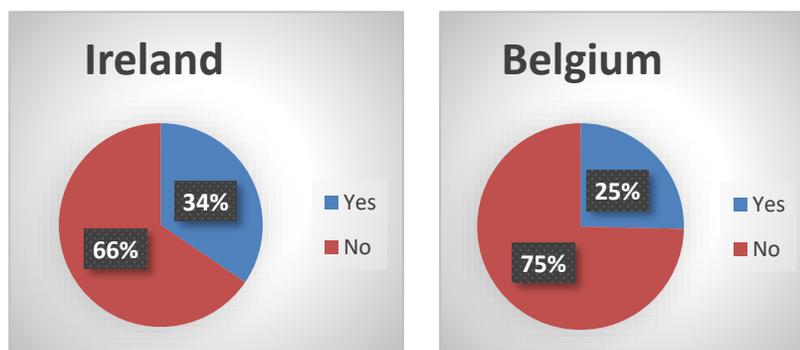
Hotel and restaurants	154	57.0%	40	14.8%	12	4.4%	64	23.7%	270
Transport Section I	74	43.8%	41	24.3%	12	7.1%	42	24.9%	169
IT	70	35.2%	25	12.6%	22	11.1%	82	41.2%	199
Other	4	3.9%	0	0.0%	14	13.7%	84	82.4%	102
<i>Size</i>									
Micro (Less than 5 people)	10	100.0%	0	0.0%	0	0.0%	0	0.0%	10
Small (between 5-19 people)	634	35.5%	312	17.5%	88	4.9%	750	42.0%	1,784
Medium (between 20-99 people)	394	31.5%	197	15.8%	78	6.2%	580	46.4%	1,249
Large (Bigger than 100 people)	82	25.4%	49	15.2%	28	8.7%	164	50.8%	323
Total	1,120	33.3%	558	16.6%	194	5.8%	1,494	44.4%	3,366

As shown in the above table, Ireland, Belgium, Luxemburg, and Netherland account for 33.3%, 16.6%, 5.8%, and 44.4% of the observations in the sample respectively. It is also obvious from the table that small (53%) and medium (37%) firms have the highest share, followed by large companies (9.7%). The micro firms have the least share among the observed firms (0.3%).

As mentioned earlier, this dataset provides several questions related to supply chain management. The participants were asked a number of questions about i) the effect of COVID-19 on e-commerce, ii) the status of online sales, iii) main technologies for supply chain and procurement management, iv) main technologies for production planning, v) main technologies for production. An analysis of each section is presented.

i) The effect of COVID-19 on e-commerce

This section analyzes the answers of participants on the effect of the COVID-19 pandemic on their decision to start e-commerce or increase their online activities. According to Figure 1, COVID-19 has caused at least 25% of firms to start their online business in response to the new conditions after the pandemic.



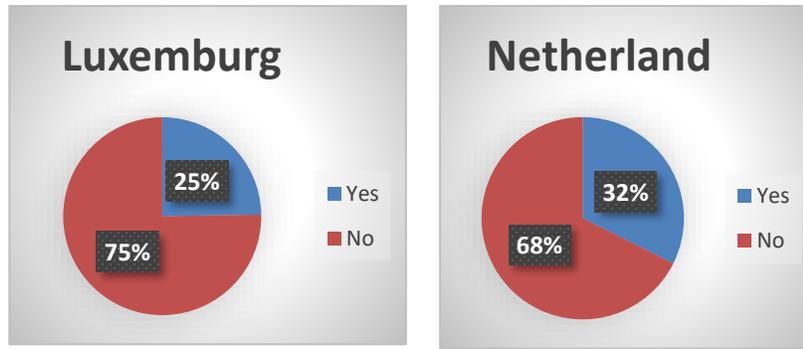


Figure 1. The proportion of firms that started or increased online business after COVID-19. As Table 3 shows, online activities in 32.3% of small firms, 31.7% of medium firms, and 30.2% of large firms have been influenced by COVID-19.

Table 3. The proportion of firms that started or increased online business after COVID-19 (by firm size)

Started or increased online activities?	Small	Share	Medium	Share	Large	Share
Yes	642	32.3%	350	31.7%	81	30.2%
No	1,347	67.7%	755	68.3%	187	69.8%
Total	1,989		1,105		268	

ii) Status of online sales

The second related question in the survey is about the firms' percentage of sales through online channels. These channels include Web-based platforms, social media platforms, websites, and smartphone applications. Figure 2 illustrates the answers of participants in the sample.

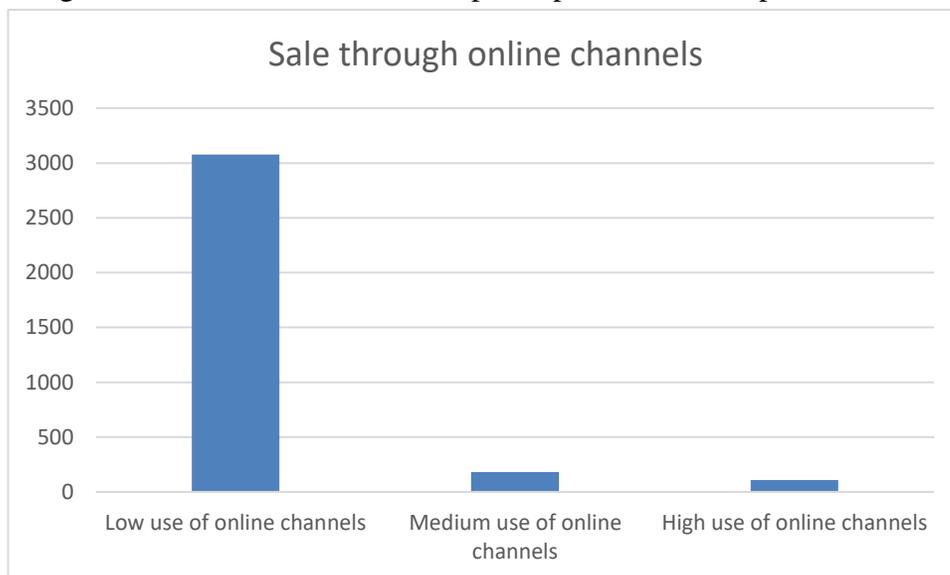


Figure 2. Sale through online channels

According to Figure 2, the vast majority of firms in the sample (91.4%) do less than 25% of their sales through online channels.

iii) Main technologies for supply chain and procurement management

This section provides information on the major technologies used by firms to manage the supply chain and procurement process. The participant firms have specified their status from the following list:

- (1) A manual search of suppliers without storing supplier’s information in a centralized database
 - (2) Database of suppliers manually updated using computers with general-purpose software
 - (3) Supplier Relation Management software (SRM)
 - (4) E-procurement with electronic orders integrated into specialized supply chain management systems
- Other technologies

As Figure 3 depicts, most of the firms (43%) use a database of suppliers for supply chain management, which are updated manually. The second highest mode of supply chain management is manual searching for suppliers without storing supplier’s information in a centralized database. 15% of firms utilize E-procurement and integrate electronic orders into their specialized supply chain management systems. This is followed by firms that employ supplier relationship management software (13%).

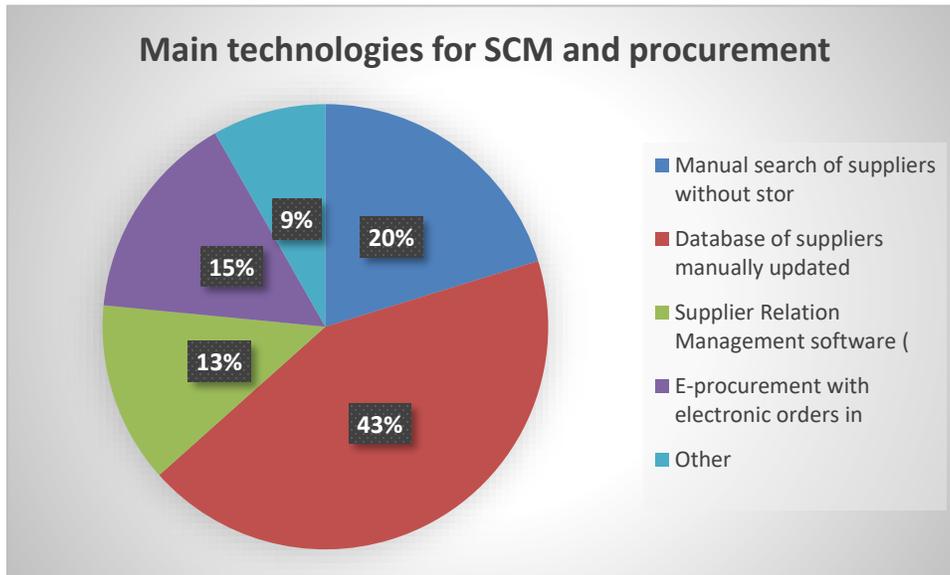


Figure 3. Distribution of main technologies for SCM and procurement

Table 4 summarizes the distribution of utilization of supply chain management technologies based on the size of firms. According to the information provided, 24.9 % of small firms, 36.6% of medium firms, and 52.2% of large firms use some sort of advanced digital technologies for the supply chain management.

Table 4. Distribution of methods of supply chain management by firm size

Main technologies	Small firms	Share	Medium firms	Share	Large firms	Share
Manual search of suppliers	488	27.4%	159	16.1%	16	6.6%
Database of suppliers (manual update)	848	47.7%	467	47.3%	100	41.2%
Supplier Relation Management systems	208	11.7%	167	16.9%	56	23.0%
E-procurement with specialized SCM system	234	13.2%	194	19.7%	71	29.2%
Total	1778	100%	987	100%	243	100%

iv) Main technologies for production planning

The survey used for this analysis also contains information on the main technologies used for production planning. These technologies include handwritten processes, computers with standard software (such as Excel or equivalent), specialized software for demand forecasting or demand planning, enterprise resource planning (ERP), or equivalent software integrated with other back-office functions. As shown in Figure 4, the most frequently used method for production planning in the sample is employing computers with standard software (35%). 33% of the firms utilize ERP software or equivalent systems and 19% of the firms are using specialized software for demand forecasting. The least favorable method is using handwritten processes (10%).

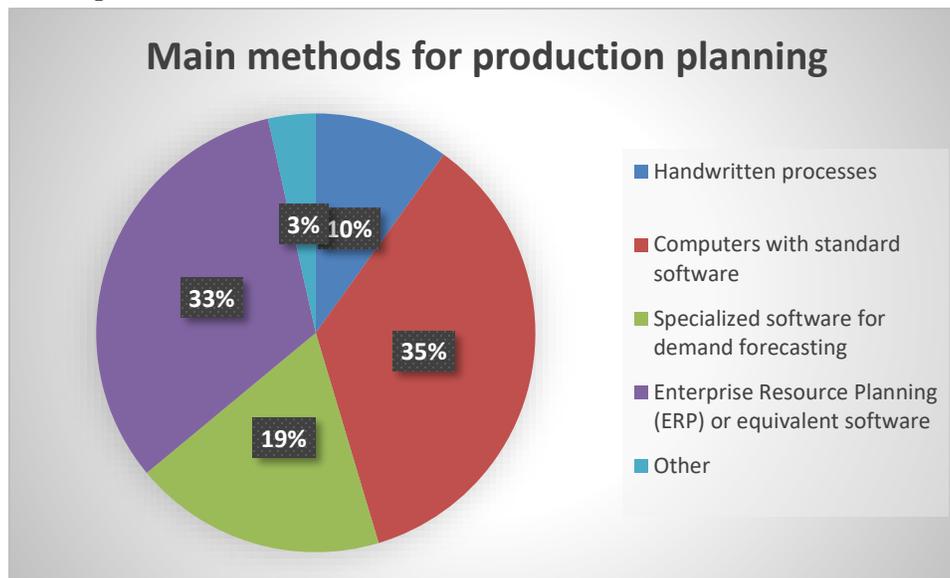


Figure 4. Distribution of main methods for production planning

According to Table 5, large firms use a higher share of advanced digital technologies for production planning (75.5%) compared to medium firms (60.4%) and small firms (39%).

Table 5. Distribution of main methods for production planning by firm size

The main method for production planning	Small	Share	Medium	Share	Large	Share
Handwritten processes	148	15.8%	29	4.1%	4	2.1%
Computers with standard software	384	41.1%	227	32.3%	37	19.3%

Specialized software for demand forecasting	157	16.8%	136	19.3%	47	24.5%
Enterprise Resource Planning (ERP)	207	22.2%	289	41.1%	98	51.0%
Other	36	3.9%	22	3.1%	6	3.1%
Total	934	100%	703	100%	192	100%

v) Main technologies for production

The last related question in the survey deals with the types of methods firms employ for production. These methods include manual processes, machines controlled by operators without computers, machines controlled by computers or computer numerical controlled machines (CNC), robots, additive manufacturing (including rapid prototyping and 3D printers), other advanced manufacturing processes (e.g., laser, plasma sputtering, high-speed machine, E-beam, micromachining).

Figure 5 illustrates the distribution of the production methods utilized by the firms in the sample. Surprisingly, non-digital methods (manual processes and machines controlled by operators) account for the highest share of production methods (62%). The next favorable method is using machines controlled by computers or CNC machines (28%). Less than 5% of firms are using advanced digital production methods (such as using robots, 3D printers, and E-beam).

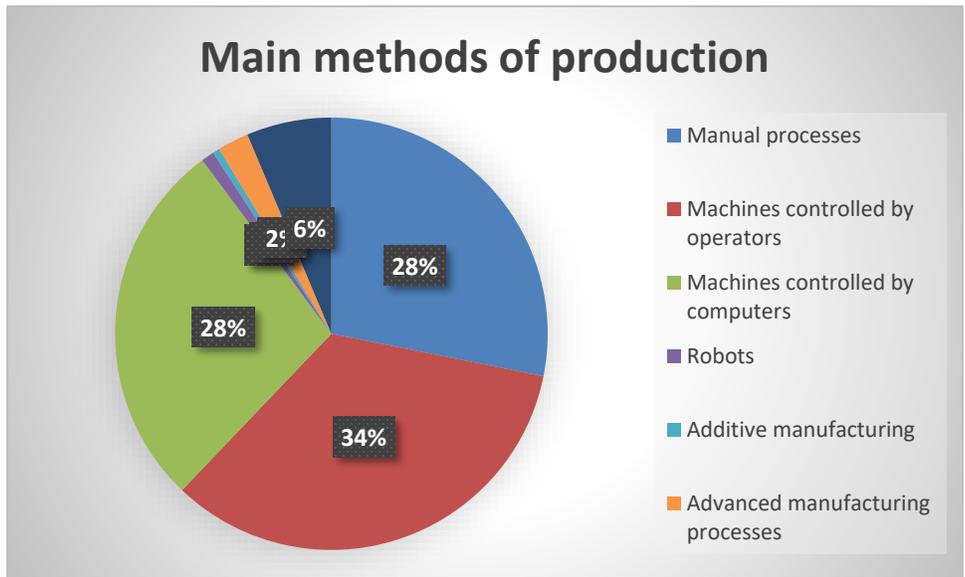


Figure 5. Distribution of main production methods

Also, as Table 6 indicates, large firms are employing more advanced digital production methods (50%) compared to medium firms (37.4%) and small firms (23.7%).

Production methods	Small	Share	Medium	Share	Large	Share
Manual processes	237	32.6%	79	21.1%	8	7.8%
Machines controlled by operators	241	33.2%	124	33.2%	26	25.5%

Machines controlled by computers	153	21.1%	125	33.4%	41	40.2%
Robots	8	1.1%	3	0.8%	0	0.0%
Additive manufacturing	4	0.6%	2	0.5%	0	0.0%
Advanced manufacturing	7	1.0%	10	2.7%	10	9.8%
Other	49	6.7%	16	4.3%	8	7.8%
Total	726		374		102	

4. Discussion

In this paper, a quantitative analysis was done to assess the status of implementing digital transformation in the supply chains of 3366 firms during the COVID-19 pandemic. To this end, a firm-level survey by World Bank in the year 2020 was used. This survey included questions about a broad range of topics on business-related factors including five questions related to the usage of digital technologies in production, operations, and supply chain management. These questions assess the i) the effect of COVID-19 on e-commerce, ii) status of online sales, iii) main technologies for supply chain and procurement management, iv) main technologies for production planning, v) main technologies for production.

The results of the quantitative analysis provided several implications. First, the analysis showed that the COVID-19 pandemic triggered the emergence or enhancement of firms' online activities. This is in line with the expectations because the beginning of the COVID-19 pandemic has changed the taste of customers and demand nature substantially. Second, the results showed that online sales account for less than 25% of the total sales of sample firms. This is somewhat unexpected because all the firms in the sample belong to developed European countries and the low level of using online channels needs to be addressed. It is one of the prerequisites of implementing digital transformation.

Another implication of the results concerns the main technologies used for supply chain and procurement management. According to the results, the vast majority of the firms use conventional and non-advanced methods for supply chain management, and only 15% of firms have implemented advanced digital technologies. This shows that despite the advancement of information and communication technologies, the lack of digital infrastructure is evident. Moreover, as large firms are the pioneers of implementing advanced digital technologies for supply chain management, it can be concluded that the lack of enough resources due to size limitation is one of the main contributors to this issue.

The next implication of the study has to do with the status of using digital technologies for production planning. As the results indicated, more than half of firms are employing advanced digital technologies such as specialized software for demand forecasting and ERP. Also, large firms have a better position in this regard. While there is a huge gap in the sample, a relatively high level of readiness for digital transformation in supply chain management can be seen. Finally, an unexpected result was obtained from the analysis of the main production methods. According to the results, most firms are still utilizing manual processes and machines controlled by operators for production purposes.

All in all, the following conclusions can be made from the quantitative analysis:

- Despite the advancement of information and communication technologies during the past years, many firms (especially SMEs) are not ready enough for implementing digital transformation in their supply chains.
- Due to the higher level of digital technologies usage among large firms, it can be concluded that having enough resources (financial, infrastructural, skilled staff, ...) are an important pre-requisite for digital transformation.

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