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ORIGINAL RESEARCH

Reshoring manufacturing: the influence of industry 4.0, Covid-19, and made-in effects

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Abstract
Empirical investigations of how the reshoring of manufacturing is affected by Industry 4.0 technologies, supply chain disruptions, and made-in effects are rare in the extant academic literature. This paper contains an empirical analysis of how these variables affect reshoring and reshoring intentions. Results from a 2022 questionnaire survey including 152 offshoring manufacturing firms show that reshoring and reshoring intentions are associated positively with investments in automation in manufacturing, and with employee made-in. Results also showed that while Covid-19 associated disruptions increased firms' reshoring intentions equally across firm sizes, smaller and larger firms reacted quite differently towards more well-known disruption types: larger firms decreasing reshoring intentions with higher levels of uncertainty and smaller firms increasing reshoring intentions with higher levels of uncertainty. These results point to the importance of creating consciousness about the dynamics of production localization and how firm-level and situation-specific contingencies may interfere with Industry 4.0 technology-, supply chain disruption-, and made-in effects on strategic reshoring decisions.

Keywords Covid-19 · Industry 4.0 · Made-in · Location of manufacturing · Supply chain disruption

1 Introduction

Where to locate manufacturing has been an important strategic decision for large as well as small and medium-sized enterprises (SMEs) during the last decades. We have seen practices of moving manufacturing abroad i.e., to low-wage countries to follow a low-cost strategy or due to proximity to customers. Opposite movements of manufacturing have also begun to occur in terms of back-to-home destinations (such as insourcing or backshoring), near-to-home destinations (nearshoring), or simply just reshored to other low-cost destinations. Research addressing drivers and barriers to reshoring practice is widely reported (e.g., Fratocchi et al. 2016; Stentoft et al. 2016a). Hence, manufacturing location decisions are not static but dynamic issues pointing to a need to view supply chain design as a dynamic capability (Arlbjørn and Mikkelsen 2014).

Reshoring is a complex decision-making process (Benstead et al. 2017; Gray et al. 2017) that involves a myriad of external and internal contingencies (Barbieri et al. 2018; Fratocchi et al. 2016; Stentoft et al. 2016a). Studies have provided valuable insights into how reshoring is affected by external contingencies in terms of increased freight and labor cost (Dachs et al. 2019), evolving political instability (MacCarthy et al. 2016), state government initiatives (Merino et al. 2021; Pegoraro et al. 2022); increased focus on sustainability (Fratocchi and Di Stefano 2019; Orzes and Sarkis 2019), and more abrupt supply chain disruptions caused by natural disasters (Benstead et al. 2017), and global pandemics (Barbieri et al. 2020; Pla-Barber et al. 2021; van Hoek and Dobrzykowski 2021).

Notably, the Covid-19 pandemic has caused supply chain disruptions with a confluence of circumstances such as sudden changes in demand, supply shortages, logistical crises, and quick recoveries in major economies (Panwar et al. 2022). Such disruptions call for new practices or strengthening ongoing practices with digitalization, building stronger regional production chains, creating resilience of supply chains that are closely connected with diversification (of suppliers), adjusting governance, and creating appropriate risk-management strategies (Kersan-Škabić 2022). Thus, the

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Covid-19 pandemic and other supply chain disruptions such as increased geopolitical challenges have prompted reconsiderations of how to structure global supply chains e.g., moving towards more regionalization (Gereffi 2020; Roscoe et al. 2022; Samson 2020; Sarkis 2021).

Clouse et al. (2022) refer to an AT Kearney survey that concludes that 92% of manufacturing executives and 78% of the CEOs said they have considered reshoring or have already reshored manufacturing to the US in the light of increased supply chain vulnerabilities as Covid-19 and the Russian invasion of Ukraine. Chen et al. (2022) refer to similar results from other practitioner-oriented surveys. Further, geopolitical tensions e.g., between China and the USA led to the introduction of the term "friendshoring" (by the Secretary of the Treasure Janet Yellen) which focuses on risk reductions by reducing dependencies on countries that are not allies. However, there are no easy shortcuts here. For some manufacturers, it will be a valid strategy to pursue reshoring while for others is more difficult due to specialization capabilities built at the offshore destination (Panwar et al. 2022). Johnsen and Haug (2021) demand research to further explore global supply chain management strategies because of the Covid-19 pandemic.

A second line of studies has examined how reshoring is affected by new opportunities provided by Industry 4.0 technologies (Ancarani et al. 2019; Dachs et al. 2019; Stentoft et al. 2016b). New digital production technologies including sensors, advanced robotics, 3D manufacturing, data analytics, artificial intelligence, etc., provide new opportunities for less labor-intensive and more flexible and efficient production systems, which may change the relative attractiveness of different production locations. Several studies have found a positive association between reshoring and firms' investments in Industry 4.0 technologies (Ancarani et al. 2019; Dachs et al. 2019; Stentoft and Rajkumar 2020). Other studies suggest that the relationship between reshoring and Industry 4.0 is likely moderated by firm-level factors, such as firm strategy and size (Ancarani et al. 2015; Stentoft et al. 2021b).

A third line of studies has attended to the importance of "made-in effects" (Ancarani et al. 2015; Bals et al. 2016; Grappi et al. 2018; Di Mauro et al. 2018). Made-in effects may operate through two main mechanisms. First, domestic manufacturing can enhance brand value when customers perceive this as an important quality benefit (McIvor and Bals 2021; Srai and Ané 2016). Second, keeping domestic manufacturing and reshoring may increase employee loyalty and commitment and thereby strengthen coordination and operative efficiency (Grappi et al. 2020). Several recent studies have supported that made-in-effects are important elements of reshoring decisions (Cassia 2020; Van Hoek and Dobrzykowski 2021). Nonetheless, evidence also suggests that this effect varies between industries (Fratocchi et al. 2016) and is relative to firm-level factors such as size (Wan et al. 2019).

While studies have provided insights into the individual effects of supply chain disruptions (Barbieri et al. 2020; Chen et al. 2022; van Hoek and Dobrzykowski 2021; Sarkis et al. 2020), Industry 4.0 technologies (Dachs et al. 2019; Stentoft and Rajkumar 2020), and made-in effects (Ancarani et al. 2015; Bals et al. 2016; Grappi et al. 2018; Di Mauro et al. 2018) on firms' reshoring decisions, these effects have mostly been attended to separately. For that reason, there is still little knowledge of the relative strength of their driving mechanisms, nor of the extent to which these mechanisms may be differentially affected by important firm-level factors such as firm size. Against these backdrops, the purpose of this paper is to advance the understanding of manufacturing reshoring practice. More specifically the paper addresses the following research question:

> RQ: What is the influence of industry 4.0 technologies/automation, supply chain disruptions, and made-in effects on manufacturers' reshoring, and how does this influence differ relative to firm size?

The research is positioned at the intersection among three streams of academic literature: The relationship between reshoring and the use of Industry 4.0 technologies; the presence of supply chain disruptions, and a possible made-in effect, and how it may differ from a firm size perspective. Extant literature demands research addressing reshoring issues from various firm-size perspectives (Arlbjørn and Mikkelsen 2014; Barbieri et al. 2018). Firm size is important to study since SMEs account for the highest number of enterprises compared with larger enterprises and they operate with fewer financial and human resources (Stentoft et al. 2021a). According to the EU definition, an SME is a company employing less than 250 persons, with a total turnover not exceeding €50 million and with an annual balance sheet total not exceeding €43 million (EU Commission 2015).

The paper provides novelty in three areas. First, it investigates reshoring issues in the light of industry 4.0, supply chain disruptions, and made-in effects, and considers how the strength of the mechanisms driving these effects may vary relative to firm size. Second, the paper is founded on empirical data collected in time with high environmental turbulence with the Covid-19 crisis imposing significant supply chain challenges, resource shortages, and high price fluctuations. Such circumstances may significantly affect the relative strength of different reshoring motives. Thirdly, the paper includes a firm-size perspective on the themes analyzed. Thus, the paper delivers empirical-based research on a dynamic phenomenon (Arlbjørn and Mikkelsen 2014).

The paper is further organized into four sections. Next, the theoretical underpinning of the paper is presented together with hypotheses development. This is followed

by a section describing the applied method. Then follows two sections where the first is presenting the results and the next is discussing the results. The final section concludes the paper including implications for theory and practice and limitations and suggestions for future research.

2 Theoretical underpinning and hypotheses

This section examines the theoretical underpinning for the relationships between reshoring and industry 4.0, supply chain disruptions, and made-in effects, which, in turn, leads to the development of hypotheses for empirical tests (see Fig. 1).

2.1 Understanding reshoring in this paper

Within the topic of moving manufacturing abroad and back again, different terminologies exist. This paper is concerned with the movement of manufacturing back to firms' home countries. Basically, manufacturing can move abroad due to outsourcing or offshoring. Outsourcing is concerned with turning all or part of an organizational activity across organizational boundaries to an outside supplier. In contrast, insourcing is concerned with the opposite flow. Offshoring refers to the relocation of value chain activities outside of the company's home countries based on the location of its headquarters (Bals et al. 2016). When manufacturing is moved home again it might be termed backshoring, reshoring, or back-reshoring (Fratocchi et al. 2014). This paper is concerned with manufacturing moving back to firms' home countries irrespective of how it previously has moved abroad and overall, it is termed reshoring.

2.2 Industry 4.0 and reshoring

Extant research has proposed a positive relationship between the use of Industry 4.0 technologies and reshoring (Ancarani et al. 2019; Fratocchi et al. 2016; Gupta et al. 2023; Stentoft et al. 2016b). Based on a structured literature review and data from a UnivAQ Manufacturing Reshoring dataset, Fratocchi and Di Stefano (2020) found a relationship between the use of Industry 4.0 technologies and the reshoring of manufacturing. Ancarani et al. (2019) researched 495 relocation initiatives and found that backshoring is associated with the adoption of Industry 4.0 when the firm's priorities are high quality and the reduction of costs tied to non-conformance. Stentoft et al. (2016b) conclude from a large-scale questionnaire survey that companies' reshoring manufacturing have invested more in manufacturing innovation technologies. Stentoft and Rajkumar (2020) found based on a questionnaire survey that a higher perceived relevance of Industry 4.0 has a positive impact on companies that have moved manufacturing back and on companies that have moved manufacturing out and back; the lower perceived relevance of Industry 4.0 harms companies that have remained domestic, and the level of perceived relevance of Industry 4.0 has no impact on companies that have moved manufacturing out. Dachs et al. (2019) conclude in their research of 1,700 companies that there is a positive correlation between the adoption of Industry 4.0 technologies and companies' backshoring initiatives. Culot et al. (2020) suggest research on the technological determinant of reshoring.

Barbieri et al. (2022) found, based on their study of 118 relocations of manufacturing activities, a positive relationship between Industry 4.0 innovation intensity and reshoring to the home country when the home country

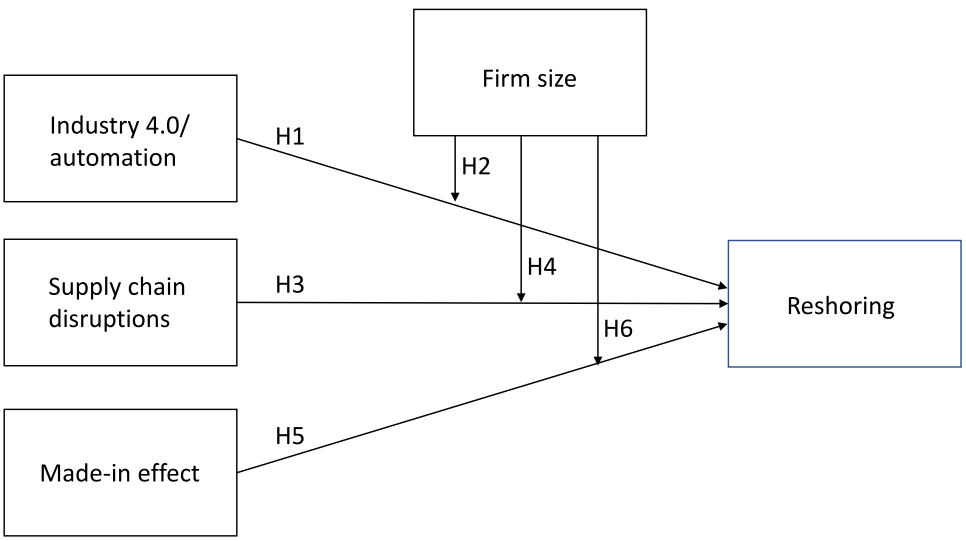


Fig. 1 Research model

can count on Industry 4.0 policy-based strategies. Lund and Steen (2020) report on a multiple case study research about Norwegian manufacturing firms and conclude that the implementation of advanced manufacturing technology is a reshoring driver when it is matched with regional assets such as automation knowledge and competencies, key human capital, and region-specific competencies. Contra-wise Müller et al. (2017) concluded on a survey with 50 responses from German manufacturing companies that they could not find a relationship between reshoring and the use of Industry 4.0 technologies.

The discussion indicates various interpretations of the effect of Industry 4.0 on manufacturing location decisions. Dachs et al. (2019) found that both firm size and Industry 4.0 technology use are associated positively with backshoring activity. They found that the positive relationships between size and backshoring were explained by larger firms investing more in Industry 4.0 technologies, yet they did not consider their potential multiplicative effects in the analysis. One reason why firm size may moderate the relationships between Industry 4.0 and reshoring is that smaller firms generally are more prone to make strategic mistakes in the ex-ante evaluation of the offshore decision and struggle more to develop effective and efficient offshoring solutions due to a lack of resources and therefore are inclined to seek back to more proximate production locations making communication, collaboration, and control more manageable (Ancarani et al. 2015; Gray et al. 2017).

Another conjecture is that larger and more resourceful firms have better opportunities to exploit the potential to build resilience from implementing Industry 4.0. technologies more fully throughout the supply chain and thus also at offshored facilities. For example, digital supply chain twins (Ivanov and Dolgui 2021) and real-time tracking and tracing systems (Razak et al. 2023) may dampen ripple effects from external disturbances. Also, placing additive manufacturing closer to customers may enable faster responses to changing customer demand (Durach et al. 2017). Making such investments, however, would typically require a certain scale of operations, thereby relating to firm size.

From these ends, emerging opportunities from Industry 4.0 technologies to counterweight otherwise disadvantages from locating production domestically, may thus be a more prominent trigger of reshoring decisions among smaller firms. Opposite, especially larger firms may see opportunities in utilizing Industry 4.0 technologies to strengthen their supply chain resilience and exploit advantages from domestic production facilities. Accordingly, we hypothesize:

H1: There is a positive relationship between reshoring and the use of Industry 4.0 technologies.

H2: The positive relationship between reshoring and the use of Industry 4.0 technologies is reinforced the smaller the firm size.

2.3 Supply chain disruptions and reshoring

Following the globalization of supply chains, this exposure has increased significantly. Disruptions and disturbances impacting the supply chain take various forms such as pandemics, natural disasters like earthquakes, volcano eruptions, flooding, tsunamis, political and financial crises, price and currency fluctuations, wars and trade wars, piracy, regional instability, and cybersecurity (Akkermans and van Wassenhove 2018; Dolgui et al. 2018; Dubey et al. 2021). Some disruptions are massive like Covid-19 and may be very difficult to foresee while others are manageable due to warnings where performance loss can be reduced (Stentoft et al. 2023). Furthermore, companies may also struggle with the ripple effect where a disturbance in one part of a supply chain propagates to other parts of the supply chain (Dolgui et al. 2018). The ripple effect, as outlined by Dolgui and Ivanov (2020), entails structural dynamics within the supply chain caused by supply chain disruptions. Its repercussions may encompass diminished revenues, delivery delays, loss of market share, and reputational damage, among other adverse impacts on supply chain profitability (Herold and Marzantowicz 2023). In the case of Covid-19, cascades of disturbances followed from the spread of infection, including production stops, supply shortage, diminishing customer service, price- and demand-fluctuations, etc. (Brusset et al. 2023). Supply chain resilience refers to the ability of a supply chain to anticipate, respond to and recover from such disruptions (Ponomarov and Holcomb 2009).

According to Van Hassel et al. (2022), a nearshoring tendency is revived by the Covid-19 pandemic that triggers reshoring processes. Pla-Barber et al. (2021) discuss how the Covid-19 pandemic might drive the development of regionalized instead of global supply chains. Sarkis et al. (2020) also discuss the shortcomings of global supply chains in light of Covid-19 and state that arguments for reshoring and insourcing have been heard. This is supported by Gereffi (2020); Roscoe et al. (2022) and Sarkis (2021). However, according to van Hoek and Dobrzykowski (2021), the Covid-19 pandemic is not the main driver behind reshoring in the short- and medium-term. Charpin (2022) proposes a relationship between supply chain disruptions and the reshoring of manufacturing because of nationalism and national animosity.

Recent literature reviews on supply chain disruptions further reveal a lack of focus on SMEs (Bak et al. 2020; Kamalahmadi and Parast 2016). Chen et al. (2022) report on a study of Taiwanese companies that found a positive

relationship between disruptions caused by Covid-19 and reshoring. Barbieri et al. (2020) refer to a secondary data analysis that the Covid-19 pandemic was a trigger to reshoring. A complex and changing global environment may pose a larger threat to SMEs than to larger companies (Bak et al. 2020). SMEs are generally more unprepared for larger environmental changes (Gunasekaran et al. 2011) and more absent of insurance, risk assessments, or business-continuity plans, which makes them especially vulnerable for example to natural disasters (Bak et al. 2020; Polyviou et al. 2020). SMEs are typically constrained by short-term decision horizons and lack of strategic planning, and SMEs have less specialized resources to quickly detect and develop responses to emerging novel and tricky operational contingencies (Burnard and Bhamra 2011). Also, SMEs have less power to negotiate favorable terms with important external stakeholders to uphold operational efficiency under such situations (Pfeffer and Salancik 2003). Due to these shortcomings, SMEs to a higher extent will likely respond to supply chain disruptions by reshoring activities. Accordingly, we hypothesize:

H3: There is a positive relationship between reshoring and the presence of supply chain disruptions.
H4: The positive relationship between reshoring and the presence of supply chain disruptions is reinforced by the smaller firm size.

2.4 Made-in effect and reshoring

A motivation for reshoring is also to capitalize on the made-in effect with domestic manufacturing that adds value for local customers such as perceived quality benefits (Benstead et al. 2017; Boffelli et al. 2021; Fratocchi et al. 2016; Gupta et al. 2023). The made-in effect can enhance brand value (McIvor and Bals 2021; Robinson and Hsieh 2016; Srai and Ané 2016) and employee behaviors (Grappi et al. 2020). Starting with the latter, Grappi et al. (2020) report from a survey with 266 respondents from an Italian Company that has reshored their manufacturing which show a positive and significant influence of the intrinsic motives (the company feels morally obligated to reshore; has a real, authentic, and long-term perspective to produce in the home country, and a belief that the company did its best to reshore) on the gratitude of the reshoring and thus the support of the company. Thus, the benefits of reshoring should also be seen from the employee's perspective.

Grappi et al. (2018) have researched consumers' beliefs about companies' reshoring practices, thus applying a demand-based perspective focusing on the home country's demand characteristics instead of a traditional firm-side. This perspective acknowledges reshoring to increase the value created within the company's value system. Their research reveals that a made-in-effect in the home country influences the reshoring decision, showing that the greater the perceptions of superior quality attributed to a reshored product, the higher probability of buying it. The work from Grappi et al. (2018) focuses on the business-to-consumer (B2C) context and does not address the business-to-business (B2B).

According to Ancarani et al. (2015), backshoring has often been described as aimed at increasing brand recognition through the made-in effect by quality-focused firms, and they find that the made-in effect is associated with a swifter reshoring for EU-based companies. The made-in effect has emerged as relevant in those industries (e.g., fashion) in which perceived quality is increasingly influenced by the production location, especially for high-end segments (Fratocchi et al. 2016). Cassia (2020) finds that reshoring increases perceived product quality, but only for customers with previous knowledge of firms' past offshoring decisions and elevated levels of affective ethnocentrism (judgment bias against foreign-made products). Van Hoek and Dobrzykowski (2021) conclude in a reshoring study from three manufacturing companies that a made-in effect is a driver for reshoring. This is also the case in the multiple case study research among SMEs and large companies reported by Boffelli et al. 2020, in which all companies reported the made-in effect as a driver of their reshoring activities. Wan et al. (2019) conclude based on an analysis of 529 reshoring projects that 18.3 percent of the projects were motivated by a made-in effect. Furthermore, they also found firm-size differences between the five countries. Large firms carried out German reshoring projects; US reshoring projects were less likely for large firms, while there were no significant differences in firm size in France, Italy, and the UK.

Moretto et al. (2020) found in their case study research that brand reputation and a made-in effect were major drivers in eight of the twenty-five analyzed cases. The companies represented a variety of industries from automotive, clothes, apparel, travel luggage, furniture, and bicycles. Henkel et al. (2022) found based on quantitative meta-analyzes of secondary case studies that low-tech firms to a higher extent backshored due to a made-in effect. In a study of backshoring initiatives in the USA, Di Mauro and Ancarani (2022) develop six clusters of backshoring patterns and here they identify a made-in effect having the highest frequency in the "legitimacy seekers" cluster. Wan et al. (2019) found in their analysis of secondary data of 529 reshoring projects that Italian reshoring projects more are likely to be motivated by a made-in effect and are considered a synonym for high production competencies that add value, especially in the fashion industry. In contrast to these positive made-in effects, Merino et al. (2021) did not find a made-in effect in their 41 studied backshoring and nearshoring strategies analyzed within the Italian and

Spanish footwear industry. Thus, contradicting results are reported in the literature regarding the impact of a made-in concerning reshoring activities.

In our review, we found no studies of the relationship between firm size and made-in as a motive for reshoring. Previous studies, however, have suggested that in several industries, such as the wine and beer industries, small firms are more inclined to pursue specialist strategies to compete with larger generalist firms (Carroll and Swaminathan 2000). The development of a robust identity and an image of high quality is central to the pursuit of such specialist strategies and the differentiation from larger generalist firms. Since manufacturing locally can constitute an important element in signaling high quality of small firms, it is a likely conjecture SMEs will be more motivated by made-in-effects to reshore activities.

Accordingly, we hypothesize:

H5: There is a positive relationship between reshoring and a made-in effect.

H6: The positive relationship between reshoring and a made-in effect is reinforced the smaller the firm size.

2.5 Summary

This section has outlined possible relationships between reshoring and the use of Industry 4.0/automation, supply chain disruptions, and made-in effects. Furthermore, these connections are illuminated with firm size as a moderator. Regarding the relationship between the use of Industry 4.0/automation and reshoring, the existing literature presents mixed evidence. Several authors suggest a connection between supply chain disruptions and reshoring, but this is primarily based on theoretical perspectives and not supported by empirical data. Lastly, there is also mixed evidence regarding the relationship between a made-in effect and reshoring in the existing literature, as well as for the moderating effect of firm size.

3 Method

3.1 Data collection

Data is from a questionnaire survey distributed to Danish manufacturers in the spring of 2022 (see Appendix A). The questionnaire focused on manufacturing enterprises (NACE codes 10–33) with 50 or more employees. A cross-list of 1,368 companies was identified from the Danish company database "Bisnode", which covers all VAT-registered firms in Denmark. The list was cleansed for companies with heavy capital-intensive manufacturing equipment only located in Denmark and only to produce for the Danish market. This includes brickfields, bakeries, shipyards, sawmills, concrete manufacturing, and printing houses. Companies declared bankrupt were also removed from the list which led to a net list of 983 companies. As some companies were not included in the list due to their legal protection against unsolicited advertising, we additionally added 162 companies from a non-profit Danish supply chain organization's member list, leading to a total list of 1,145 contacted companies. E-mails were distributed to the supply chain manager or the operations manager. In cases where contact information was not available for these persons, an email was sent to the CEOs with a request to be directed to the right person. Again, for some companies no contact information was available on their homepages, so an email was sent to the companies' main mail address addressed "to whom it may concern". In all, 293 accepted to attend the survey of which 212 have delivered full answers. Out of these, 60 respondents indicated that their company did not have any production that could be reshored. These firms were removed from the dataset leaving a sample of 152 firms for which reshoring could be relevant. Characteristics of the respondents and the companies are included in Tables 1 and 2.

The average firm size in the sample is significantly larger than the average firm size in the targeted population. Generally, larger firms have higher out-sourcing propensities and

Table 1 Characteristics of the respondents

Job titles of the respondents	0–250 employees	> 250 employees	Total
CEO	18	3	21
CFO	1	0	1
COO	11	2	13
Executive Assistant	1	0	1
Factory/Operations Manager/Director	13	1	14
Logistical/Planning Manager/Director	2	7	9
Purchaser/Strategic Purchaser/Category Manager	17	2	19
Purchasing/Sourcing Manager/Director	24	30	54
Supply Chain Manager/Director	10	10	20
Total	97	55	152

Table 2 Characteristics of the companies

	Sample	Population	Difference
Average firm size (std.dev.)	3,251 (1286.829)	609 (165.6292)	-2641.446*[a] z-test[b]
Industry type (in%)			
Manufacture of food products (10)	7.89%	15.27%	-7,38*
Manufacture of beverages (11)	0.0%	1.05%	-1.05
Manufacture of tobacco products (12)	0.66%	0.29%	0.37
Manufacture of textiles (13)	1.32%	1.62%	-0,30
Manufacture of wearing apparel (14)	0.66%	0,48%	0,18
Manufacture of leather and related products (15)	0.66%	0,10%	0,56
Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials (16)	4.61%	4.68%	-0.07
Manufacture of paper and paper products (17)	0.66%	2.29%	-1.63
Printing and reproduction of recorded media (18)	0.66%	0.10%	0.56
Manufacture of coke and refined petroleum products (19)	0.0%	0.38%	-0.38
Manufacture of chemicals and chemical products (20)	1.97%	4.29%	-2.32
Manufacture of basic pharmaceutical products and pharmaceutical preparations (21)	1.97%	2.00%	-0.03
Manufacture of rubber and plastic products (22)	3.29%	7.73%	-4.44
Manufacture of non-metallic mineral products (23)	3.95%	3.82%	0.03
Manufacture of basic metals (24)	0.0%	1.72%	-1.72
Manufacture of fabricated metal products, except machinery and equipment (25)	14.47%	13.45%	1.02
Manufacture of computer, electronic and optical products (26)	3.95%	6.30%	-2.35
Manufacture of electrical equipment (27)	5.92%	4.96%	0.96
Manufacture of machinery and equipment n.e.c. (28)	26.97%	19.94%	7.03***
Manufacture of motor vehicles, trailers; and semi-trailers (29)	0.66%	0.95%	-0.29
Manufacture of other transport equipment (30)	0.0%	1.24%	-1.24
Manufacture of furniture (31)	3.29%	5.15%	-1.86
Other manufacturing (32)	16.45%	2.19%	14.26**
Total	**100.0%**	**100.0%**	

Numbers in parenthesis are the respective European NACE code

Ordinary t-test is significant with p = .0001

*$p < .05$; **$p < .01$; ***$p < .001$

[a]Welch t-test assuming unequal variance (p = .0434)

[b]z-test of difference in proportions

thereby fulfill the selection criteria of having activities that can be reshored. Also, given the industry demography with only a few considerably large firms, a high presence of these firms in the sample may highly influence the average firm size in the sample. Table 2 shows the distribution of firms across manufacturing industries for the resulting sample and for the total list of firms (i.e., population). A Chi-square (Chi-square(df = 22) = 98.00; p < .001) shows the significant difference in the two distributions. The main difference is here that the sample is significantly underrepresented by firms in the Manufacture of food products industry and underrepresented by firms in the Manufacture of machinery and equipment industry and the other manufacturing categories. These differences to a high extent resemble differences in out-sourcing propensities between the three industry groups. This is not surprising given the subject of the questionnaire, but also since firms with no back-shoring opportunities are deselected for the analysis. In the remaining industries, the sample does not differ significantly from the overall population. Hence, overall, while a sample is not random—since it only contains firms with out-flagged activities—it still composes a fairly representative sample of Danish manufacturing firms.

3.2 Measures

3.2.1 Dependent variable

Two variables are applied to indicate reshoring activity. First, reshoring is measured by asking respondents "Has

your company within the last three years taken production back from abroad to Denmark either from your own factory or from a supplier?" Reshoring is coded 1 if affirmative, and 0 if not affirmative. Second, intentions to reshore, resh_int, is measured by asking respondents on a Likert scale from 1 (very unlikely) to 5 (very likely) "To what extent is it likely that your company within the next three years will take back production from abroad to Denmark". The motivation for including intended reshoring as a dependent variable is that firms' reactions to environmental changes typically take some time to plan and execute. A limitation here, however, is that not all intentions may be followed through. With these differences in pros and cons, actual and intended reshoring provide different insights into the hypothesized relationships.

3.2.2 Independent variables

To assess firms' use of Industry 4.0 technology, two variables are applied. First, firms' investments in automation (autom) are assessed by asking respondents on a Likert scale from 1 (very low/none) to 5 (very high) "To which extent has your company invested in automation of production in Denmark over that last three years?" (adapted from Stentoft and Rajkumar 2020). Digital technology use, DigTech, was measured by asking respondents to indicate on a Likert scale from 1 (very low) to 5 (very high) to which extent their company used the following seven Industry 4.0 technologies in their production processes (adapted from Stentoft and Rajkumar 2020): 1. Big data and analytics, 2. Autonomous robots, 3. Simulation, 4. Internet of Things (IoT), 5. Additive manufacturing, 6. Augmented reality, and 7. Artificial Intelligence. Generally, firms' use of these Industry 4.0 technologies is low, highest for Autonomous robots (mean score = 2.27) and Big Data and analytics (means score = 2.16). Principal component analysis of the standardized values provides a single-factor solution explaining 48.191 percent of the total variance. Cronbach's alpha is .817 and rho_c is .827 (Appendix B). DigTech is thus measured as the mean of the seven standardized questionnaire items.

To assess supply chain disruption, respondents were asked on a Likert scale from 1 (very low) to 5 (very high) to what degree their firm's supply chain was affected by: 1. Pandemics, 2. Cybercrime, 3. Natural disasters, 4. Human error, 5. Price fluctuations, 6. Exchange rate fluctuations, 7. Trade wars, 8. Regional disturbances, and 9. Other issues (scale developed based on Akkermans and Wassenhove 2018; Chowdhury and Quaddus 2016; Moradlou et al. 2021; Nguyen et al. 2021; Roscoe et al. 2022; Stecke and Kumar 2009). The most influential disruptors were Price fluctuation and Pandemics with mean scores of 4.19 and 3.69, respectively. The least influential disruptors were Cybercrime and Natural disasters with mean scores of 1.72 and 1.94, respectively. The principal component analysis returns a two-factor solution explaining 57.002 percent of variance with factor one containing items 2, 3, 4, 6, 7, and 8, and factor two containing the two items 1 and 5 (Appendix B). Factor one can here be understood as more general factors of supply chain disruption from which firms are imposed with familiar uncertainty (known risks according to Heckmann et al. (2015)). Factor two, on the other hand, resembles uncertainty that associated with the Covid-19 situation and the associated supply chain crisis and associated price fluctuations, and can be labeled unknown risks (Heckmann et al. 2015). These two circumstances have presented firms with unfamiliar market and supply chain uncertainties. Cronbach's alpha for factor one is .783 and rho_c is .853, which justifies using an index composed by the mean of the five standardized items as an indicator for general disruptions (GenDis). Since factor two is composed of only two items, each item is used as a separate indicator of supply chain disruptors, CovDis, and PriDis, respectively.

Made-in effects were measured by two variables (scale adapted by Grappi et al. 2018, 2020). First, a made-in effect from customers, MI_cu, was measured by asking respondents to indicate on a Likert scale from 1 (very low) to 5 (very high) to which extent made-in-Denmark has a positive impact on their customers. In a similar vein, made-in effect from employees, MI_em, was measured by asking respondents to indicate on a Likert scale from 1 (very low) to 5 (very high) to which extent made-in-Denmark has a positive impact on their employees.

Following previous studies on the relationship between firm size and reshoring (Ancarani et al. 2019; Stentoft and Rajkumar 2020), the moderator firm size was measured as a number of employees, logged (Size(ln)).

3.2.3 Control variables

To include the effect of firms' international orientation on reshoring, we controlled for firm exporting measured by the percentage of firms' turnover that derived from export. We also controlled for firms' strategic orientation in terms of cost and differentiation. Cost strategy was assessed by asking respondents to indicate on a five-point Likert scale (1 = very low to 5 = very high) to which extent the strategy of their firm is cost-focused (competing on price). Differentiation strategy was assessed by asking respondents to indicate on a five-point Likert scale (1 = very low to 5 = very high) to which extent the strategy of their firm is focused on differentiation (competing by providing better or more advanced products). We further included a control for product type, either, standardized, customized, or a mix of standardized and customized – the latter used as a reference group. Finally, we controlled for Industry using the Nade 2-digit

classification with firms in industries with less than five observations re-classified in a common residual category.

3.3 Analyses

While covariance-based approaches are generally advocated for the conformation of existing theory (Hair et al. 2021), they are vulnerable to violations of the assumption of multivariate normality, which may lead to biased standard errors. Even though covariance-based methods that are robust to non-normal data have been developed, these have so far shown to work best under large sample sizes (Hair et al. 2021). Shapiro-Wilks tests of the items considered for the construction of the GenDis index and the DigTech index show that fourteen out of these sixteen items significantly violate the normality assumption. The non-normality of the data and the rather small sample size hence speak in favor of a variance-based approach. Following this view and with the overall model containing only direct and moderating effects, hypotheses are tested using logit regressions on reshoring, and linear regressions on reshoring intentions.

To assess the goodness of fit for the identified two-factor model, confirmatory factor analysis was performed with Satorra-Bentler scaled chi-squared statistics, which is robust to nonnormality. Chi-square (df:34) = 63.593 is significant at p = .002, but within the 2:1 ratio conservatively suggested by Tabachnick et al. (2013). RMSEA = .076 is within the .08 threshold suggested by Maccallum et al. (1996) but above the more conservative cut-point of .06 argued by Hu and Bentler (1999). CFI = .927 and TLI = .904 are within the .90 threshold for a good fit suggested by Hair et al. (2021). SRMR = .066 is within the .08 cutoff value (Hu and Bentler 1999). Overall, this indicates an acceptable fit. Discriminant validity was assessed through the Fornell-Larcker criterion. The square root of the average variance extracted (AVE) for the two indexes DigTech (.694) and GenDis (.734) is well above the bivariate correlations of all other related constructs (Hair et al. 2021). In addition, Heterotrait-monotrait-ratio (HTMT) analysis returns values that are well below the suggested threshold of .90 (Hair et al. 2021), with the highest value .331 being between CovDis and PriDis. Results thus signify discriminant validity for the two indexes. Finally, Harman's single-factor test is used to test for common method bias, which is a potential concern in self-report questionnaire surveys (Podsakoff and Organ 1986). The resulting one-factor solution explains 25.94 percent of the total variance. Along with the low VIF scores (Table 3), this indicates that common method bias is not a concern.

Table 3 Descriptive statistics

Variable	Mean	Std. Dev.	Min	Max	VIF[a]
Reshore	.386	.488	0	1	-
Resh_Int	2.595	1.274	1	5	-
DigTech	.000	.688	-.832	2.100	1.75
Autom	3.072	1.358	1	5	1.46
GenDis	.000	.723	-.956	1.959	1.18
CovDis	3.719	.892	1	5	1.24
PriDis	4.235	.849	1	5	1.23
MI_Cu	2.922	1.173	1	5	1.51
MI_Em	3.183	1.138	1	5	1.52
Size(ln)	5.492	1.671	2.996	12.062	1.72
Export	65.356	30.672	0	100	1.26
StraCost	2.739	1.093	1	5	1.21
Diff	4.235	.801	1	5	1.26
Standard	.185	.389	0	1	1.34
Custom.	.452	.499	0	1	1.40
Mixed.	.338	.474	0	1	-

[a]VIF-values above 5.0 indicate collinearity problems (Hair et al. 2021)

4 Results

The descriptive statistics (Table 3) show that 38.56 percent of the 152 firms in the sample have reshored during the last three years.

The mean score for reshoring intentions (resh_int) is 2.595. Underlying this number, the distribution of answers is as follow: 10.46 percent to a *very high degree,* 13.72 percent to a *high degree*, 24.18 percent to a *moderate degree*, 28.10 to a low degree, and 23.53 percent to a *very low degree* consider reshoring within the next three years. The Reshore and the Resh_Int measures correlate positively and significantly (Table 4), signifying that firms with previous reshoring experience to a higher degree consider reshoring soon.

Reshoring and reshoring intentions correlate positively with automation and made-in for employees, respectively, but not with the remaining five independent variables of interest. Correlations are generally low among the independent variables, the highest being 0.54 between made-in customers (MI_Cu) and made-in employees (MI_Em). This indicates a low risk of multi-collinearity.

4.1 Industry 4.0 technology effects

Hypothesis 1 states a positive relationship between reshoring and industry 4.0. This is tested in model 1 (Table 5) for reshoring and in model 3 for reshoring intentions. The coefficient for the digital technology index (DigTech) is negative but insignificant for both reshoring (b = -.191 p = .452) and reshoring intentions (b = -.111 p = .400). Yet, the coefficient for automation investments (Autom) is positive and significant for both reshoring (b = .665 p = .006) and reshoring

Table 4 Pairwise correlations

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
(1) Reshore														
(2) Resh_Int	0.39**													
(3) DigTech	0.06	0.05												
(4) Autom	0.22**	0.17*	0.35**											
(5) GenDis	0.03	0.09	0.20*	0.12										
(6) CovDis	0.05	0.21**	0.05	-0.10	0.20*									
(7) PriDis	0.10	0.20*	-0.05	0.01	0.05	0.33**								
(8) MI_Cu	0.06	0.14	0.02	0.28**	-0.08	0.02	0.11							
(9) MI_Em	0.17*	0.27**	0.02	0.25**	-0.07	0.02	0.15	0.54**						
(10) Size(ln)	0.04	0.03	0.52**	0.06	0.03	-0.07	-0.24**	-0.19*	-0.23**					
(11) Export	0.06	0.05	0.27**	-0.06	0.11	0.07	-0.07	-0.04	-0.12	0.32**				
(12) StraCost	0.04	0.15	0.05	-0.04	0.15	0.06	0.14	0.04	0.09	0.02	-0.13			
(13) Diff	0.04	0.00	0.13*	0.11	-0.02	0.11	-0.03	0.04	0.00	0.10	0.27**	-0.32**		
(14) Standard	0.20*	0.06	0.06	0.05	0.14	0.10	-0.06	-0.02	0.01	0.16*	0.08	0.01	0.13	
(15) Custom.	-0.06	-0.01	-0.11	-0.25**	-0.07	0.04	0.05	0.01	-0.10	-0.08	-0.02	0.01	-0.18*	-0.43**

Significance level *$p < 0.05$; **$p < 0.01$

intentions (b = .202 p = .094). Hypothesis 1 is thus supported for investments in automation but not for the current use of industry 4.0 technologies.

Hypothesis 2 states a reinforcing effect of firm size on the relationship between reshoring and industry 4.0. This is tested in models 2 and 4 for reshoring and reshoring intentions, respectively. The coefficient for the interaction between firm size and digital technology use (DigTech) is positive but insignificant for both reshoring (b = -.085 p = .731) and reshoring intentions (b = .043 p = .686). The coefficient for the interaction between firm size and automation investments (Autom) is negative and insignificant for reshoring (b = .304 p = .306) and positive and insignificant for reshoring intentions (b = .013 p = .918). Hypothesis 2 is thus not supported.

4.2 Disruption effects

Hypothesis 3 states a positive relationship between reshoring and supply chain disruptions. The results show no significant association between Reshore (model 1) and the three disruption variables GenDis (b = -.029; p = .892), CovDis (b = .021; p = .923), and PrDis (b = .236; p = .281). Hypothesis 3 is thus not supported for reshoring activity during the last three years. In model 3, the coefficient for the index for the general disruption factor (GenDis: b = .054; p = .629) and the coefficient for price fluctuations (PrDis: b = .121; p = .272) are both positive but insignificant. Yet, the coefficient for Covid-19 (CovDis) is positive and significant (b = .258, p = .023). Altogether, the hypothesized positive association between reshoring and supply chain disruptions is thus only supported by the relationship between reshoring intentions and Covid-19.

Hypothesis 4 states a reinforcing effect of firm size on the relationship between reshoring and supply chain disruptions. Counter to this expectation, Model 2 reveals no significant interaction between size and two of the disruption variables CovDis (b = .238; p = 386), and PrDis (b = -.141; p = .592), while the interaction with GenDis (b = -.440; p = .070) is significantly negative at the .10 level. Correspondingly, model 4 shows a significant negative coefficient for the interaction between firm size and the index for the general disruption factor (GenDis) (b = -.275, p = .037), while the interaction effects for CovDis (b = .125, p = .319) and PriDis (b = -.032, p = .806) are insignificant. Hypothesis 4 is thus supported by the interaction between firm size and general disruptions in their combined effect on reshoring intentions. The marginal effects plot in Fig. 2 provides more detail to this association, indicating that smaller firms have less reshoring intentions than larger firms at the lowest level of disruptions. Yet, as disruption increasingly affects firms' supply chains, small and large firms respond differently. Reshoring intentions increase in smaller firms (logged size one standard deviation below the mean) whereas they decrease in larger firms (logged size one standard deviation above the mean). From a point around half a standard deviation above the mean experienced disruption level reshoring intentions of smaller firms come to exceed the reshoring intention of larger firms.

4.3 Made-in effects

Hypothesis 5 is that there is a positive relationship between reshoring and made-in the preferences of

Table 5 Probit and linier regression

	Dependent variable							
	Reshore				Resh_int			
	Model 1		Model 2		Model 3		Model 4	
Variable:	Coef. (p-value)	Std.err	Coef. (p-value)	Std.err	Coef. (p-value)	Std.err	Coef. (p-value)	Std.err
DigTech	-.191(.452)	.254	-.078(.769)	267	-.111(.400)	.132	-.036(.791)	.136
Autom	.665**(.006)	.241	.673** (.009)	.258	.202*** (.094)	.120	.193(.115)	.122
GenDis	.029(.892)	.216	.010(.969)	.246	.054(.629)	.111	023.(.844)	.118
CovDis	.021(.923)	.215	-.030(.901)	.239	.258**(.023)	.113	.208*** (.083)	.119
PriDis	.236(.281)	.219	.259(.250)	.225	.121(.272)	.109	-.136(.221)	.110
MI_Cu	-.226(.338)	.236	-.176(.531)	.281	-.076(.536)	.122	-.089(.481)	.126
MI_Em	.401*** (.096)	.241	.328(238)	.278	.273*(.028)	.124	.255*** (.052)	.130
Size(ln)	.161	.247	.084(.804)	.338	.152	.132	.132(.402)	..157
Export	,128	.233	.027	.252	.161	.116	.113	.120
StraCost	.134	.211	.017	.235	.106	.106	.062	.103
Diff	.114	.219	.062	.231	-.013	.113	-.035	.141
Standard	1.786***(.002)	.588	2.071	.645	.290	.295	.456	.302
Custom	.838	.462	.804	.504	.261	.238	.257	.249
DigTech*size			.085(.731)	.249			-.043(.686)	.105
Autom*size			-.304(.306)	.297			.013(.918)	.123
GenDis*size			-.440(.070)***	.299			-.275*(.037)	.130
CovDis*size			.238	.274			.125(.319)	.125
PriDis*size			-.141(.592)	.263			-.032(.806)	.128
MI_Cu*size			.454(.281)	.421			.009(.951)	.147
MI_Em*size			-.226(.553)	.380			.041(.781)	..148
Industry	yes		yes		yes		yes	
Constant	1.043	1.118	-1.582	.682	2.234	.316	2.081	.798
Pseudo R2	.146		.187					
R-Squared					.256**		.311**	

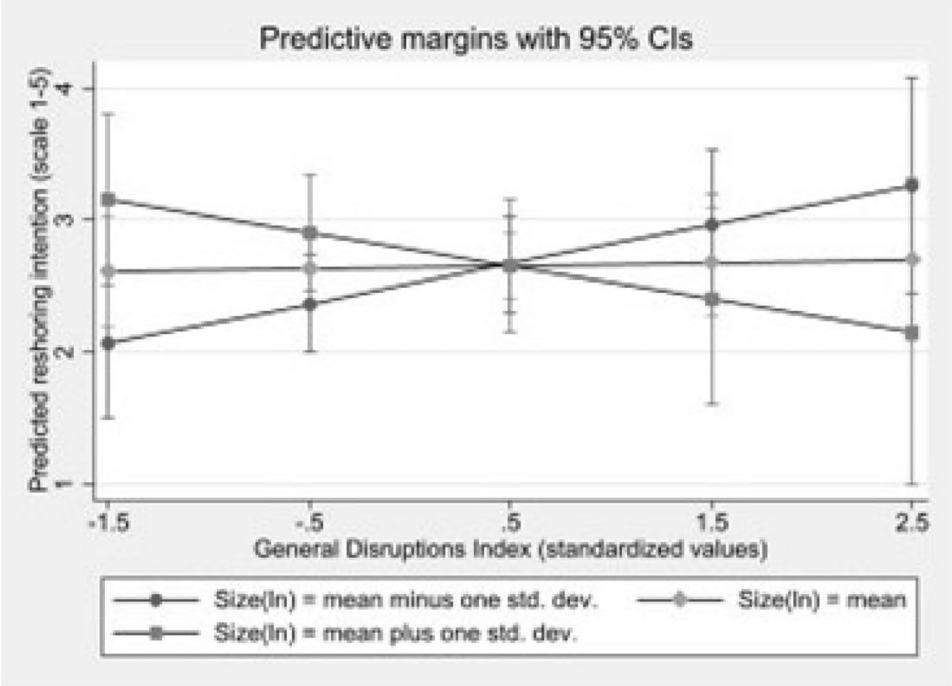
Significance level *$p < 0.05$; **$p < 0.01$; ***$p < 0.10$

stakeholders. Results from model 1 show a positive but insignificant association between customers' made-in preferences (MI_Cu) and reshoring (b = .226; p = .338). The coefficient for employee's made-in preferences (MI_Em), however, is positive (b = .401; p = .096) and significant at the .10 level. For reshoring intentions, model 3, there is a negative and insignificant coefficient for customers' made-in preferences (MI_Cu: b = -.076; p = .536). Yet, the coefficient for employee's made-in preferences (MI_Em) is positive and this time significant at the .05 level (b = .273; p = .028). The results thus give some support for the hypothesized positive association between reshoring and made-in, but only for employees' made-in preferences, and most strongly for reshoring intentions. Finally, hypothesis 6 expresses the expectation that firm size moderates the relationship between stakeholder's made-in preferences and reshoring. In model 2, coefficients for the interaction of size with MI_Cu (b = .454; p = .281) and MI_Em (b = -.226; p = .553) are both insignificant, hence not supporting Hypothesis 6. In model 4, the coefficient for the interaction between size and MI_Cu is positive but not significant (b = .009; p = .951). The coefficient for the interaction between size and MI_Em is negative and insignificant (b = -.041; p = .781). Thus, hypothesis 6 is not supported.

4.4 Evaluating model fit and robustness of results

While acknowledging the limitations of covariance-based (CB) approaches assuming joint normality models 1–4 are repeated using CB-SEM with the Satorra-Bentler chi-squared statistics to indicate model fit with the data

Fig. 2 Marginal effects



and to assess the robustness of results. Fit statistics are here reported for models 1 and 3. In model 3 chi- square (df:145) = 378.477 with the p-value being insignificant (p = .230) and with chi-square/df = 1.054 being within the conservative 1:2 ratio (Tabachnick et al. 2013). RMSEA = .019 is within a conservative cut-point of .06 (Hu and Bentler 1999). CFI = .938 is within a less conservative threshold of .90 (Hu and Bentler 1999). TLI = .930 is within the .90 threshold (Hair et al. 2021). SRMR = .108 is, however, just outside the less conservative .10 cutoff value (Hu and Bentler 1999). Except for the value of SRMR, these fit statistics suggest an acceptable model fit. In model 3 chi-square (df:145) = 182.599 with the p-value being significant (p = .019), but with chi-square/df = 1.259 within the conservative 1:2 ratio (Tabachnick et al. 2013). RMSEA = .041 is within a conservative cut-point of .06 (Hu and Bentler 1999). CFI = .952 is above a conservative threshold of .95 (Hu and Bentler 1999). TLI = .866 is below the .90 threshold (Hair et al. 2021). SRMR = .040 is within the .08 cutoff value (Hu and Bentler 1999). Except for the value of TLI, these fit statistics suggest an acceptable model fit. Results from CB-SEM model 1 support the finding of a positive relationship between Autom and Reshoring (b = .304; p = .001), hence supporting hypothesis 1. CB-SEM model 3 does not find similar significant support for a positive relationship between Autom and Resh_Int (b = .148; p = .130). Nonetheless, supporting hypotheses 3 and 5, respectively, both the positive relationship between CovDis and Resh_Int (b = 296; p = .013) and between MI_Em and Resh_Int (b = .231; p = .023) are reaffirmed by CB-SEM model 3. Finally, the finding of size moderating the effect of GenDis is confirmed for Resh_Int (CB-SEM model 4: b = -.305; p = .019) but not for Reshoring (CB-SEM model 2: b = -.074; p = .556).

5 Discussion and conclusions

This paper has set out to investigate how reshoring of manufacturing is affected by Industry 4.0 technologies, supply chain disruptions, and made-in effects. The analysis uncovered several interesting associations between reshoring and important environmental contingencies. First, results suggest that firms' current extent of using Industry 4.0 technologies, as measured by the digital technology index, is unrelated to firms' reshoring activity over the last three years, and unrelated to intentions to reshore in the near future. This finding is against suggestions from previous studies of a positive relationship (Ancarani et al. 2019; Fratocchi et al. 2016; Stentoft et al. 2016b) but mirrors with findings by Müller et al. (2017). One factor that may have influenced this result is that the Industry 4.0 index does not capture changes in firms' use of Industry 4.0 technologies and that decisions to reshore associate more tightly with changes in the use of technologies rather than in the intensity of their use. Also,

studies have found that several contingencies, such as high-quality focus and low-cost motives (Ancarani et al. 2019; Dachs et al. 2019) highly influence the effect of Industry 4.0 on reshoring decisions (2019). Another plausible reason is that the Industry 4.0 umbrella includes a wide spectrum of technologies, which may have different effects on the relative advantages of production at home or abroad.

The finding that firms that invest more in automation are more likely to have reshored during the last three years and have higher intentions to reshore in near the future is well in line with previous findings by Lund and Steen (2020). Findings further suggest that mechanisms underlying this effect work equally across firm size. Results thus suggest that smaller firms, which generally have larger difficulties than larger firms operating abroad, do not more actively engage automation technology (nor Industry 4.0 technologies in general) as part of their reshoring strategy compared to larger firms. Very likely, the same resource shortages that bound their offshoring capabilities also constrain their capabilities to identify and enact opportunities from new automation technologies.

Mirroring our initial anticipations, factor analysis confirmed the distinction between familiar and unfamiliar environmental disturbances with Covid-19 and price fluctuations standing out as the unfamiliar disturbances. Results from the further analysis revealed no relationship between reshoring with the known supply chain disruptors (factor 1) nor with price fluctuations, why hypothesis 3 is not supported for this part. Thus, when it comes to known risks where companies can make traditional risk analyses and assess their probability and impact it seems not that such disruptions influence their reshoring practice or their intention. This is something that can be prepared. Nonetheless, risk assessment and preparedness are highly contingent on firm resources. Much consistent with this view, results showed that larger firms reacted to increases in supply chain disturbances from these sources by decreasing their reshoring activity. Opposite, smaller firms reacted by increasing their reshoring activity. Seemingly larger firms are more capable of utilizing mere specialized managerial capital and larger production volume to reduce supply chain risk by geographical dispersion of activities. Smaller firms with less managerial capital and smaller production volume may not have the critical mass to do so, which makes the geographical concentration of activities more favorable when confronted with high environmental uncertainties. For the unknown risks associated with Covid-19, results were somewhat different. Results here showed that Covid-19 supply chain disturbances were associated positively with reshoring intentions but not with reshoring activity, which supports previous findings by van Hoek and Dobrzykowski (2021) and findings by Chen et al. (2022).

The difference in findings for reshoring intentions and activities, respectively, is not surprising since it takes time to effectuate such complex decisions, and since the survey asks for reshoring activity that includes time both during and before the pandemic. The Covid-19 situation has exposed several unanticipated supply chain vulnerabilities that independent of firm size have pushed firms to consider reshoring more favorably. Despite the more speculative views of supply chain disruptions' influence on reshoring activities (Clouse et al. 2022; Gereffi 2020; Sarkis 2021), we still lack empirically founded research focusing more detail on the relationships between various supply chain disruptions and reshoring activities.

Finally, employees' preferences, but not customers' preferences, for made-in associated positively with reshoring which is different from the findings by Ancarani et al. (2015), Di Mauro and Ancarani (2022), and Moretto et al. (2020). The finding of a positive association between reshoring and employees' preferences for made-in, findings confirm the expectation that made-in is a driver of reshoring (source) and where emotional elements come into play (Benstead et al. 2017; Boffelli et al. 2020; Di Mauro et al. 2018). A plausible explanation for why customer-related made-in-effects were not confirmed could be that firms whose customers have very high preferences for made-in are underrepresented in our sample. Many such firms may not have any outsourced activities in the first place. Second, previous studies have shown that both industry and country-level differences affect the prominence of made-in-effects (Wan et al. 2019). A significant proportion of the firms in the sample consisted of machinery, equipment, and metal product manufacturing companies, which mostly operate in B2B markets. These characteristics may likely decrease the prominence of made-in effects.

Overall, the results suggest that a broad set of factors including investment in automatization, unfamiliar environmental disturbances such as Covid-19, and employee made-in preferences were influential in driving reshoring intentions for the sampled firms, while recent reshoring activity was influenced by investments in automation technology employee made-in preferences. Considering the timing of the survey, it is highly plausible that the severity of the supply chain crisis at the time of data collection has downplayed the importance of Industry 4.0 technologies and of the made-in-effect as firms and their customers have been more occupied with

the security of supply. Indeed, the timing issue seems highly important in interpreting the results in comparison to findings from previous. Interestingly, the effect of general (familiar) environmental disturbance was only discernable when simultaneously considering the effect of firm size.

6 Implications, limitations, and suggestion for future research

6.1 Implications for theory

This study has several implications for theory. Firstly, reshoring manufacturing is a dynamic and multi-complex phenomenon where the conditions for location manufacturing at home or abroad constantly is changing. This means, that even though a company has decided to maintain offshored manufacturing instead of back-reshoring, while there are obvious advantages of using Industry 4.0 technologies, is not the same to conclude that such manufacturing never will be reshored. With the opposite movement, the same is true for manufacturing that continues to take place in the home country or has been reshored. Reshoring manufacturing is not context-free. Extant literature is rich in drivers for reshoring practices such as eroding competitive advantages (e.g., costs, quality, and lead-time), changes in the global economy, increased levels of supply chain disruptions (e.g., geopolitical tensions and climate changes), nation-wide incentive programs, developments in new digital technologies, made-in effects, and a stronger public demand on sustainability. In this discussion, we should not forget that reshoring of manufacturing for some companies is not on the strategic agenda since their overall purpose of being present abroad is to have proximity to markets and customers.

This paper reveals a positive relationship between reshoring and investments in Industry 4.0 technologies but not for the actual use of the technologies. In the present context, investments have taken place, but these have yet not been effectuated in concrete implementations. Thus, there is a time dimension from investments to actual use which calls for more longitudinal studies. Different results are reported in the literature about reshoring decisions due to the actual use of Industry 4.0 technologies. More empirical founded research is needed here that also compares practices across nations, what specific technologies are used, and their antecedents. There are also reported different results regarding whether firm size has an impact on the reshoring phenomenon.

In this paper, there was no evidence to suggest that firm size alter the relationship between Industry 4.0. technology adaptation and reshoring. While smaller firms with less specialized resources may struggle more to establish effective offshoring solutions and consequently may be more prone to backshore activities (Ancarani et al. 2015; Gray et al. 2017), seemingly, such propensities are not linked to higher investments in Industry 4.0 technologies. A reasonable explanation may be that with a lack of specialized resources, smaller firms may experience many struggles seeing and developing the potential of new technologies.

The paper identifies a positive relationship between the intentions to reshore and Covid-19 pandemic. This finding supports the limited academic research in this area, but, again, it takes time to be able to analyze the true effects of Covid-19 since deciding to reshore to its actual implementation might require much time e.g., assuring the needed competencies and the right supply network to enable local-for-local sourcing. Furthermore, this theme taps into a possible regionalization agenda of supply chains – a phenomenon that needs empirical research and may uncover different contingencies and challenges.

It is an intriguing result that intentions to reshore in response to supply chain disruptions related to firm size. Initially, when disruptions are perceived as low, the data indicates that larger firms exhibit a stronger inclination to reshore manufacturing compared to small and medium-sized enterprises (SMEs). One potential explanation for this disparity is that SMEs, in contrast to their larger counterparts, possess fewer human and financial resources (Zach et al. 2014), tend to focus more on operational rather than strategic and development-oriented tasks (Stentoft et al. 2021a), and often lack well-defined strategic approaches (Löfving et al. 2014). Consequently, minor disruptions may not significantly influence SMEs' intent to reshore due to their resource constraints, while large corporations tend to be more strategically aware, evaluating threats, even small-scale ones.

Conversely, when confronted with substantial disruptions, SMEs demonstrate an increased intention to reshore, surpassing that of larger companies. This finding strengthens interpretations from previous research that smaller firms are less prepared for (Gunasekaran et al. 2011) and have less specialized resources to detect and respond to larger environmental changes (Burnard and Bhamra 2011), and hence are more highly affected (Bak et al. 2020; Polyviou et al. 2020). Under such circumstances it is highly likely that smaller firms to a higher extent consider reshoring in contrast to other solutions as the most viable, and perhaps the only possible solution to reduce risk and retain operational efficiency.

It is noteworthy that larger firms in contrast to smaller firms decrease their intentions to reshore when well-known types of disruptions increase in magnitude. A plausible explanation, however, is that larger firms in many cases outsource activities to multiple geographical locations, which may provide for higher levels of strategic flexibility, and hence function as a risk-handling mechanism. An important condition to derive such benefits is that disruptions are observable, and that firms possess the resources to monitor and analyze the business implications of such disruptions.

The paper does not find any relationship between a brand-wise made-in effect and reshoring as is found in the extant literature. The reason might be that the dataset is dominated by B2B companies. Yet, it may also be that in such volatile times as during the Covid-19 pandemic, when this survey was conducted, there has been a suppression of mangers' attention to the made-in-effect, as other environmental contingencies have been more present. Again, more research is needed on the made-in effect across contexts, industries, and nations.

Interestingly, the data reveals that the employee perspective on a made-in effect has a positive relationship with reshoring intentions. This indicates a general awareness of the importance of having production jobs in a high-salary country. Yet, again here, it is also likely that the experiences of lockdowns and increased difficulties of coordinating and controlling activities across geographical distances, have fortified managers' awareness of the values of locally performed activities and from a local workforce. To be able to conclude on such conjectures, however, requires further research, preferably in a longitudinal perspective.

6.2 Implications for practice

The result of this paper also has several implications for practice. First of all, reshoring decisions is complex and requires much data and analysis to provide the right decision foundation. When it comes to Industry 4.0 technologies it is important to be conscious about which technology or technologies are relevant in a reshoring perspective and how they should be applied. Time is needed to be invested to be capable of investigating whether it makes sense. Prior research (Stentoft et al. 2021a) identified barriers to investing in Industry 4.0 as being e.g., lack of knowledge about Industry 4.0 and the strategic importance of using the technologies). For such decisions to mature, knowledge regarding national governmental programs to support Industry 4.0 technology deployment and knowledge resources may be required. The business environment has also become more vulnerable and uncertain due to e.g., the Covid-19 pandemic and increased geopolitical tensions which stress the importance for senior managers to reconsider their global supply chain footprint and location of manufacturing. Important questions to raise are e.g., what types of supply chain disruptions (known and unknown) are the company disposed to and what are their probability and impact? What is the impact of disruptions beyond an environmental jolt as Covid-19 that are more minor in nature, and which can arise from seemingly insignificant scenarios that temporarily impact the supply chains? Do the current and the perceived developments in different types of supply chain disruptions catalyze a process towards reshoring manufacturing to the home country or nearshoring from a regionalization perspective? These are important strategic questions for senior managers to address.

SMEs should be aware of the potential effects of supply chain disruptions due to their relatively lower level of financial and human resources compared with large companies. These, along with the smaller scale of their operations and their typically less powerful network positions would seem to imply that for most smaller firms, pursuing offshoring as a mean to bolster against times of high but familiar uncertainty is not a viable strategi. For larger firms, however, offshoring may opposite be important elements in creating resilient capabilities during such circumstances. Last, the research also demonstrates some impact of a made-in effect on reshoring intentions. Again, this suggests a consciousness of whether the made-in effect brand-wise or employee-wise is a factor that needs to be further investigated.

6.3 Limitations and suggestions for future research

This study has several limitations. Firstly, the data is based on only single respondents from each company which opens for respondent bias. Future research can include multiple respondents from each company. Secondly, the paper is based on a questionnaire survey that informs about the extent to which companies are pursuing reshoring practices in the light of three investigated themes. Future research can supplement this study through qualitative research e.g., through case studies to more detailly explore what specific practices that have taken place. Thirdly, notably not all reshoring intentions are likely to lead to reshoring. Implementing reshoring decisions takes time, and environmental jolts may resettle while new ones emerge. Thus, results may overstate the actual reshoring effect of recent Covid-19 and associated price fluctuations. Continuing the study of firms' reshoring

activity and the relationship between reshoring intentions and reshoring activity is important to cast new lights on these issues. Fourthly, the cross-sectional design of this study bears its limitations. Thus, longitudinal studies that follow firms' reshoring activities over longer periods, and which in more detail inquire into the specific operational and strategic consequences of environmental dynamics are important to build further knowledge of the results from this study. Fifthly, this paper has invested in made-in effects by asking one respondent from the focal company. Future research could address this important topic area by including the voice of the companies' customers. Sixthly, in this paper, the term reshoring has been used to denote the movement of production back to Denmark either from its facilities abroad or from external suppliers. These are two different governance structures that the present analysis does not cover but are important to be addressed in future research. Seventhly, data in this paper is based on Danish firms, and Denmark is according to OECD among the countries at the forefront when it comes to digital adoption. Thus, future research may focus on the themes in this paper and extend its application across nations and lesser developed countries.

Appendix A - Questionnaire items for the dependent, independent and control variables

Dependent variable

Reshoring

1. Has your company within the last three years taken production back from abroad to Denmark either from its factory or from a supplier? Yes /No
2. To what extent is it likely that your company within the next three years will take back production from abroad to Denmark? (A five-point Likert scale: 1 = to a very low degree and 5 = to a very high degree)

Independent variables

Industry 4.0/automation (Scale adapted from Dachs et al. 2019; Stentoft et al. 2016a, b; Stentoft and Rajkumar 2020).

1. To what degree has your company invested in automation of production in Denmark over the last three years? (A five-point Likert scale: 1 = to a very low degree/none and 5 = to a very high degree).
2. To what extent is your company using the following technologies in your production processes? (A five-point Likert scale: 1 = to a very low degree and 5 = to a very high degree).

- Big data and analytics
- Autonomous robots
- Simulation
- Internet of Things (IoT)
- Additive manufacturing
- Augmented reality
- Artificial Intelligence

Supply chain disruptions (Scale developed based on Akkermans and Wassenhove 2018; Chowdhury and Quaddus 2016; Moradlou et al. 2021; Nguyen et al. 2021; Roscoe et al. 2022; Stecke and Kumar 2009).

1. On a five-point Likert scale: 1 = to a very low degree and 5 = to a very high degree), to what degree is your supply affected by:

- Pandemics
- Cybercrime
- Natural disasters
- Human error
- Price fluctuations
- Exchange rate fluctuations
- Trade wars
- Regional disturbances
- Other issues

Made-in effect (Scale adapted from Benstead et al. 2017; Fratocchi et al. 2016; Grappi et al. 2018, 2020).

1. On a five-point Likert scale: 1 = to a very low degree and 5 = to a very high degree), to what degree has "made-in Denmark" a positive impact on your customers?
2. On a five-point Likert scale: 1 = to a very low degree and 5 = to a very high degree), to what degree has "made-in Denmark" a positive impact on your employees?

Moderator variable

Firm size (Scale adapted from Ancarani et al. 2019; Stentoft and Rajkumar 2020).

1. How many employees are employed in the company divided by white and blue color?

Appendix B - Principal component analyses

Digital technology use

	Mean	Std.dev	Shapiro Wilks W	Factor loadings (EFA)	Factor loadings (CFA)
To which extent do your company use each of the following technologies in the production processes:					
1. Big data and analytics	2.16	1.138	.906**	.737	.673
2. Autonomous robots	2.27	1.285	.976**	.544	.460
3. Simulation	2.12	1.158	.953**	.707	.661
4. Internet of Things (IoT)	2.05	1.216	.949**	.768	.708
5. Additive Manufacturing	1.92	1.104	.941**	.599	.531
6. Augmented Reality	1.51	.845	.928**	.704	.667
7. Artificial Intelligence	1.39	.710	.894**	.768	.740
Total variance explained (%)				48.191	
Cronbach's Alpha				.817	
Rho_c				.827	

Principal component analysis of standardized items

**$p < 0.01$

Disruptions

	Mean	Std.dev	Shapiro Wilks W	Factor loadings (EFA)		Factor loadings (CFA)
				Factor 1	Factor 2:	Factor 1
To which extent is your supply chain affected by:						
1. Pandemics (Covid-19, etc.)	3.69	.909	.985		.779	
2. Cybercrime	1.72	.832	.932**	.685		.489
3. Natural disasters	1.94	.935	.956**	.739		.605
4. Human error (Grounding, fire, etc.)	1.97	.921	.972**	.684		.482
5. Price fluctuations	4.19	.897	.888**		.823	
6. Exchange rate fluctuations[a]	2.67	1.026	.996			
7. Trade wars	2.37	1.103	.987	.738		.769
8. Regional disturbances	2.02	1.009	.957**	.752		.830
9. Other issues[a]	1.52	.945	.896**			
Total variance explained (%)				38.532	18.961	
Cronbach's Alpha				.783		
Rho_c				.853		

Principal component analysis of standardized items (varimax rotation)

**$p < 0.001$

[a]Removed from factor analysis because of high loadings on both factors**Funding** Open access funding provided by University of Southern Denmark

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