



Report 2023:15

Does risk diversification work?

A case study of supply disruptions during the pandemic and measures taken by the Swedish industry to improve resilience

The coronavirus pandemic caused major disruptions in the global supply chains of the Swedish manufacturing industry, forcing many companies to scale back or stop production for a period due to a lack of parts and components. Did companies with greater risk diversification in their supply chains fare better than others? And what measures have been taken since the pandemic to improve resilience?

Ref: 2023/34

The Swedish Agency for Growth Policy Analyses

Studentplan 3, 831 40 Östersund

Telephone: +46 10 447 44 00

E-mail: info@tillvaxtanalys.se

www.tillvaxtanalys.se

For further information contact: Håkan Nordström

Telephone: +46 72 546 98 00

E-mail: hakan.nordstrom@tillvaxtanalys.se

Preface

The mission of the Swedish Agency for Growth Policy Analysis is to evaluate the impact of government policies on sustainable growth at regional and national levels. We also provide data and recommendations for the development, review and streamlining of government policies.

The purpose of this report is to analyse the supply disruptions during the COVID-19 pandemic in the Swedish manufacturing industry and the impact of risk diversification in supply chains. The report also presents data on what the industry has done or plans to do to improve its resilience in the future. The report is written by Håkan Nordström.

The study is part of a wider project on the resilience of Swedish industry in times of rising geopolitical tensions and increased uncertainty in the world market. The project is led by Håkan Nordström in collaboration with Josefin Videnord.

We are grateful to all those who have contributed to this report.

Östersund, November 2023

Sverker Härd
Director-General, Tillväxtanalys

Table of contents

Preface	2
Summary	4
Sammanfattning	5
1. Introduction.....	6
2. Background and data	12
2.1 Prologue	12
2.2 Scope and data sources	13
2.3 Quarter-by-quarter developments in 2020	15
2.4 Geographical risk diversification.....	16
2.5 Summing up	19
3. Statistical analysis.....	20
3.1 Measurement issues.....	20
3.2 Results.....	20
3.3 One-size-fits-all?.....	23
4. What measures have been taken to improve resilience?.....	24
4.1 Basic facts about the survey	24
4.2 Supply disruptions during the pandemic.....	26
4.3 Actions taken or planned	27
4.4 Measurable actions up to 2021	29
4.5 Sourcing closer to home?	30
5. Summary and conclusions	32
Bibliography	33

Summary

The pandemic caused major disruptions to industrial production in Sweden, especially in the early stages when supply and logistics chains were disrupted as first China and then other countries shut down society to prevent the spread of the virus. Despite the global nature of the pandemic, not all industries were affected to the same extent, nor were all companies within each industry. In this report, we have analysed supply disruptions in the manufacturing sector during the pandemic and the relationship between disruptions and risk diversification. Did companies with diversified supply chains fare better than others? Based on a survey supplemented by data analysis, the report also documents what the industry is doing to improve resilience in the future.

The study is based on monthly microdata for 2570 industrial companies in Sweden for the period from January 2019 to December 2021. The study shows that the risk of supply disruption is lower when inputs are sourced from suppliers in different countries, referred to as geographical risk diversification, but that the return at the margin is diminishing. Excessive risk diversification can even be counterproductive, probably because splitting purchases makes the company a less important customer of each supplier, with the risk of being deprioritised in a shortage situation.

In practice, risk diversification varies considerably according to the size of the enterprise and, to some extent, according to the industry. Large enterprises diversify risks more than small enterprises in the same industry, suggesting that costs are a limiting factor for smaller enterprises. Risk diversification also varies to some extent across industries, probably because they use different inputs. Where supply is concentrated on the world market, the scope for risk diversification is reduced, as in the case of microchips and certain metals and minerals, where supply is dominated by a few countries. The scope for risk diversification therefore depends on the opportunities, costs and benefits, which vary between companies according to size and industry.

The survey, conducted in collaboration with the Confederation of Swedish Enterprises, shows that six out of ten industrial companies have taken or planned measures to reduce their vulnerability to future crises. The most active companies are those that experienced problems during the pandemic, where 67 percent say they have taken or planned a measure, compared with 37 percent of other companies. The most common measure is increased stockpiling (37 percent), followed by increased risk diversification (33 percent) and increased sourcing in Sweden and EU/EFTA (22 percent). Only 3 percent are considering bringing production back to Sweden.

Due to a lack of data, we are unable to verify the extent to which industry actually increased input stocks after the pandemic to bridge temporary supply disruptions. In terms of increased risk diversification and sourcing closer to home, the data do not provide clear evidence, possibly because supply chain reorganisation takes longer than we have been able to track in our databases. The jury is still out.

In summary, risk diversification works to some extent, but with diminishing returns. In practice, risk diversification varies by sector and company size. 60 percent of industrial companies in Sweden are planning measures to improve resilience, but the data show little evidence of action so far, with the possible exception of increased stockpiling.

Sammanfattning

Coronapandemin orsakade stora störningar i industriproduktionen i Sverige, särskilt i det tidiga skedet när leverans- och logistikkedjorna bröts när först Kina och sedan andra länder stängde ner samhället för att stoppa spridningen av viruset. Trots pandemins globala karaktär påverkades inte alla branscher i samma utsträckning, och inte heller alla företag inom varje bransch. I den här rapporten har vi analyserat leveransstörningarna i tillverkningsindustrin under pandemin och effekten av att sprida riskerna i leverantörsledet mellan olika länder. Klarade sig företag med större riskspridning bättre än andra? Studien kartlägger även industrins åtgärder för att stärka sin motståndskraft.

Den empiriska studien på mikrodata för 2570 industriföretag visar att risken för leveransavbrott är mindre om inköpen delas upp mellan olika leverantörer, men att avkastningen av ökad riskspridning är avtagande på marginalen. En alltför stor riskspridning kan till och med vara kontraproduktiv, förmodligen för att en uppdelning av inköpen medför att en blir en mindre viktig kund hos varje leverantör, med risk för att bli nedprioriterad i en bristsituation.

I praktiken varierar riskspridningen avsevärt mellan olika företagsstorlekar och, i viss utsträckning, mellan olika branscher. Stora företag sprider riskerna mer än små företag i samma bransch, vilket antyder att kostnaderna är en begränsande faktor för framförallt de mindre företagen i industrin. Riskspridningen varierar i viss utsträckning även mellan olika näringsgrenar av industrin, förmodligen för att de använder olika insatsvaror. Om utbudet är koncentrerat på världsmarknaden minskar möjligheten att sprida riskerna mellan olika länder, vilket till exempel är fallet med mikrochips samt vissa metaller och mineraler där utbudet domineras av ett fåtal länder. Riskspridning är med andra ord en avvägning mellan kostnader, möjligheter och nytta.

Enkätundersökningen som genomfördes i slutet av första pandemiåret i samarbete med Svenskt Näringsliv visar att sex av tio industriföretag har vidtagit eller planerat åtgärder för att minska sårbarheten inför kommande kriser. Mest aktiva är företagen som hade problem under pandemin där 67 procent uppger att de har vidtagit eller planerat någon åtgärd, jämfört med 37 procent för de andra företagen. Den vanligaste åtgärden är ökad lagerhållning (37 procent), följt av ökad riskspridning (33 procent) och ökade inköp i Sverige och EU/ EFTA (22 procent).

Eftersom vi saknar data kan vi inte verifiera i vilken utsträckning som industrin faktiskt har ökat sina lager efter pandemin för att överbrygga tillfälliga störningar i leveranserna. När det gäller riskspridningen och flytt av inköpen närmare Sverige ser vi inga större förändringar i data, med reservation för att en omläggning av leverantörskedjorna tar längre tid än vad vi har kunnat följa i våra databaser.

Slutsatsen är att riskspridning fungerar till en viss gräns och att industrin har planerat åtgärder för att stärka sin motståndskraft inför kommande kriser, men att de ännu inte går att verifiera hur stora åtgärder som faktiskt genomförts. Det är därför en öppen fråga om industrin i Sverige har blivit mer "resilient" sedan pandemin.

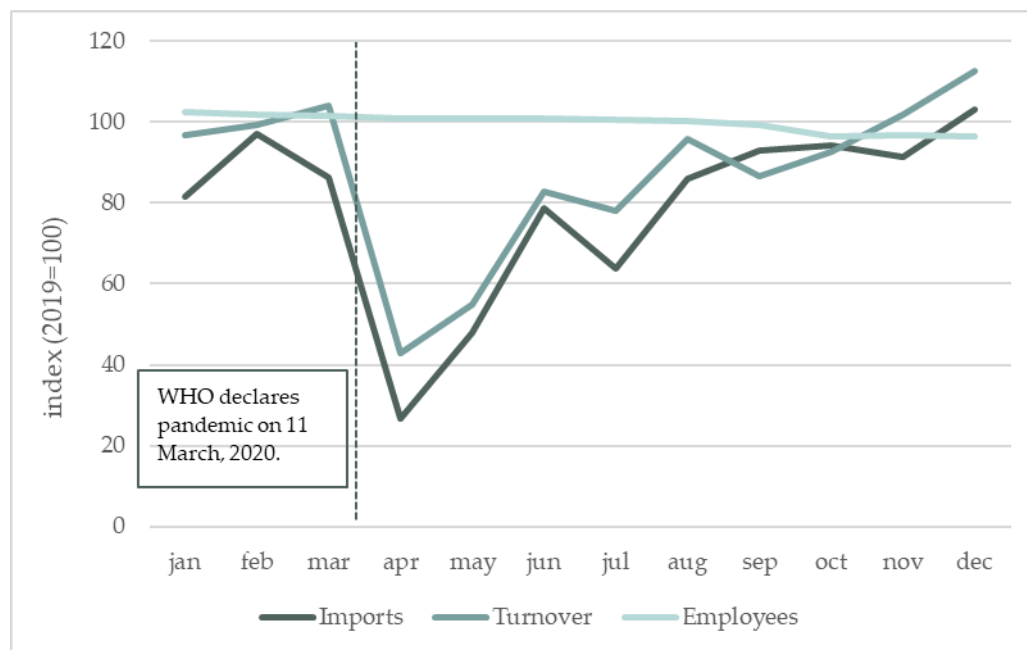
1. Introduction

"The first quarter 2020 started well, but from March it was dominated by the outbreak of the Corona virus and the extraordinary social measures taken to limit the spread of the infection. Scania's ability to deliver was increasingly affected by component shortages and disruptions in the supply and logistics chain. At the end of March, the decision was taken to stop Scania's European production, followed by a structured shutdown of the remaining production worldwide."

Interim report January-March 2020, Henrik Henriksson, CEO Scania

The coronavirus pandemic declared by the WHO on 11 March 2020 caused severe disruptions to industrial production in Sweden, especially in the early stages when supply and logistics chains were disrupted as China and then other countries shut down society to prevent the spread of the virus. For example, the automotive manufacturer Scania, whose CEO is quoted above, was forced to halt production at the end of March due to a growing shortage of components. The same happened at Volvo. The dynamic of the crisis from supply disruption to production disruption is illustrated in Figure 1 for the automotive industry, which was particularly hard hit by shortages of microchips and other components. At its peak in the spring, imports of intermediate goods were only a quarter of their 2019 level, and production came to a temporary halt. However, layoffs were avoided thanks to the short-time working scheme introduced in March 2020.¹

Figure 1. Imports of inputs, turnover and number of employees in the Swedish automotive industry in 2020, compared to the same month in 2019 (2019 = 100)

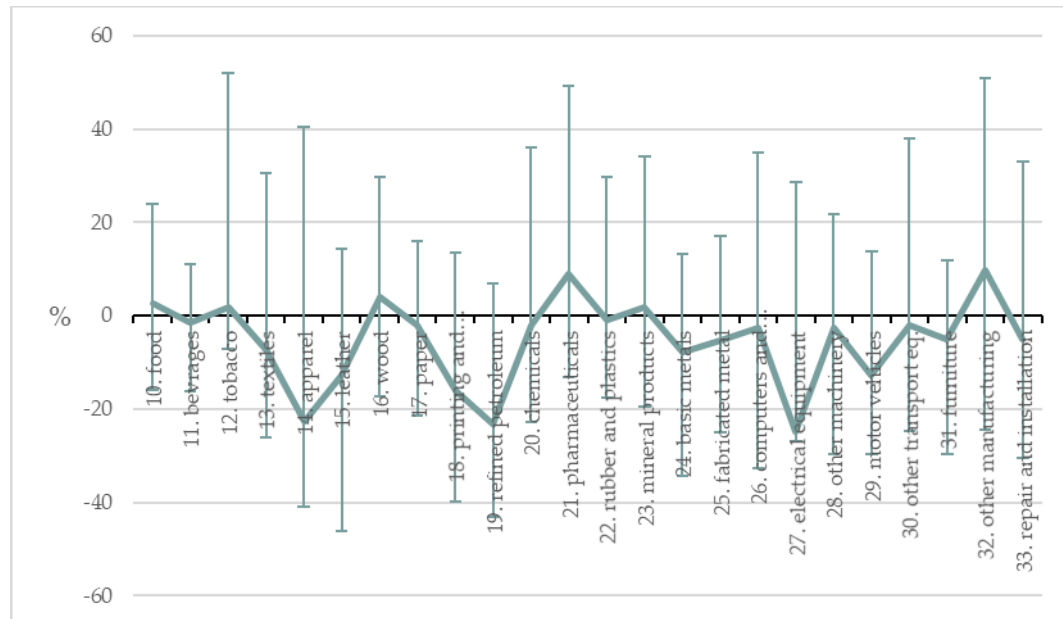


Source: Author's calculations based on monthly imports and turnover declarations. An index of 100 means that the situation is unchanged compared to the same month of the previous year.

¹ The assessment of the short-time working scheme by Tillväxtanalys (2022) suggests that it saved about 40 000 jobs during the pandemic at an estimated cost of SEK 660 thousand per job.

Despite the global nature of the pandemic, the impact varied both between and within sectors. The heterogeneous impact is illustrated in Figure 2. The horizontal curve shows the change in turnover in 2020 compared to 2019 for different industries at the 2-digit ISIC level, and the vertical bars show the range between enterprises at the 10th and 90th percentile of the distribution in each industry. For example, looking at the food industry on the far left of the graph, turnover increased by 2.5 per cent on average, with a range from -16.0 percent at the 10th percentile to +23.9 percent at the 90th percentile.

Figure 2. The change in turnover in 2020 compared with 2019. Differences between and within sectors



Source: Author's calculations based on turnover declarations. The bars show the range between the 10th and 90th percentile in each sector and the horizontal curve shows the weighted average.

One reason for the differential impact is that each sector uses different types of inputs, which were disrupted to different degrees during the pandemic. Another reason is that consumption patterns changed during the pandemic, as the labour market shifted from on-site to home-based work and people had more time to cook and undertake projects at home. In fact, some industries even fared better than the previous year due to changes in consumption, including industries producing food products (ISIC 10), tobacco products (ISIC 12), wood products (ISIC 16), pharmaceuticals (ISIC 21), non-metallic mineral products (ISIC 23) and other manufacturing (ISIC 32), including games and sport goods. In most sectors, however, sales fell by between a few percent and 25 percent. The impact of the pandemic was therefore very uneven across industries, depending on the extent of supply disruptions and changes in consumption patterns.

But the differences within sectors suggest that the outcome also reflected the resilience of individual companies, that is, their ability to withstand and recover from a supply shock. And perhaps we can learn something from this for future crises. What characterised the companies that were relatively unscathed by the pandemic? Were they lucky with their suppliers, or were their supply chains organised in a more resilient way, with alternative suppliers for each input? In other words, what role did risk diversification play?

In this report, which is part of a broader project on the resilience of Swedish industry in times of rising geopolitical tensions and increased uncertainty in the global market, we take a closer look at how the Swedish manufacturing industry was affected by supply disruptions during the pandemic and how this varied within each industry depending on the risk diversification in the supply chains. The analysis is based on detailed import data for 2570 companies in ISIC sectors 10 to 33. In the second part, we look at the measures being taken to build resilience for the future. The data comes from a survey conducted by Tillväxtanalys (2021) in collaboration with the Confederation of Swedish Enterprise in November 2020, where a random sample was asked to answer questions about supply disruptions during the pandemic and what measures they had taken or planned to take to reduce their vulnerability to future crises. In addition, we will compare the actual *ex-ante* sourcing in 2019 with the *ex-post* sourcing in 2021 to see what measures, if any, have been taken so far. Has the Swedish industry become more resilient after the pandemic?

Given that the government spent approximately SEK 200 billion² to support companies and employees during the pandemic (Tillväxtanalys 2023), the resilience of the business sector is in the public interest, even though the government cannot directly control how companies organise their supply chains and the risks involved. Individual companies may not always "internalise" (take into account) the costs to customers of delayed and cancelled deliveries when claims can be avoided by invoking "force majeure", i.e. external factors beyond their control. Firms' risk-taking may also be influenced by expectations of government support in a crisis, which may lead less prudent firms to take greater risks than they otherwise would - the so-called "moral hazard" problem.³ If business incentives are misaligned, risk diversification may be suboptimal from a societal perspective.

The study contributes empirically to the growing literature on global economic risk, where disruptions in one country can ripple through global value chains, as we saw during the 2020 coronavirus pandemic. The experience of the pandemic, combined with the renewed shockwaves following Russia's invasion of Ukraine in February 2022 and the rise in geopolitical tensions, has brought resilience to the forefront of the international policy debate,⁴ with more and more people seemingly believing that the solution is to reduce global exposure and redirect trade to the closest allies.⁵ This discourse, which has been ongoing in the US since Trump was elected president on a protectionist platform in 2017, has now reached the EU, with the aim of increasing the EU's "strategic autonomy", in particular by reducing its dependence on China and other input suppliers, which have started to use export restrictions on critical raw materials to secure their own needs and competitive position on the global market.⁶

² Equivalent to 20 billion euros at an exchange rate of SEK 10 to the euro.

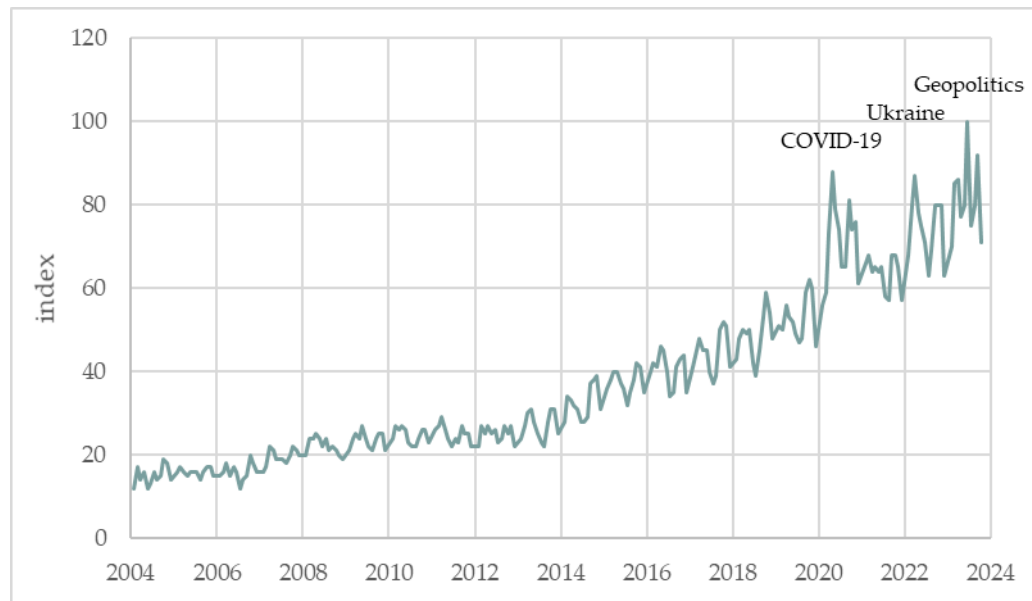
³ https://en.wikipedia.org/wiki/Moral_hazard

⁴ Goldberg and Reed (2023).

⁵ *The Economist*, 7 October 2023, "Are free markets history? The rise of homeland economics". See also the World Trade Organization (WTO) (2023) annual report on world trade with the subtitle "Re-globalisation for a secure, inclusive and sustainable future".

⁶ The global trade in strategic commodities and related policies will be examined in a forthcoming study under this project, including the EU's quest for greater 'strategic autonomy'.

Figure 3. Search for "resilience" on Google trends



The fact that world trade is risky is certainly not new, nor is the question of how to manage the risks without isolating oneself from the world market. As early as the mid-1960s, Brainard and Cooper (1968) showed that the same strategy used in the financial sector could be used to manage risks in foreign trade.⁷ The basic principle is not to put all your eggs in one basket, but to spread the risks across different markets. This lesson has now been rediscovered by a new generation of economists. The new literature shows *theoretically* that the risks in each export market can be balanced by exporting to many different markets, so that the ups and downs cancel each other out.⁸ The same principle applies on the sourcing side, where the risk of running out of inputs is reduced by spreading purchases across suppliers in different countries.⁹ However, little is known about how effective different risk management strategies are in practice.¹⁰

To our knowledge, the only study that has attempted to quantify the impact of risk diversification on microdata is a French study by Lafrogne-Joussier, Martin and Mejean (2023). The study follows 30,000 French firms during the early stages of the pandemic, from September 2019 to June 2020, and divides them into different groups according to their dependence on Chinese inputs. Unsurprisingly, the study found that companies sourcing inputs from China were hit first during the pandemic, but the difference with companies sourcing their inputs elsewhere had disappeared by June, when the virus had

⁷ The theory of financial risk diversification and the pricing of risky assets was developed by Markowitz (1952), Sharpe (1964) and Lintner (1965), the first two of whom were awarded the Nobel Prize in Economics in 1990. The basic principle is to save in a 'portfolio' of assets with different risk profiles, with assets that are negatively correlated with the portfolio being particularly valuable from a risk diversification perspective.

⁸ De Sousa, Disdier, Gaigné (2020); Esposito (2022); Caselli, Koren, Lisicky, Tenreyro (2020).

⁹ Gervais (2021); Inomata and Hanaka (2021); Lafrogne-Joussier, Martin, Mejean (2023); Finck, Tillmann (2022).

¹⁰ A good introduction to the literature on global production risks and knowledge gaps is the article by Baldwin and Freeman (2022) entitled "Risks and Global Supply Chains: What We Know and What We Need to Know". See also the business literature review by Thakur-Weigold and Miroudot (2023).

spread globally.¹¹ To test whether risk diversification played a role, companies importing inputs from China were divided into two groups, one highly dependent on Chinese inputs and the other more diversified, a strategy known as "China plus one". No significant differences were found between the groups, which surprised the authors, who had expected the diversified group to perform better, at least initially.

The French study suggests that geographical risk diversification does not work when the disruptions are global, as was the case during the coronavirus pandemic. And this is a reasonable interpretation if the disruptions were perfectly synchronised. But the data do not support this view.¹² The pandemic went back and forth in waves, with alternating periods of openness and closure. The closures began in China and gradually spread through neighbouring Asian countries to the rest of the world. By the time Europe shut down in the spring, Asia, including China and Korea, had begun to reopen its factories, only to close again as the situation worsened. So even in global crises, geographical diversification can provide some protection, as long as not everyone is affected at the same time. But you also need to be lucky with your suppliers, because it is too expensive to spread the risk around the world.

Given that the empirical literature is scarce, while interest in the issues of global trade risk and business resilience is growing (Figure 3), there is a great need for empirical studies that examine the impact of different risk management strategies. Is it possible to manage the risks without breaking the link with the world market, with all the increased costs and loss of efficiency that would entail? According to calculations by the European Bank for Reconstruction and Development, shifting purchases to geographically and politically allied countries, referred to as "friend-shoring", would lead to efficiency losses of 4.6 per cent of global GDP.¹³ In other words, the world would be poorer if we only traded with our closest allies, and may not even be safer - perhaps even the opposite, as we would be depriving ourselves of the opportunity to spread risk across a wider range of countries.¹⁴

Sweden, like France, is one of the few countries with microdata on firms' imports across products and countries, making it possible to measure risk dispersion and examine its relationship with supply disruptions on the world market. Our study differs from the French study in several ways: we follow developments throughout the pandemic year 2020; we use a broader measure of risk dispersion based on the Herfindal-Hirschman index of market concentration instead of exposure to China; and we use a different econometric method (Tobit) to estimate the relationship between risk dispersion and supply disruptions. The studies are thus complementary. In addition, we analyse firms'

¹¹ The shutdown in China began in mid-January 2020 and affected exposed French companies by February, while other companies sourcing from other countries were first affected around six weeks later.

¹² Hale et al (2021).

¹³ Javorcik, Kitzmueller, Schweiger, Yıldırım (2022).

¹⁴ Tillväxtnalys (2019) shows how one can calculate the "risk" of each market in a market portfolio by estimating the variance-covariance matrix between different markets. The individual risks are the calculated using the standard CAPM formula in financial economics, $\beta_i = Cov(i, portfolio) / Var(portfolio)$, where the boundary between stabilising and de-stabilising markets is at a β_i -coefficient of one.

plans to strengthen their resilience, based on the survey mentioned above, and also examine whether import patterns have indeed changed after the pandemic.

The paper is structured as follows. Section 2 presents our micro data and how we measure the geographical dispersion of risk in input imports. Section 3 analyses the relationship between risk dispersion and supply disruptions during the pandemic. Section 4 uses the business survey to map the measures that industrial firms have taken or are planning to take to strengthen their resilience for the future. Section 5 summarises the report.

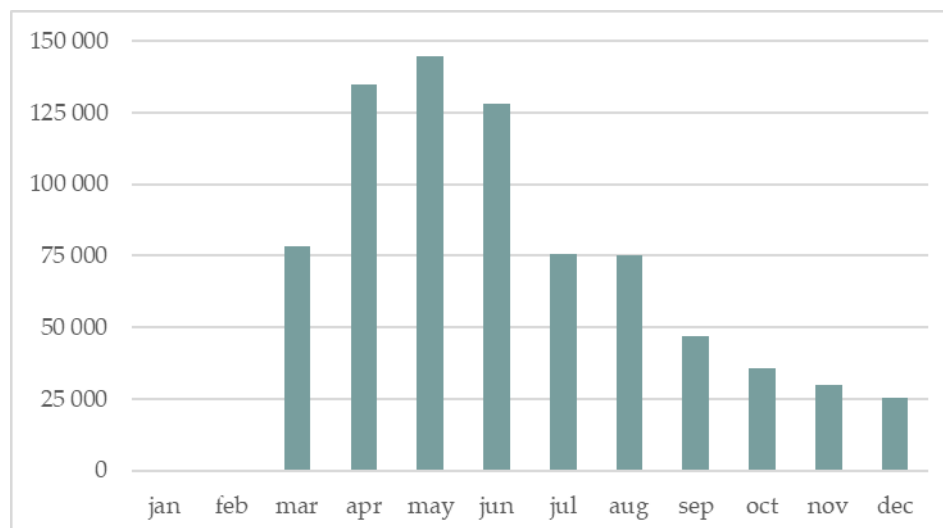
2. Background and data

2.1 Prologue

The pandemic caught everyone off guard. In its December projection for the upcoming year, the National Institute for Economic Research foresaw a slight economic slowdown for 2020.¹⁵ However, it was not attributed to the virus outbreak in China, but rather to the anticipated downturn in the business cycle. The contagion risk was considered low by the National Board of Health until end of January, when the WHO issued its first warning of an international threat to human health. In February, infections surged worldwide, impacting Europe significantly, with Italy and Austria facing particular hardship. On March 11, the WHO declared a pandemic. This declaration coincided with the first wave hitting Sweden as holidaymakers returned from their winter break in the Alps and other countries that were ahead of the curve.

Sweden, like other countries, now hastily introduced extraordinary measures to prevent the spread of the virus. The Public Health Authority urged people to keep their distance and work from home. Schools and universities switched to distance learning. Restrictions were placed on the number of people allowed in public places. These measures had a direct impact on the services sector. For the manufacturing sector, which is the focus of this report, the problems were mainly related to the disruption of the supply and logistics chains. However, despite the disruptions, redundancies were avoided thanks to the short-time working scheme that was introduced in March of that year. At its peak, 145 thousand industrial workers, about a third of the workforce, were enrolled in the scheme (Figure 4), but most had returned by autumn when the wheels started turning again.

Figure 4. Number of industrial workers enrolled in the short-term working week in 2020



Source: The Swedish Agency for Economic and Regional Growth (Tillväxtverket).

¹⁵ <https://www.konj.se/publikationer/konjunkturlaget/konjunkturlaget/2019-12-18-arbetslosheten-stiger-och-inflationen-blir-tydligt-lagre-an-riksbankens-mal.html>

Despite the global nature of the pandemic, the impact varied both between and within sectors, as shown earlier in Figure 2. Some companies were able to continue production throughout the pandemic. Were they fortunate with their suppliers, or were their supply chains organised in a more resilient way, with alternative suppliers for each input? In other words, what role did risk diversification play?

2.2 Scope and data sources

The study encompasses 2,570 enterprises in the manufacturing sector that meet the following conditions for the base year 2019:

- Each enterprise must have at least 1 employee and a production value of at least SEK 1 million.
- At least 50 percent of the annual turnover should come from own production (as opposed to resales of other products), and it should not exceed 150 percent.
- The enterprise must have at least SEK 100,000 in own imports of inputs.

The first condition excludes the smallest enterprises that report annually instead of monthly or quarterly.¹⁶ The second condition identifies enterprises where the primary source of income is from own production, and most of the production is sold in the same calendar year.¹⁷ The third condition is a prerequisite for calculating geographical risk diversification in the supply chain.

The data are sourced from three microdata registers linked by a serial number assigned by Statistics Sweden: Business, VAT, and Foreign Trade. The Business Register, an annual compilation, is utilized to identify enterprises in the manufacturing sector (ISIC 10-33), ascertain their size based on the number of persons employed (micro, small, medium-sized, large),¹⁸ and determine their affiliation with a group of companies.¹⁹ The latter are treated as a single unit in the analysis, as subsidiaries are often functionally divided with centralized purchasing units, making it challenging to allocate inputs to individual production units. The 2-digit ISIC code of a group is determined by the activity with the highest turnover in 2019. The VAT register contains monthly turnover data, serving as a proxy for production in the absence of monthly data. The foreign trade register provides information on monthly imports by enterprises at the 8-digit product level, categorized by country of origin. To distinguish intermediate goods from consumer and capital

¹⁶ Companies with an annual turnover of more than 40 million must report VAT monthly, companies with an annual turnover of between 1 and 40 million can report quarterly and companies with an annual turnover of less than 1 million once a year.

¹⁷ Output in year X may be greater than turnover in year X if sales are made in the following year.

¹⁸ The size classification is based on the number of persons employed: micro enterprises with 1-9 persons employed, small enterprises with 10-49 persons employed, medium-sized enterprises with 50-249 persons employed and large enterprises with 250+ persons employed.

¹⁹ A 'corporate group' is an association of two or more enterprises with different organisation numbers. There is no size limit or integration requirement to qualify as a 'group'. Most groups are small, with a few subsidiaries and fewer than 50 employees in total, but there are also many examples of very large groups with thousands of employees and a large number of subsidiaries.

goods, we utilize the primary and intermediate goods categories of the Broad Economic Categories Classification (BEC Rev.5).²⁰

The study covers 2,570 industrial enterprises (1,883 corporate groups and 678 individual), accounting for over 90 percent of manufacturing turnover. The distribution across ISIC sectors and size classes is shown in Table 1. The dashed fields, containing fewer than three units, are not shown separately in the analysis for reasons of confidentiality.

Table 1. Number of enterprises per sector and size class

Sector (ISIC)	micro	small	medium	large	total
10. Food	36	54	41	22	153
11. Beverages	2	9	3	4	18
12. Tobacco			2	2	4
13. Textiles	19	23	14	3	59
14. Apparel	7	6	3		16
15. Leather	7	8	1		16
16. Wood	27	33	39	18	117
17. Paper	7	30	18	15	70
18. Printing and reproduction	12	16	12	3	43
19. Refined petroleum		2	2	3	7
20. Chemicals	34	48	42	14	138
21. Pharmaceuticals	5	11	7	8	31
22. Rubber and plastics	35	82	47	13	177
23. Mineral products	21	27	23	12	83
24. Basic metals	8	27	24	15	74
25. Fabricated metal	110	202	113	19	444
26. Computers and electronics	70	75	37	14	196
27. Electrical equipment	23	47	25	6	101
28. Other machinery	71	143	107	39	360
29. Motor vehicles	36	36	37	28	137
30. Other transport equipment	16	20	14	4	54
31. Furniture	12	20	28	6	66
32. Other manufacturing	44	43	14	4	105
33. Repair and installation	49	26	21	5	101
Total	651	988	674	257	2570

Note: The dashed fields contain fewer than three units and are not shown separately in the analysis for reasons of confidentiality.

²⁰ All items falling under BEC categories 111, 121, 211, 221, 311, 321, 411, 421, 511, 521, 611, 621, 711, 721, 811, and 821 are designated as production inputs, encompassing both primary and intermediate goods.

2.3 Quarter-by-quarter developments in 2020

The quarterly evolution of input imports and turnover in 2020, compared to the same quarter in 2019, is presented in Table 2. For ease of interpretation, the table is color-coded, with index numbers below 100 in red (indicating a decrease compared to 2019) and index numbers above 100 in blue (indicating an increase compared to 2019). Year-on-year changes are also provided for additional comparison.

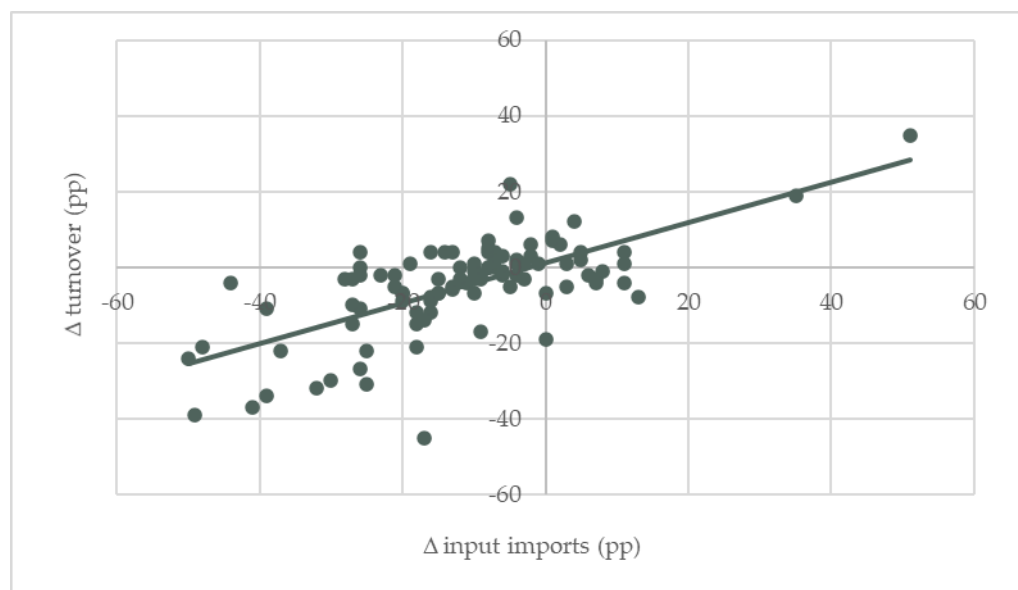
Table 2. Input imports and turnover in 2020 compared to the same quarter in 2019 (2019=100).

Sector (ISIC)	Input imports					Turnover				
	Q1	Q2	Q3	Q4	Year	Q1	Q2	Q3	Q4	Year
10. Food	101	106	98	96	100	108	98	103	101	103
11. Beverages	93	90	94	103	94	102	99	99	95	99
12. Tobacco	102	92	74	84	86	106	100	98	104	102
13. Textiles	89	82	84	90	86	96	88	88	101	93
14. Apparel	111	83	75	82	87	96	55	78	79	77
15. Leather	85	59	61	74	71	93	63	89	104	87
16. Wood	93	81	92	92	89	104	101	105	107	104
17. Paper	92	91	80	88	88	104	97	93	97	98
18. Printing and reprod.	56	63	52	91	62	96	78	79	83	84
19. Refined petroleum	96	50	61	75	70	98	76	66	69	77
20. Chemicals	105	90	87	94	94	102	93	94	103	98
21. Pharmaceuticals	111	151	100	95	113	104	135	81	122	109
22. Rubber and plastics	93	87	85	86	88	100	95	97	104	99
23. Mineral products	101	108	98	72	94	107	99	106	97	102
24. Basic metals	80	73	73	87	78	91	85	90	104	92
25. Fabricated metal	91	74	80	94	85	98	89	93	98	95
26. Computers and elect.	107	100	95	105	102	97	93	95	104	97
27. Electrical equipment	74	70	68	85	74	73	70	68	93	75
28. Other machinery	97	84	90	92	91	101	92	97	100	97
29. Motor vehicles	88	51	83	96	79	100	61	86	102	87
30. Other transport eq.	97	73	74	77	80	97	97	100	98	98
31. Furniture	103	82	84	99	92	101	85	91	101	95
32. Other manufacturing	96	104	135	111	111	113	112	119	101	110
33. Repair and instal.	79	107	79	113	93	98	96	95	92	95
Total	92	70	79	89	83	100	85	90	100	94

As observed, red tones predominate in 2020 (index < 100), particularly in the second and third quarters when supply disruptions were at their peak. Industries such as textiles, clothing, and leather (ISIC 12-14), printing and reproduction (ISIC 18), refineries (ISIC 19), basic metals and fabricated metal products (ISIC 24-25), machinery and electrical equipment (ISIC 26-28), motor vehicles and other transport equipment (ISIC 29-30), furniture (ISIC 31), and repair and installation (ISIC 33) were notably affected, experiencing declines in both imports and turnover. However, six industries defied the trend, showing an increase in turnover for the entire year. These industries include food products (ISIC 10), tobacco (ISIC 12), wood products (ISIC 16), pharmaceuticals (ISIC 21), mineral products (ISIC 23), and other manufacturing (ISIC 32), which among other things encompasses games and sporting goods.

The fact that some industries grew while others declined suggests the involvement of both demand and supply-side factors. The pharmaceutical industry's growth during the pandemic is self-explanatory. Other successful industries benefited from a shift in consumption patterns as people worked from home. Winners also faced fewer import disruptions than losers, as indicated by the correlation between the change in turnover and input imports between 2019 and 2020, shown in the quarterly data in Table 2. The Ordinary Least Squares (OLS) estimate of this statistical relationship is depicted by the solid line in Figure 5, with an explanatory value (R^2) of 0.47 on a scale from 0 to 1. Quarters with decreasing imports of inputs correlated with declining turnover (lower left quadrant), and vice versa (upper right quadrant). However, due to firms holding stocks to smooth out fluctuations, the relationship is not strictly one-to-one.

Figure 5. Relationship between import disruption and turnover in 2020, Q1-Q4



Although the pattern is clear, establishing causality is not possible simply by plotting the data. Sales may have declined in 2020 due to either a shortage of inputs or a decrease in demand as the economy slowed. The prevailing factor is likely to differ across industries. In the automotive industry, interim reports suggest that supply disruptions caused production stoppages. In contrast, for refineries, sales may have decreased because demand for transport services and, consequently, fuel, declined during the pandemic. For those sectors that defied the trend with sales growth for the entire year, it is evident that positive demand factors played a dominant role.

Simultaneously, there were winners and losers within each sector. The question arises: was this merely a matter of good or bad fortune with suppliers, or did it also depend on how well companies had diversified risk in the supply chain?

2.4 Geographical risk diversification

To calculate the geographical risk diversification of intermediate imports, we employ the Herfindahl-Hirschman Index (HHI), a measure of market concentration commonly used by antitrust authorities to assess potential competition impacts following a merger. The HHI is computed by summing the squares of market shares, expressed as $HHI = \sum_{j=1} s_j^2$.

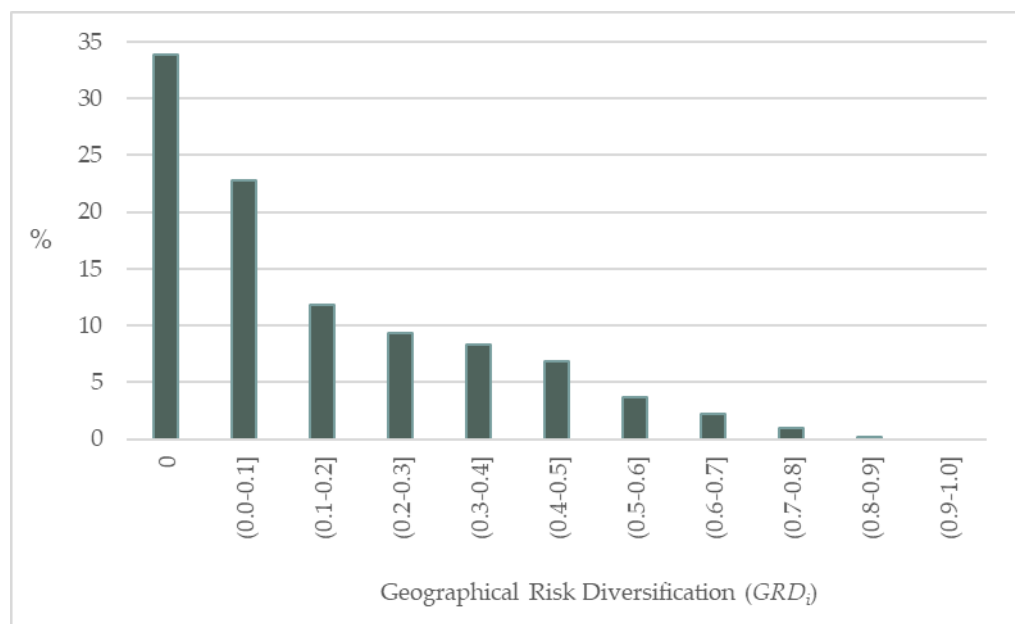
The index ranges from 1 in a monopoly market to 0 in a perfectly competitive market where no firm dominates.

The complement, 1-HHI, is widely used in financial economics to measure risk diversification in portfolios of financial assets. In a comparison of five measures (Woerheide and Persson, 1993), the 1-HHI index demonstrated the highest explanatory value for portfolio variance over time. Therefore, we posit that this index can also measure geographical risk diversification (GRD) in import portfolios. Specifically, we first calculate the HHI across supplying countries for each input $j = \{1, 2, \dots, n\}$ at the 8-digit level of the EU product classification (CN) using pre-pandemic data for 2019. In a second step, we weigh the results with the cost shares for each input (w_j),

$$(1) \text{GRD}_i = 1 - \sum_i \sum_j w_j s_{ij}^2.$$

The index ranges from 0, indicating that each input is solely imported from one country (which may vary for different inputs), to 1, signifying even distribution across multiple countries. For a given number of countries, an equal distribution among them results in a higher index value.²¹

Figure 6. Distribution of the geographical risk diversification index (2019)



When the distribution of GRD is depicted in Figure 6, we observe an extreme skewness. At the onset of the pandemic, one-third of the companies exhibited no risk diversification ($\text{GRS} = 0$), while an additional 23 percent had only a minimal GRD falling within the range of (0-0.1]. The average GRD was 0.15, equivalent to a split of 0.92 / 0.08 between two suppliers.²²

²¹ It's worth noting that the index doesn't consider risk diversification between foreign suppliers within the same country, nor between foreign and domestic suppliers, including domestic wholesalers of foreign inputs. These dimensions are omitted due to a lack of data.

²² $\text{GRD} = 1 - (0.92)^2 - (0.08)^2 \approx 0.15$.

As we break down the data by sector and size class in Table 3, it becomes evident that risk diversification systematically increases with the size of the enterprise. The average for micro-enterprises was 0.06, compared to 0.12 for small enterprises, 0.24 for medium-sized enterprises, and 0.30 for large enterprises. This trend holds consistently across most sectors. The pattern suggests that the potential for risk diversification depends on the volume of imports and the administrative capacity to manage complex supply chains with many suppliers.

Table 3. Geographical risk diversification by industry and size class (2019), unweighted average

Sector (ISIC)	micro	small	medium	large	total
10. Food	0.12	0.10	0.18	0.27	0.15
11. Beverages		0.18	0.15	0.12	0.14
12. Tobacco					0.12
13. Textiles	0.03	0.14	0.30	0.16	0.14
14. Apparel	0.03	0.12	0.12		0.08
15. Leather	0.00	0.05			0.04
16. Wood	0.06	0.06	0.11	0.16	0.09
17. Paper	0.07	0.15	0.36	0.28	0.22
18. Printing and reprod.	0.13	0.10	0.22	0.20	0.15
19. Refined petroleum				0.44	0.31
20. Chemicals	0.04	0.15	0.29	0.26	0.18
21. Pharmaceuticals	0.09	0.06	0.12	0.27	0.13
22. Rubber and plastics	0.11	0.17	0.27	0.35	0.20
23. Mineral products	0.04	0.14	0.22	0.23	0.15
24. Basic metals	0.12	0.11	0.23	0.32	0.19
25. Fabricated metal	0.04	0.08	0.18	0.25	0.10
26. Computers and elect.	0.06	0.11	0.27	0.42	0.14
27. Electrical equipment	0.06	0.16	0.18	0.41	0.16
28. Other machinery	0.07	0.14	0.31	0.35	0.20
29. Motor vehicles	0.07	0.13	0.29	0.36	0.20
30. Other transport eq.	0.04	0.12	0.25	0.41	0.15
31. Furniture	0.01	0.09	0.20	0.21	0.13
32. Other manufacturing	0.06	0.09	0.19	0.27	0.10
33. Repair and instal.	0.05	0.05	0.31	0.23	0.11
Total	0.06	0.12	0.24	0.30	0.15

Note: The dashed fields contain fewer than three units and are not shown separately in the analysis for reasons of confidentiality.

When comparing risk diversification across industries in Table 3, the pattern is less clear, and so are the underlying causes. Different 'risk preferences' could explain the pattern, but there is no obvious reason why some industries would be more willing to take on risk than others. A more likely hypothesis is that the ability to diversify risk varies according to the inputs used in each industry. For example, the scope for diversification may be greater for homogeneous products such as crude oil than for heterogeneous products like microchips, where the makes of different suppliers are not fully substitutable. Another dimension of the opportunity space is the number of suppliers in the global market.²³

²³ Rauch (1999).

While the issue of different opportunities for risk diversification is a relevant dimension for policy makers,²⁴ we will not explore this issue in the current paper as we can control for the opportunity space simply by introducing two dummy variables in the regressions for industry and size, respectively.

2.5 Summing up

Despite the global nature of the pandemic, supply shocks varied both between and within sectors. While most sectors experienced setbacks, there were also those that defied the trend, likely due to changes in consumption patterns during the pandemic. Importantly, there were both winners and losers within each sector, indicating that 'resilience'—the ability to withstand and recover from a crisis—varied among firms in the same sector. In the next section, we explore the role that risk diversification may have played in this context.

²⁴ For example, if world market concentration for a critical input is very high and the ability to diversify risk is correspondingly very low, governments may want to consider policies that encourage domestic production to reduce import dependence on the inputs concerned. These issues will be explored in a future case study on critical (strategic) inputs, where the European Union is considering a more active policy stance.

3. Statistical analysis

In this section, we will analyse whether companies with greater risk diversification in their supply chains experienced fewer supply disruptions in 2020.

3.1 Measurement issues

Supply disruptions cannot be measured directly from data since we can only observe actual imports, not desired imports, and, consequently, cannot quantify the disruption defined as the difference between the two without further assumptions:

$$(2) \text{ supply disruption} = \text{actual imports} - \text{desired imports}$$

The first challenge is to find a reasonable proxy for desired imports in 2020. In our view, last year's imports are not only the simplest choice, as they can be directly derived from the data, but also a logical one, aligning with the forecasts of the National Institute of Economic Research of a stagnating economy in 2020.²⁵ Being based on industry surveys, the forecast serves as a suitable proxy for production plans before the pandemic broke out. Thus, assuming that input orders for 2020 remained at the same level as in 2019, we can assess the supply disruptions (SD_i) in 2020 with this simple formula,

$$(3) SD_i = \begin{cases} \text{import}_{i,2019} - \text{import}_{i,2020}, & \text{if } \text{import}_{i,2020} < \text{import}_{i,2019}, \\ 0, & \text{if } \text{import}_{i,2020} \geq \text{import}_{i,2019}, \end{cases}$$

where the SD_i -index is defined positively. The index is bounded at zero for companies that did not experience significant disruption, as their imports defied the general trend by increasing in 2020. Finally, by normalizing 2019 imports to 100, we obtain a disruption index ranging from 0 (no disruption) to 100 (total disruption with no deliveries).

3.2 Results

Since the SD_i index is censored (i.e., bounded downwards) at zero, we will use a *Tobit model*, which is adapted to situations where the dependent variable is not observable below the threshold and is therefore set at the threshold. The objective is to estimate the relationship between risk diversification (GRD_i) and supply disruptions (SD_i),

$$(4) SD_i = \text{Tobit}(GRD_i, GRD_i^2, sector_i, size_i),$$

where the control variables for $sector_i$ and $size_i$ capture different opportunities for risk diversification and other systematic differences. The GRD coefficients may then be interpreted as the effect of risk diversification, other things being equal. Note in the Tobit regression that we have included GRD_i both at its level and squared to allow a non-linear (quadratic) relationship. The model is estimated separately for each quarter (Q1, Q2, Q3, Q4) and for all quarters simultaneously (Q1-Q4) with an additional control variable for the specific quarter. The estimation results are presented in Table 4 on the next page.

²⁵ <https://www.konj.se/publikationer/konjunkturlaget/konjunkturlaget/2019-12-18-arbetslosheten-stiger-och-inflationen-blir-tydligt-lagre-an-riksbankens-mal.html>

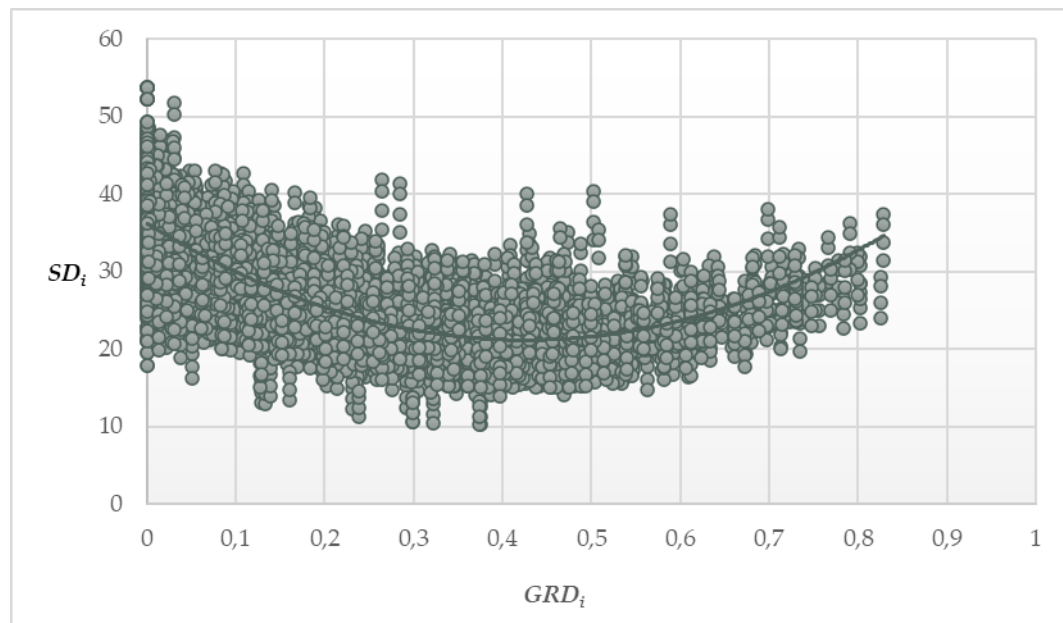
Table 4. Estimation results

	O1	O2	O3	O4	O1-O4
Geographical risk diversification					
<i>GRD</i>	-109.5**	-71.0**	-76.3**	-74.3**	-82.6**
<i>GRD</i> ²	132.9**	76.6*	96.5**	82.4**	97.1**
Size (base = micro enterprises)					
Small	16.6**	10.7**	13.1**	10.1**	12.6**
Medium	8.4**	6.0*	4.4	6.7*	6.4**
Large	-2.0	-0.3	-5.2	-2.8	-2.6
Sector (base = Food products)					
11. Beverages	20.1	11.7	9.8	-19.5	6.6
12. Tobacco	-34.9	-17.3	20.5	-15.7	-9.4
13. Textiles	3.5	17.1*	-5.4	14.5	7.8
14. Apparel	-2.7	9.1	15.2	15.0	9.5
15. Leather	8.1	-4.0	18.9	13.8	9.4
16. Wood	14.9*	11.3	11.8	6.1	11.1**
17. Paper	3.5	1.5	8.1	-9.6	1.1
18. Printing and reprod.	26.0**	9.1	23.6*	13.9	18.2**
19. Refined petroleum	-3.1	8.6	22.8	10.7	10.6
20. Chemicals	7.1	-10.0	-5.6	-6.4	-3.7
21. Pharmaceuticals	-18.1	-15.0	-17.5	-8.6	-14.6*
22. Rubber and plastics	2.2	-2.5	-0.6	1.4	0.1
23. Mineral products	12.5	-8.7	4.5	5.3	3.2
24. Basic metals	14.1	6.8	13.3	1.1	8.9*
25. Fabricated metal	9.9	3.4	9.6	2.6	6.4*
26. Computers and elect.	4.3	-7.7	4.8	-5.0	-0.9
27. Electrical equipment	6.1	2.4	1.1	-7.4	0.5
28. Other machinery	10.8	-0.9	9.8	1.0	5.2
29. Motor vehicles	12.3	16.2*	10.8	-6.4	8.4*
30. Other transport eq.	25.4**	4.8	7.0	3.3	10.5*
31. Furniture	-6.6	1.4	8.1	-6.2	-0.5
32. Other manufacturing	-0.2	2.3	13.6	11.2	7.0
33. Repair and instal.	0.2	-0.6	14.2*	6.9	5.5
Quarter (base = Q1)					
Q2					7.0**
Q3					8.8**
Q4					3.4*
Observations, total	2349	2379	2333	2356	9417
Observations, uncensored	1338	1470	1509	1392	5709
Observations, censored	1011	909	824	964	3708
Pseudo R2	0.01	0.01	0.01	0.01	0.01

Note: * significant at the 5 per cent level; ** significant at the 1 per cent level.

Observe in Table 4 that both the level and the square of GRD are statistically significant with different signs (the level is negative, and the square is positive). This suggests that the effect of risk diversification diminishes at the margin and, as we shall see, becomes statistically insignificant beyond a certain point. To illustrate this non-linear relationship, we have plotted the *predicted* supply disruption (SD_i) for each firm on the vertical axis in Figure 7 against the geographical risk diversification (GRD_i) on the horizontal axis.

Figure 7. The non-linear relationship between risk diversification and supply disturbances



As we move from left to right in the figure, predicted supply disruptions decrease with increasing risk diversification. However, this trend holds only up to a certain point where the relationship levels off and then reverses. The reversal suggests that excessive risk diversification may even be counterproductive, a topic we will discuss later. To pinpoint the turning point, we calculated 'marginal effects' at various GRD values using the Delta method. The estimation reveals that supply disruptions are at their minimum in the GRD range from 0.39 to 0.50. On the left of the flat area ($GRD < 0.39$), the risk of disruptions decreases with higher GRD, while on the right ($GRD > 0.50$), the risk increases. In the flat area between 0.39 and 0.50, the outcome of a marginal change in GRD is indeterminate due to the margin of error.

Why does the correlation between GRD and SD change direction after a certain point? One reason is technical: unbounded quadratic relationships always have a maximum or minimum unless the quadratic term is zero. However, more fundamental reasons exist for why excessive risk diversification can be counterproductive. As Sébastien Miroudot of the OECD Secretariat pointed out, companies that diversify their purchases too much may lose priority and end up among the last to be served in the event of a shortage. The benefits of spreading purchases too thinly across different suppliers must, therefore, be weighed against the risk of being deprioritized by each supplier when demand exceeds supply. In other words, risk management involves a trade-off between using alternative suppliers and maintaining priority with each of them.

The optimal range for Generalized Resilience Diversification (GRD) was estimated to be between 0.39 and 0.50. What does this mean in practice? Well, there is no single answer to this question, as the "optimal" range can be achieved in various ways. For instance, the minimum range can be attained by splitting purchases into two parts, with one supplier receiving $2/3$ of the contract and the other $1/3$, resulting in a GRD of approximately 0.44.²⁶ Alternatively, the contract can be split into three parts with proportions of $0.7 / 0.2 / 0.1$,²⁷ and so forth. Thus, it does not require an extreme level of diversification, but one main supplier and one or two additional suppliers with the capability to scale up deliveries if the main supplier is unable to meet deadlines. The primary advantage of a diversified supply network is likely to be the speed with which a supply shock can be addressed, in contrast to the alternative of seeking new suppliers once a disruption has occurred. However, it's important to note that this is merely a hypothesis that requires testing in further research.

3.3 One-size-fits-all?

In reality, approximately 85% of the industrial companies in our sample lie to the left of the flat area (0.39-0.50), while 7% are to the right. That is, 92% of companies either fall below or exceed the optimal range in terms of minimizing the risk of supply disruption.

However, this does not necessarily imply that they are 'wrong.' The optimal risk for each firm involves a trade-off between the benefits and costs of risk diversification. Our study does not indicate a uniform trade-off for all firms; instead, the systematic differences we observe between industries and company sizes suggest the opposite. As a rule, small companies are less diversified than larger ones. This implies that they cannot profitably split their purchases in the same way as large companies, as it would raise both the unit price and administrative burden. For smaller firms, a more cost-effective option might be to maintain larger stockpiles of inputs 'just-in-case' or even accept occasional disruptions.

The optimal strategy may also depend on how the government handles crises. If firms anticipate government support in a crisis, the incentive to diversify risk or build up inventories is likely to be diminished – a situation commonly referred to as the 'moral hazard' problem. Whether this is a problem in reality is difficult to determine, as we can only observe what firms are doing and not their motivations. However, from a theoretical viewpoint, the government may consider the moral hazard implications before adopting a more generous practice of burden-sharing during times of crisis.

In conclusion, considering the systematic differences observed between small and large firms, along with the reasonable arguments supporting these distinctions, we conclude that there is no one-size-fits-all risk management strategy for firms. Furthermore, what was considered optimal yesterday may not hold true today, as the risks in world markets are constantly evolving. Consequently, defining optimal public interventions in this area is challenging, particularly given the moral hazard dilemma, where any intervention may have repercussions on the management of risk.

²⁶ $GRS = 1 - \left(\frac{2}{3}\right)^2 - \left(\frac{1}{3}\right)^2 \approx 0.44.$

²⁷ $GRS = 1 - (0,7)^2 - (0,2)^2 - (0,1)^2 = 0.44.$

4. What measures have been taken to improve resilience?

What measures has the industry taken to enhance its resilience for the future? To explore this issue, we rely primarily on the results of a survey conducted by Tillväxtanalys in collaboration with the Confederation of Swedish Enterprise (CSE) in November 2020. In this survey a representative sample of CSE members was asked about supply disruptions during the pandemic and the measures they have taken or plan to take to improve their resilience to future crises. Published in PM 2021:05, the survey covered all sectors of the economy, including services. In this study, we will closely examine the survey responses from the manufacturing sector, complementing the survey with micro data that shows how supply chains have evolved since the onset of the pandemic.

4.1 Basic facts about the survey

The survey was distributed on 3 November 2020 to a random sample of 8,500 members of the Confederation of Swedish Enterprise's business panel. The response rate was 42.6 per cent, with a sector and size distribution that is representative of the Swedish business community as a whole, with the exception of sole proprietors without employees, who were excluded for this reason. A total of 719 manufacturing enterprises responded to the survey, of which 586 were sourcing inputs from abroad. The latter were asked about the supply disruptions during the pandemic and what measures they had taken or planned to take to reduce their vulnerability in the future. The distribution of the respondents by firm size is shown in Table 5. It is not possible to break down the data by ISIC sector, as this information is lacking.

Table 5. Number of respondents by size class (%)

Size	number of respondents	with foreign suppliers
Total	719	586
Micro	140	91
Small	364	293
Medium	171	159
Large	44	43

The questions posed to the respondents are listed in Table 6. The survey identifies companies that use foreign suppliers (question 1), their main supply regions (question 2), disruptions experienced during the pandemic (question 3), whether these disruptions were temporary or ongoing (question 4), and measures taken or planned to reduce vulnerability to future disruptions (question 5). In a final open-ended question, respondents were asked about the role of the government in reducing risks in international trade, where the few answers received from the manufacturing sector stressed the importance of keeping markets open.

Table 6. The survey

<p>Question 1: Does your company use foreign suppliers of goods/services?</p> <ol style="list-style-type: none"> 1. Yes 2. No 3. Don't know <p>Question 2. From which regions do your main suppliers come? Multiple answers possible</p> <ol style="list-style-type: none"> 1. Sweden 2. EU/EFTA area (excl. Sweden) 3. UK 4. Other Europe/Middle East 5. North America 6. South and Central America 7. China 8. Japan 9. India 10. Other Asia 11. Australia 12. Africa <p>Question 3. What difficulties with deliveries from abroad has your company experienced due to the Covid-19 pandemic? Multiple answers possible</p> <ol style="list-style-type: none"> 1. Have not experienced any difficulties 2. Shortage of goods/services 3. More expensive goods/services 4. Longer delivery times 5. Lower quality of goods/services 6. Obstacles to the mobility of staff 7. Other difficulties, namely (free text) 8. Don't know/No opinion <p>Question 4: Are you still experiencing supply disruptions from abroad?</p> <ol style="list-style-type: none"> 1. No, the problems were only temporary 2. Yes, we still have some problems 3. Yes, we still have major problems 4. Don't know/No opinion <p>Question 5. Since the outbreak of the COVID-19 pandemic, what measures has your company taken or plans to take to reduce the vulnerability to future disruptions in the international trade flow of goods/services? Multiple answers possible</p> <ol style="list-style-type: none"> 1. Have not taken or plan to take any measures 2. increase the number of suppliers 3. spread purchases across more countries 4. spread purchases across more suppliers 5. place a larger share of purchases within the EU/EFTA area 6. place a larger share of purchases in Sweden 7. increase ownership of supply chains 8. bring foreign production back to Sweden 9. increase stockholding 10. other measure, namely (free text) 11. Don't know/no opinion <p>Question 6. Please give examples of what you think the government can do to reduce the vulnerability of your company to future disruptions in international trade flows (free text).</p>
--

4.2 Supply disruptions during the pandemic

When asked about their main supply regions, almost all respondents selected the EU/EFTA region and Sweden, with China ranking third (Table 7). Larger and medium-sized enterprises generally reported more regions as important than micro and small enterprises. In general, larger enterprises tend to operate globally, while smaller ones operate regionally. Although the specific question wasn't asked, it is reasonable to assume that sourcing decisions are at least partly driven by risk perception and the ability to manage risk.

Table 7. Main supplier regions according to enterprises' own assessment (%)

	micro	small	Medium	large	total
EU/EFTA area (excl. Sweden)	89	85	94	91	89
Sweden	64	76	79	79	75
China	21	20	30	44	25
United Kingdom	22	18	20	23	20
Other Europe/Middle East	4	10	9	33	11
North America	10	8	12	16	10
Other Asia	3	7	8	14	7
India	2	4	8	16	6
Japan	3	5	6	7	5
South and Central America	2	2	2	5	2
Australia	0	1	1	2	1
Africa	0	0	1	0	0

Source: Survey of Confederation of Swedish Enterprise member companies, November 2020.

Among the companies sourcing abroad, 71% reported facing issues during the pandemic, as shown in Table 8. The most common problems were longer delivery times (57%) and a lack of goods/services (38%). Larger companies cited obstacles to staff mobility (between group entities) as the third most common problem, while smaller companies were more likely to mention higher costs for goods/services.

Table 8. Supply disruptions in the first pandemic year 2020 (%)

Size	micro	small	Medium	large	total
Supply disruptions	63	71	76	77	71
Longer delivery times	51	60	57	53	57
Lack of goods/services	29	35	44	49	38
More expensive goods/services	20	13	16	16	15
Obstacles to staff mobility	5	11	21	33	15
Other difficulties, namely (free text)	2	3	4	2	3
Lower quality of goods/services	1	3	2	2	2

Source: Survey of Confederation of Swedish Enterprise member companies, November 2020.

"In response to questions about the duration of the problems (Table 9), the majority indicated they were still facing some issues in November 2020 when the survey was conducted (58%). However, the most pressing issues had been resolved for all but 6 per cent of respondents by then. This aligns with the data reported in Table 2, showing a strong recovery in the final quarter of 2020. Supply chain problems appear to have been

resolved somewhat more swiftly for larger companies, which tend to have more diversified supply chains, as shown earlier in this report.

Table 9. Were the problems temporary or do the problems persist (%)

Size	Micro	small	medium	large	total
Yes, we still have major problems	7	9	2	9	6
Yes, we still have some problems	53	60	61	48	58
No, the problems were only temporary	32	27	34	39	31
Don't know/No opinion	9	4	3	3	4

Source: Survey of Confederation of Swedish Enterprise member companies, November 2020.

4.3 Actions taken or planned

The fifth set of forward-looking questions is perhaps the most interesting from a policy perspective, along with the final open-ended question on the role of government in reducing risk in international trade. The question was: "Since the outbreak of the COVID-19 pandemic, what measures has your company taken or plans to take to reduce vulnerability to future disruptions in the international flow of goods/services?" This question was posed to all companies that sourced inputs from abroad, whether or not they experienced problems during the pandemic.

Table 10. Correlation between supply disruptions and measures taken/planned (%)

Size	micro	small	medium	large	total
Actions taken/planned	43	58	68	63	59
Firms with supply disruptions	54	66	75	70	67
Firms without supply disruptions	24	38	46	40	37

Source: Survey of Confederation of Swedish Enterprise member companies, November 2020.

The first finding is that companies that experienced problems during the pandemic were much more likely to take steps to reduce their vulnerability to future crises (Table 10). Among the affected firms, 67 percent were actively taking or considering steps, while only 37 percent of firms without any supply disruptions during the pandemic were doing so. The difference may reflect that the latter group was more diversified at the outset and consequently had fewer reasons to review their risk policies. However, we cannot test this hypothesis with our data, as we lack the key to match the survey respondents with the dataset used to calculate the geographical risk diversification. Future research will hopefully tell. Notwithstanding, it may still be worthwhile to review the supply chain risks given the evolving nature of threats over time. That a firm has passed the current hurdle is no assurance that it will pass the next.²⁸

²⁸ Generals are sometimes accused, perhaps unfairly, of planning to win the last war rather than preparing for the next one, which will be fought in a new way (with drones in the air rather than soldiers on the ground). The message we are trying to get across is that it is important to learn from the past, but also to recognise that the problems ahead may be of a different nature, which may require some adjustments to current strategies.

In terms of specific actions, Table 11 shows the percentage of respondents who say they have taken or plan to take action in a particular area. Three of the fixed options that could be ticked in the survey were different variations of risk diversification. We have grouped them together under the common heading of 'risk diversification' to show the proportion of firms considering action in this area, broken down by the specific variations for those who require further details.²⁹ We have also introduced a common heading for the option to bring purchases closer to home, divided between Sweden and EU/EFTA.

Table 11. Actions taken and planned (%).

Type of measures	Micro	small	medium	large	total
Increased stockholding	22	38	48	42	39
Increased risk diversification	22	33	38	33	33
number of suppliers	11	17	21	12	17
across more countries	4	5	11	19	8
across more suppliers in same country	14	24	28	21	23
Sourcing closer to home	18	25	22	16	22
Sweden	11	20	19	9	18
EU/EFTA	9	9	9	12	9
Bringing production back to Sweden	1	3	4	0	3
Increasing ownership in supply chains	1	1	1	0	1
Other measure	4	1	3	2	2

Source: Survey of Confederation of Swedish Enterprise member companies, November 2020

The most common post-pandemic measure is to increase stock levels (39%), followed by increasing risk diversification (33%) and increasing the proportion of purchases in Sweden and/or EU/EFTA (22%). The option of bringing outsourced production back to Sweden is considered by only 3 percent of the respondents.

For companies considering the option of risk diversification, the most common strategy is to spread purchases across more suppliers in the countries where they already operate, rather than exploring new countries.³⁰ This choice is rational if disruptions are local rather than national, both for logistical reasons and because of familiarity with the business environment in their current countries of operation. On the other hand, if the supply chain risks are national, it may be more effective to diversify the supply network into entirely new countries or even new regions of the world. For instance, the main supplier in the EU could be complemented by an alternative supplier in China. The advantage of the broader strategy is that it can cope with national supply disruptions, such as strikes, blockades and natural disasters, and possibly global disruptions as long as they do not affect all countries or regions simultaneously.

Determining which strategy offers the most 'bang for the buck' is an empirical question that necessitates further research.

²⁹ Two of the three alternatives are difficult to distinguish, namely (a) increasing the number of suppliers and (b) spreading purchases across more suppliers. We interpret the first option as a lack of specificity regarding the dimension of risk diversification (more suppliers in each country or more suppliers in different countries).

³⁰ See the caveat on the interpretation of the various options in the previous footnote.

4.4 Measurable actions up to 2021

Ambition is one thing; action is another. Measurable actions up to 2021 concerning increased risk diversification are shown in Table 12, where blue colours indicate an increase in GRD compared to 2019, and red colours indicate a decrease.

Table 12. The change in the geographical risk diversification between 2019 and 2021 (%)

Sector (ISICI)	micro	small	medium	Large	total
10. Food	-0,02	0,01	0,02	-0,07	-0,01
11. Beverages		-0,01	-0,11	0	-0,02
12. Tobacco				-0,03	0,03
13. Textiles	0,01	-0,02	-0,05	0,05	-0,01
14. Apparel	-0,01	-0,02	-0,02		-0,01
15. Leather	0	0,06			0,03
16. Wood	0	0	-0,02	-0,01	0
17. Paper	-0,07	0,02	-0,05	-0,03	-0,01
18. Printing and reprod.	0,11	0,06	-0,06	0,07	0,03
19. Refined petroleum				0,09	0,05
20. Chemicals	0,02	-0,01	0,02	-0,01	0
21. Pharmaceuticals	-0,01	0,19	0,01	-0,01	0,07
22. Rubber and plastics	0,01	-0,01	0,02	-0,01	0
23. Mineral products	0,01	-0,01	-0,03	0,05	0
24. Basic metals	-0,12	0	0,01	0,01	0
25. Fabricated metal	0,01	0	-0,02	0	0
26. Computers and elect.	0,04	0,03	0,02	0,01	0,04
27. Electrical equipment	-0,03	-0,01	0,03	-0,03	-0,01
28. Other machinery	-0,01	0	-0,04	0	-0,01
29. Motor vehicles	0,05	0	-0,03	-0,01	0,01
30. Other transport eq.	0,05	0,02	-0,02	-0,04	0,02
31. Furniture	0	0,01	0,03	-0,01	0,02
32. Other manufacturing	0,04	0,02	0,01	-0,01	0,03
33. Repair and instal.	0,03	0,02	-0,02	0,14	0,03
Total	0,01	0	-0,01	-0,01	0,01

Note: Dashed fields contain less than three units and are not reported separately for confidentiality reasons.

Overall, there has been only a marginal increase in risk diversification since the onset of the pandemic, especially among micro-enterprises, where diversification was initially at its lowest. In the case of medium and large enterprises, risk diversification has, in fact, decreased somewhat. This decline might be attributed to a preference for alternative measures, such as maintaining larger stocks of inputs to address temporary supply disruptions. It's worth noting that the full extent of these changes may take longer to become evident than our data can currently track, extending until December 2021. Additionally, some firms might have abandoned their plans upon realizing that the disruptions would be temporary and that the associated costs could be managed, thanks to financial support from the government.

The final point raises the question of whether and to what extent the 'inaction' observed in the data is attributable to the 'moral hazard' problem presented in the introduction to this paper. In other words, does the government's crisis policy influence firms' risk-taking behaviour? The answer is unknown, but it may warrant further research, particularly

considering that the taxpayer cost for pandemic-related support to employers and employees reached approximately SEK 200 billion in total (Tillväxtanalys, 2023).

4.5 Sourcing closer to home?

Our final point pertains to whether companies are increasingly sourcing goods closer to home in the aftermath of the pandemic, a topic that garnered considerable attention at the time. To investigate this, we computed import shares for four distinct regions: the EU, EFTA+, other OECD countries, and the rest of the world. Notably, the UK, which exited the EU on January 31, 2020, is categorized within the EFTA+ group, alongside Norway, Iceland, Liechtenstein, and Switzerland. This group stands out for its extensive free trade agreements with the EU, effectively making it part of the single market, with certain exceptions for particularly sensitive agricultural products. Additionally, for each group, we have further analysed the import shares of the largest countries.

Table 13. Import shares for different regions and countries in 2019 and 2021 (%)

Region/country	2019	2021	2021- 2019
EU	56,8	55,4	-1,4
Germany	16,2	14,9	-1,3
The Netherlands	5,6	5,7	+0,1
Finland	5,0	5,4	+0,4
Poland	4,6	5,1	+0,4
France	4,0	4,2	+0,2
EFTA+	18,1	23,8	+5,7
Norway	10,7	17,0	+6,3
United Kingdom	6,5	5,7	-0,8
Switzerland	0,8	1,0	+0,2
Other OECD	8,1	8,3	+0,2
USA	4,4	5,1	+0,7
Turkey	0,7	0,9	+0,2
Japan	1,4	0,8	-0,5
Canada	0,3	0,6	+0,2
Rest of the world	17,0	12,5	-4,5
Russia	6,7	3,4	-3,3
China	2,4	2,7	+0,3
Brazil	0,7	1,2	+0,5
Nigeria	2,5	0,9	-1,6
India	0,5	0,6	-0,1

The data in Table 13 supports the hypothesis that supply chains have shifted closer to home after the pandemic. Specifically, the import share for the EU and EFTA+ has gone up from 74.9% to 79.2% between 2019 and 2021. However, it is crucial to note that the entire increase is attributed to Norway, with its share rising from 10.7% to 17.0% during this period. The primary reason for this change is the redirection of oil imports from Russia, Nigeria, Venezuela, and other OPEC countries.

Apart from the 'Norway effect,' there were no major changes in sourcing patterns. Note, in particular, that China's share of imports of industrial inputs has not declined, as many expected, but instead increased slightly from 2.4 to 2.7 percent. While this may surprise many, we should keep in mind that the sourcing, and therefore risks, were already highly concentrated in the home region to begin with. Further concentration might have been counterproductive, and perhaps this is why we haven't seen much action on this point.

5. Summary and conclusions

The coronavirus pandemic caused major disruptions to industrial production in Sweden, especially in the early stages when supply and logistics chains were disrupted as first China and then other countries shut down society to stop the spread of the virus. Despite the global nature of the pandemic, not all industries were affected to the same extent, nor all companies within each industry. In this report, we have analysed supply disruptions in the manufacturing industry during the pandemic and the impact of spreading supply chain risks across countries. Did companies with greater risk diversification fare better than others? The study also maps the measures taken by the industry to strengthen its resilience.

The empirical study on micro data for 2570 industrial companies shows that the risk of supply disruption is lower if purchases are split between different suppliers, but that the return on increased risk diversification is diminishing at the margin. Excessive risk diversification may even be counterproductive, probably because splitting purchases makes the company a less important customer of each supplier, with the risk of being deprioritised in a shortage situation.

In practice, risk diversification varies considerably across firm sizes and, to some extent, across industries. Large firms spread risks more than small firms in the same industry, suggesting that costs are a limiting factor for smaller firms in the industry in particular. Risk spreading also varies to some extent across industries, probably because they use different inputs. If supply is concentrated on the world market, the possibility of spreading risks across countries is reduced, as is the case with microchips and certain metals and minerals where supply is dominated by a few countries. In other words, risk diversification is a trade-off between costs, opportunities and benefits.

The survey conducted at the end of the first year of the pandemic in collaboration with the Confederation of Swedish Enterprise shows that six out of ten industrial companies have taken or planned measures to reduce their vulnerability to future crises. Most active are the companies that had problems during the pandemic, where 67 per cent state that they have taken or planned some measure, compared to 37 per cent for the other companies. The most common measure is increased stockpiling (37 per cent), followed by increased risk diversification (33 per cent) and increased purchases in Sweden and the EU/EFTA (22 per cent).

Due to the lack of data, we cannot verify to what extent the industry has actually increased its stocks after the pandemic to bridge temporary supply disruptions. In terms of risk diversification and moving purchases closer to Sweden, we see no major changes in the data, with the caveat that reorganising supply chains takes longer than we have been able to track in our databases.

The conclusion is that risk diversification works to a certain extent and that the industry has planned measures to strengthen its resilience to future crises, but it is not yet possible to verify the extent of the measures actually implemented. It is therefore an open question whether industry in Sweden has become more "resilient" since the pandemic.

Bibliography

- Baldwin, Richard and Rebecca Freeman (2022). "Risks and Global Supply Chains: What We Know and What We Need to Know", *Annual Review of Economics*, Volume 14, pp. 153-180.
- Brainard, W.C. and Cooper, R.N. (1968). "Uncertainty and Diversification in International Trade". *Studies in Agriculture Economics, Trade and Development*, 8, 256-285.
- Caselli, Francesco, Miklós Koren, Milan Lisicky, Silvana Tenreyro (2020). "Diversification Through Trade", *The Quarterly Journal of Economics*, Volume 135, Issue 1, February 2020, Pages 449-502.
- De Sousa, José, Anne-Célia Disdier, Carl Gaigné (2020). "Export decision under risk", *European Economic Review*, Volume 121, January.
- Esposito (2022). "Demand risk and diversification through international trade", *Journal of International Economics*, Volume 135, March.
- Finck, David, Peter Tillmann (2022) : The macroeconomic effects of global supply chain disruptions, BOFIT Discussion Papers, No. 14/2022, ISBN 978-952-323-429-1, Bank of Finland, Bank of Finland Institute for Emerging Economies (BOFIT), Helsinki
- Gervais, Antoine (2021). "Global sourcing under uncertainty", *Canadian Journal of Economics*, Volume 26, May.
- Goldberg, Pinelopi, and Tristan Reed (2021). "Is the Global Economy Deglobalising? And if so, Why? And What is Next?". NBER working paper 31115, April.
- Hale et. al (2021). "A global panel database of pandemic policies (Oxford COVID-19 Government Response Tracker)", *Nature Human Behaviour*, Vol. 5, April, pp. 529-538.
- Inomata, S., T. Hanaka (2021), "A risk analysis on geographical concentration of global supply chains", IDE discussion paper No. 828, October.
- Javorci, B., L. Kitzmueller; H. Schweiger; M. Yıldırım (2022), "Economic Costs of Friend-Shoring," European Bank for reconstruction and Development, W.P. No. 274.
- Lafrogne-Joussier, Raphael, Julien Martin, Isabelle Mejean (2022). "Supply Shocks in Supply Chains: Evidence from the Early Lockdown in China," *IMF Economic Review*, Vol. 71, pp. 170-15.
- Lintner, J. (1965). Security Prices, Risk, and Maximal Gains from Diversification, *The Journal of Finance*, Vol. 20(4), December, pp. 587-615.
- Markowitz, H. (1952) Portfolio Selection, *Journal of Finance*, Vol. 7(1), pp. 77-99.
- Rauch, James E (1999). "Networks versus markets in international trade." *Journal of international Economics* Vol. 48.1, pp. 7-35.
- Sharpe, W.F. (1964) "Capital Asset Prices: A Theory of Market Equilibrium under Conditions of Risk", *The Journal of Finance*, Vol. 19(3), September, pp. 425-4. 425-442.

Thakur-Weigold, Bubl, and Sebastien Miroudot (2023). "Supply chain myths in the resilience and deglobalisation narrative: consequences for policy", *Journal of international Business Policy*, pp. 1-13.

Growth Analysis (2019). "Sweden's export dependence - vulnerability to fluctuations in international demand", PM 2019:04.

Growth Analysis (2021). "The effects of the corona pandemic on the supply of imported input goods and measures to reduce vulnerability - A survey in collaboration with the Confederation of Swedish Enterprise", PM 2021:05.

Growth Analysis (2022). "The effects of short-term work on employment during the pandemic year 2020", PM 2022:12.

Growth Analysis (2023). "Business support during the pandemic - lessons for future crises", PM 2023:01.

Woerheide, Walt J.; Persson, Don (1993). "An Index of Portfolio Diversification" (PDF) *Financial Services Review*. 2 (2): 73-85.

World Trade Organisation (2023). "World Trade Report 2023 - Re-globalisation for a secure, inclusive and sustainable future", Geneva, Switzerland.

Our reports focus on how government initiatives contribute to Swedish growth and business development.

Read more about who we are and the benefits of what we do at www.tillvaxtanalys.se. You can also follow us on LinkedIn and YouTube.

Please subscribe to our [newsletter](#) to stay updated on ongoing and planned analysis and evaluation projects.

You are welcome to contact us!



Growth analysis

Studentplan 3, 831 40 Östersund

Telephone: 010-447 44 00

E-mail: info@tillvaxtanalys.se

Web: www.tillvaxtanalys.se