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Impact of COVID-19 on the Manufacturing Industry: A Case Study of 3M Company

Liting Yang[1,a,*]

[1]Newcastle university, Newcastle, NE1 7RU, United Kingdom
a. yangliting0728@gmail.com
**corresponding author*

Abstract: The 2019 coronavirus pandemic is the largest impact on manufacturing since the 2008 financial crisis. The impact on the manufacturing supply chain is particularly prominent. Much of the research by economists on the impact of the pandemic on industries has focused on risk transmission and macroeconomics. However, there is a lack of research on the financial status of individual companies and the adjustment strategies of companies in the face of shocks. Through a case study of 3M company, this paper aims to explore the impact of COVID-19 on the manufacturing industry. By analyzing the company's internal financial situation and external environmental impact, this paper illustrates whether the company's adjustment strategy is useful during the pandemic. The results show that large manufacturing companies have the ability to internalize the impact of risks. At the same time, backward integration of supply chain management strategy is one of the best ways for companies to improve the robustness of the supply chain.

Keywords: supply chain management, COVID-19, financial contagion, supply contagion, financial statement

1. Introduction

COVID-19 has had a huge impact on the world economy, and manufacturing is the largest component of the real economy, so it is worthwhile to study the dynamics of manufacturing in the context of COVID-19. As one of the large manufacturers in North America, 3M's internal financial data and adjustment strategy against the background of COVID-19 can reflect the situation of manufacturing enterprises. This paper uses qualitative research and conducts a case study on 3M company. The second part discusses the change of the output of the world manufacturing industry, the third part analyzes the impact of financial contagion on the manufacturing industry, the fourth part analyzes the impact of supply contagion on the manufacturing supply chain, and the fifth part analyzes and evaluates the financial statements and supply chain management strategies of 3M Company. This paper provides guidance for the development of the manufacturing industry under the background of COVID-19 and provides adjustment strategies that companies can refer to under the impact of COVID-19 on the supply chain.

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2. The Impact of COVID-19 on Worldwide Manufacturing Industries

The impact of COVID-19 on manufacturing is enormous. When the pandemic began, governments responded with a variety of strategies that sealed off countries by severely restricting their borders. In this process, consumer spending, international trade, and global supply chains are all affected, often negatively [1]. For manufacturing, where supply chains are critical, the impact of the pandemic is direct [2].

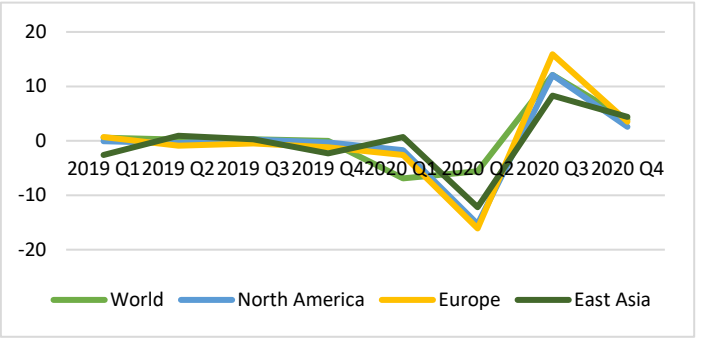

Figure 1: The growth rate of worldwide total manufacturing output compared to the previous quarter.

As shown in Figure 1, in the Q1 of 2020, the growth rate of worldwide total manufacturing output decreased by 6.9%, with the growth rate of North America and Europe decreasing by 1.7% and 2.6%. (Total output decreased by 2.4% and 4.4% quarter-on-quarter respectively), nevertheless, East Asia grew by 0.7% [3]. Worldwide manufacturing output growth declined by 5.6% in the Q2 of 2020. Growth in North America, Europe, and East Asia fell by 15.3%, 16.1%, and 12.2%, respectively [4]. According to a report provided by the UNIDO, the impact of COVID-19 on the manufacturing industry is reflected in the fragility of supply chains and restrictions on labor activities.

3. Financial Contagion

3.1. Relationship Between Banking Sectors and Manufacturing Industries

The interdependence of the banking sector and manufacturing has a long history. For example, in the Middle Ages, banks in Sheffield had close dealings with local manufacturing companies [5]. Mature industries make deposits or investments in banks, while the banking sector provides credit to manufacturing companies to help them expand or turn over capital. In addition, there is also evidence proving that the higher the concentration of banks, the better the performance of local manufacturing industry [6]. The close relationship between the banking sector and manufacturing firms also forms a network.

3.2. Status of the Banking Sector in the Context of the Pandemic

The pandemic has spurred growth in global demand for credit, and banks, as providers of credit, have also been hit by the pandemic. At the start of the pandemic, banks faced increased demand for commercial loans. However, because of the liquidity injection plan and the inflow of depositors, banks can mobilize funds to face the increased demand for commercial credit [7]. But in the post-pandemic period, banks' financial positions were not able to meet the increasing demand for credit from day to day. Evidence suggests that quarterly global bank loan growth declined by 1.04% in the post-pandemic period, with 0.69% and 5.50% declines in the US and non-US regions respectively [8]. In any case, a well-functioning banking system needs to stimulate economic growth through

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liquidity [9] and especially credit allocation. But the impact of the pandemic on banks makes the sector less able to play a role.

3.3. Status of the Manufacturing Industries in the Context of the Pandemic

The dual impact of COVID-19 and the trade war on the manufacturing industry makes it more in need of capital turnover for its operation [1]. For example, the American manufacturing industry is restricted by epidemic prevention policies and trade wars, and many manufacturers need to choose local enterprises to produce intermediate products instead of overseas manufacturers [10], which means higher production costs. If American manufacturers choose to make those intermediate goods themselves, that means they need more money to expand their production lines and build factories to store. These adjustment strategies due to the pandemic and the trade war have increased demand for credit from American manufacturers.

To sum up, the dual factors of COVID-19 and the trade war have had an impact on the network formed by the banking sector and the manufacturing sector. On the one hand, the banking sector is unable to cope with the growing demand for credit. On the other hand, credit demand for manufacturing has increased during the pandemic. This indicates that the financial contagion caused by COVID-19 has spread among the banking sector and the manufacturing sector.

4. Supply Contagion

4.1. Importance of Analysing Supply Chain

There are many drawbacks to the supply chain. With increasingly complex supply networks, globalization, natural disasters and political interference, manufacturing supply chains face the problem of inelasticity [7]. The composition of the supply network is made up of upstream, internal manufacturing and downstream parts of the supply chain, which reflects its complexity [11]. Second, globalization has created supply chains with suppliers in different countries. Tax policies in different countries and labor prices in different regions have more constraints on manufacturers, affecting their supply efficiency [12]. Natural disasters (such as earthquakes, tsunamis, and droughts) will then damage suppliers' infrastructure, disrupt supply chains, and affect the profitability of manufacturing companies that produce the final product [13]. Finally, political interference is reflected in the setting of carbon emission standards by local governments. When standards are too high, they hurt manufacturers' profits [14]. These problems result in high maintenance costs even if the supply chain does not suffer any shocks.

4.2. The Impact of COVID-19 on Supply Chains

In the wake of the pandemic in late 2019, no event will hit supply chain robustness more than COVID-19 [7]. First, manufacturers could not have foreseen an event of such magnitude and high impact. Therefore, the preparation for dealing with such uncertain events is not sufficient [7]. Secondly, due to the complexity of the supply chain itself and the extensive distribution of the supply network, enterprises are unable to make adequate adjustments in the short term [15]. Third, governments have restricted travel, temporarily closed factories and outlets, and imposed mandatory quarantines to contain the scale of the COVID-19 epidemic. These government intervention measures lead to the restriction of labor activities [15]. All these reasons will lead to an impact on the manufacturers of supply chain nodes, and then lead to the inability of the final product manufacturers to get intermediate products and to produce. Foxconn's factories in China, for example, have closed and Apple has had to delay the launch of new products. Samsung and LG suspended production at factories in South Korea and India. Tesla Motors is closing plants in Reinjury, California and New

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York. Airbus, Boeing and Lockheed suspended production activities at some of their plants in Europe and the United States [15]. The above examples are a good example of the passive situation of manufacturers in the face of a pandemic, when the supply chain is hit.

5. Case Analysis

As a leading manufacturing enterprise in North America, 3M can well respond to the impact of COVID-19. This section will analyze 3M's internal financial situation from 2019 to 2020 to observe whether 3M has encountered financial problems. Secondly, observe the state of 3M's supply chain when it was affected by the epidemic and its coping strategies, and then evaluate the performance of these coping strategies.

5.1. Financial Statement Analysis

The financial statements can clearly see the changes of 3M's financial status, through which one can see whether the company has been affected by the pandemic and how it copes with those problems. This section studies the financial statements of 3M Company from 2015 to 2020, observing the comprehensive situation of 3M Company before and during the pandemic through four dimensions. They are profitability, operating efficiency, short-term liquidity, and supply chain management ability.

Profitability. ROE and ROA are indicators used to measure a company's ability to make profits using its own capital and assets, respectively. It can be seen from Table 1 that the ROE of 3M Company reached its lowest point in 2017, while the ROA reached its lowest point in 2019. As can be seen from Figure 2, the growth rate of ROE in 2019 also declined significantly. It is due to the decline in net income in 2019 and the increase in shareholder's equity and total asset. However, the biggest impact of COVID-19 on global manufacturers' profitability will be in early 2020. This indicates that the change of 3M financial items is more related to the adjustment of its development strategy, rather than the impact of COVID-19. However, 3M mentioned in its 2019 financial report that despite the negative impact of COVID-19 on its supply chain, 3M has enough inventory to withstand the shock [16].

Table 1: ROE and ROA of 3M from 2015 to 2020.

Items	2015	2016	2017	2018	2019	2020
Net income	4841	5058	4869	5363	4582	5393
Shareholder's Equity	11708	10298	11563	9796	10063	12867
Total Asset	32718	32906	37987	36500	44659	47344
ROE (%)	41.35	49.12	42.11	54.75	45.53	41.91
ROA (%)	14.80	15.37	12.82	14.69	10.26	11.39

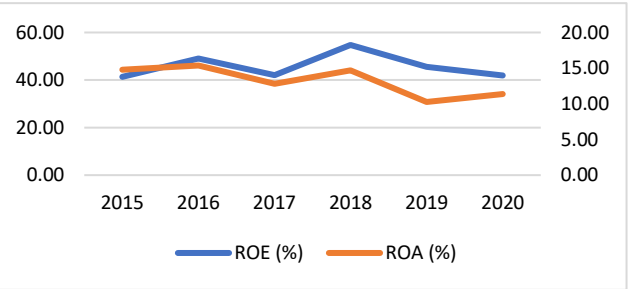

Figure 2: Growth rate of 3M's ROE and ROA from 2015 to 2020.

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Operating Efficiency. This section looks at 3M's operating efficiency by using the ratio of asset turnover (ATR), days of accounts receivable (ADR), and days of accounts payable (ADP). As can be seen from Table 2, 3M's ATR reached its lowest point in 2020 because 3M's total assets increased by 6% compared with the previous year (cash and cash equivalents increased by 96.94%). This was due to an increase in cash, cash equivalents and marketable securities balances from debt offerings prior to the acquisition of the Acfidelity in October 2019 [16]. In 2020, ADR of 3M decreased, but ADP reached the highest value in the past five years, which indicates that 3M's strategy in the face of the impact of the pandemic is to improve the company's internal revolving capital. 3M is using its bargaining power with suppliers to occupy the funds of suppliers to provide funds internally for a smooth turnover. On the other side, 3M avoids borrowing short-term funds from banks, which is related to the shrinking of bank credit during the epidemic mentioned in section 3 of this paper. To sum up, COVID-19 did have an impact on 3M's operating efficiency, but 3M quickly responded with corresponding adjustment strategies.

Table 2: ATR, ADR and ADP of 3M from 2015 to 2020.

Items	2015	2016	2017	2018	2019	2020
SALES	30274	30109	31675	32765	32136	32184
total assets	32718	32906	37987	36500	44659	47344
ATR	0.93	0.92	0.83	0.9	0.72	0.68
account receivable	4154	4392	4911	5020	4791	4705
revenue	30274	30109	31675	32765	32136	32184
ADR (days)	50.08	53.24	56.59	55.92	54.42	53.36
account payable	1692	1798	1945	2266	2228	2561
cost of sales	15383	15040	16001	16682	17136	16605
ADP (days)	40.19	43.63	44.37	49.58	47.46	56.29

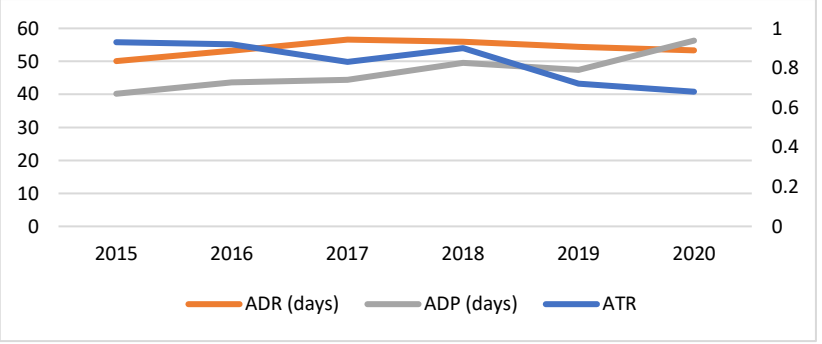

Figure 3: The trend of ADR, ADP and ATR of 3M from 2015 to 2019.

Short-Term Liquidity. This section uses the current ratio and the ratio of working capital to total assets (WCTA) to look at 3M's short-term liquidity. Both the current ratio and the WCTA are measures of a company's ability to pay its debts over a period of one year or less. The rise in the ratio is a positive sign for the company that its liquidity is improving. It can be seen from table 3 that 3M's short-term debt repayment ability is relatively stable. Current ratio peaked in 2020 and WCTA was relatively high, especially when compared with the previous year. The reason was the growth of current assets and the decline of current liabilities. Such changes further proved that as mentioned in section 5.1.2., 3M's strategy to cope with the pandemic was to increase the accumulation of internal liquid funds and reduce its dependence on external lending.

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Table 3: Current ratio and working capital to total assets ratio of 3M from 2015 to 2020.

Items	2015	2016	2017	2018	2019	2020
CURRENT ASSETS	1775.4	1904.8	2237.9	2298	2340.6	2416.2
current labilities	1485.1	2004.3	1971.8	1994	2253.8	1926
working capital	3868	5507	6590	6465	3749	7034
total assets	32718	32906	37987	36500	44659	47344
current ratio	1.22	0.95	1.13	1.15	1.04	1.25
WCTA (%)	11.82	16.74	17.35	17.71	8.39	14.86

Supply Chain Management Ability. Inventory turnover ratio and days in inventory ratios can be used to observe 3M's management of the supply chain. Both ratios are comprehensive indicators that measure a business's input into production, inventory management level and ability to recover sales. The higher the inventory turnover rate, the shorter the number of days, indicating the stronger the realization ability of the inventory assets, the faster the turnover speed of the inventory and the capital occupied in the inventory. It also shows the integrity and efficiency of the supply chain. As can be seen from table 4, the inventory turnover of 3M was the lowest in Q2 2020, and reached the highest number of inventory days in Q2 2020. This was the period when total global manufacturing output was most affected by COVID-19. From the above analysis, 3M's profitability and operating efficiency have not been greatly affected by COVID-19, but its inventory turnover rate becomes low and inventory turnover days become long. That means that the impact on inventories is not caused by 3M adjusting its production strategy, but by manufacturers in the supply chain being hit and possibly unable to deliver as scheduled.

Table 4: Inventory turnover ratio and days in inventory of 3M from 2019 Q1 to 2020 Q4.

Items	2019 Q1	2019 Q2	2019 Q3	2019 Q4	2020 Q1	2020 Q2	2020 Q3	2020 Q4
Inventory turnover ratio	0.97	0.98	1.01	1.06	0.98	0.91	1.06	1.07
cost of sales	4310	4313	4188	4325	4109	3805	4303	4388
closing inventory of previous quarter	4366	4538	4300	4007	4134	4217	4168	3984
closing inventory of this quarter	4538	4300	4007	4134	4217	4168	3984	4239
average inventory	4452	4419	4153.5	4070.5	4175.5	4192.5	4076	4111.5
days in inventory	368	365	353	335	362	392	337	334

5.2. Supply Contagion and Supply Chain Management

In 3M's 2020 Sustainability report, 3M has adjusted its supply chain management strategy in response to the impact of COVID-19 on its supply chain. The main strategy is divided into the following three points: first is to expand the choice of suppliers; second is to evaluate the whole supply chain to assess whether the supplier's supply chain is robust; third is to prepare to integrate suppliers upward to ensure that the upstream suppliers are controllable [17].

This section will use the network graph theory to evaluate 3M's new strategies. First, nodes are used to stand for manufacturers: node a1 represents 3M; b1 and b2 stand for a1's suppliers; nodes c1, c2, c3, and c4 represent suppliers of b1 and b2. The arrow between every two nodes represents the supply relationship between the two manufacturers. Assume that the probability of each firm being hit is x, and the probability of not being hit is $(1 - x)$. If the manufacturer is shocked, then it is

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unfunctional. The following paragraphs calculate the probability of a1 being hit in each supply network and make comparisons in the diagram. In this way, whether 3M's new supply chain management strategy can effectively improve 3M's reliability can be observed.

Supply Network 1 vs Supply Network 2. Figure 4 and Figure 5 respectively indicate that a1 uses single procurement mode and multiple procurement mode as supply chain management strategies. In supply network 1, a1 is shocked with a probability of x^3. And in supply network 2, a1 is hit with probability $x(1-(1-x(1-x)^2))^2)$. Meanwhile, it can be seen from Figure 6 that a1 in supply network 2 has higher reliability than a1 in supply network 1 under the same firm strength. This evidence suggests that 3M's strategy of expanding supplier selection is beneficial to improving the company's reliability.

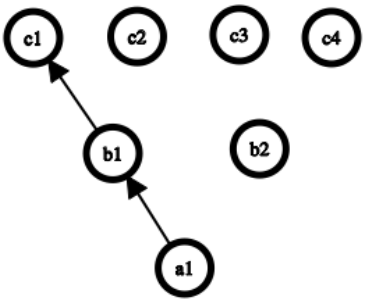

Figure 4: Supply network 1.

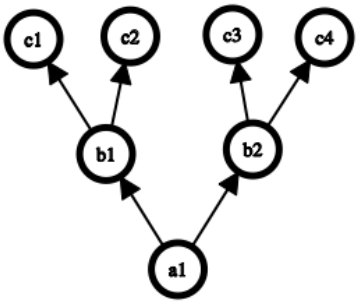

Figure 5: Supply network 2.

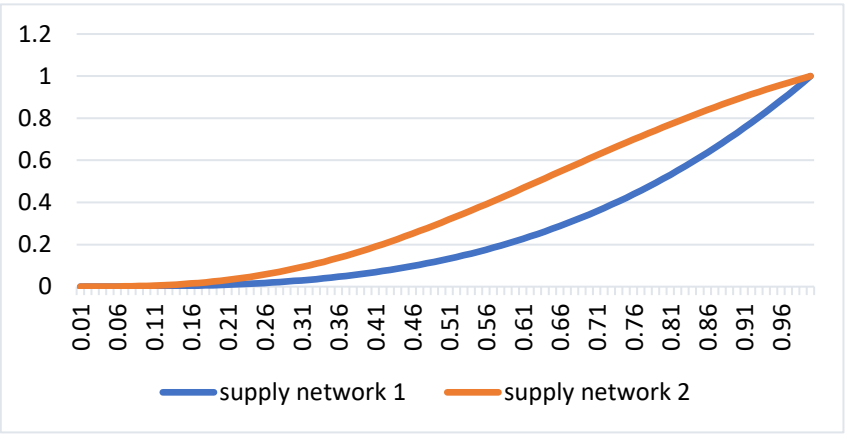

Figure 6: Comparison of a1's reliability in supply network 1 and supply network 2.

Supply Network 3 vs Supply Network 4. Supply network 3 represents that a1's suppliers (b1 and b2) have a supply relationship with two suppliers (c1 and c2). and a1's probability of being hit is $x(1-(1-x)^2)^2$. Supply network 4 represents that a1's suppliers have a supply relationship with four suppliers (c1, c2, c3, and c4). And the probability of a1 in this network equals to $x[1-(1-x)^4][1-(1-x)^2]$. This section compares the probability of a1 which represents 3M in this case being shocked in the two supply networks to test whether 3M's supply chain management strategy is effective. Meanwhile, it can be seen from Figure 9 that a1 in supply network 4 has higher reliability than a1 in supply network 3 under the same firm strength. This evidence shows that 3M's strategy of evaluating suppliers' suppliers and reassessing the robustness of the entire supply chain is correct. If 3M's suppliers only select suppliers in a narrow channel and choose the common suppliers

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as their competitors, the supply chain reliability of 3M will be low. If 3M's suppliers consider a multi-sourcing approach, the impact of a pandemic or other factors on the supply chain can be reduced.

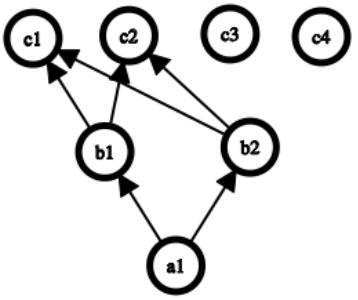

Figure 7: Supply network 3.

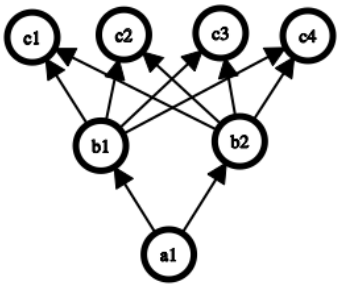

Figure 8: Supply network 4.

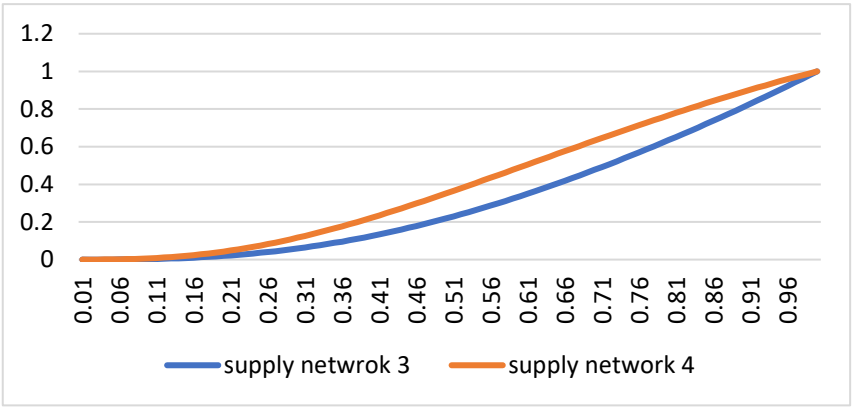

Figure 9: Comparison of 3M reliability in supply network 3 and supply network 4.

Supply Network 4 vs Supply Network 5. In this section, supply network 4 represents the supply chain network without backward integration, and supply network 5 represents the supply chain network after backward integration (b3, as the supplier of a1, has realized backward integration). In the two supply networks, the reliability of a1 equals to $x[1-(1-x)^4][1-(1-x)^2]$ and $x[1-(1-y)(1-x)]$ respectively (where, $y=[1-(1-x)^3][1-(1-x)^2]$). As can be seen from Figure 12, supply network 5 is more reliable for a1 than supply network 4 for the same firm forces. This evidence indicates that 3M's upwardly integrated supply chain management strategy can indeed help the company reduce the fragility of its supply chain under the influence of COVID-19 factors.

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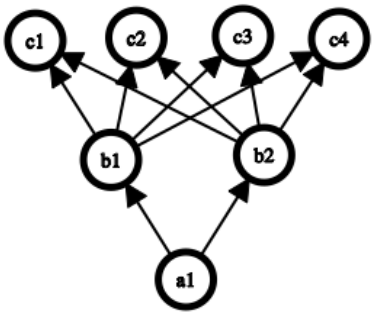

Figure 10: Supply network 4.

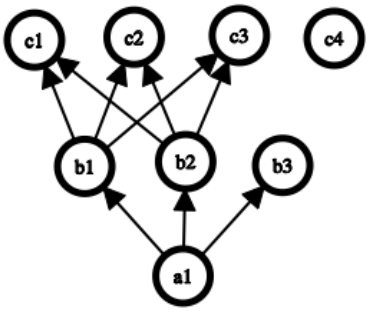

Figure 11: Supply network 5.

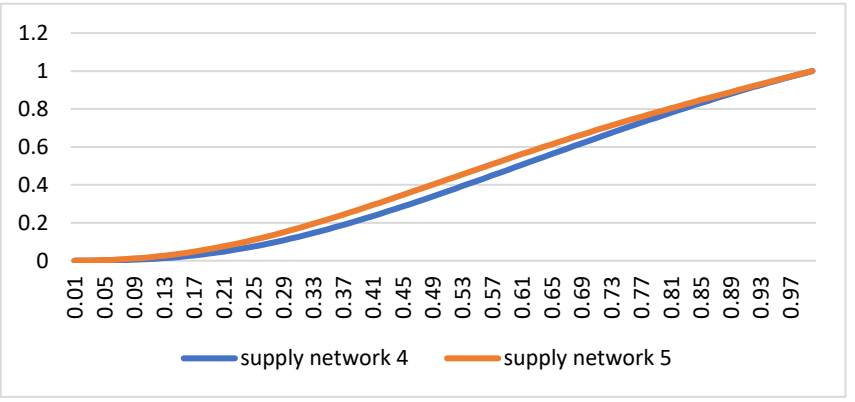

Figure 12: Comparison of 3M reliability in supply network 4 and supply network 5.

Supply Network 5 vs Supply Network 6. In sections 5, 5.1.1, 5.1.2 and 5.1.3, the effectiveness of the supply chain management strategy proposed by 3M has been discussed. It is worth mentioning that 5.1.3 deals with geographic and financial backward integration. That is, after integration, b3 needs to produce intermediate products that would otherwise be provided by upstream suppliers. However, many companies are only integrating at the financial level, not geographically. This section discusses the influence of regional differences on the supply chain in two situations. Supply network 5 represents the backward integration of b3 at the geographical level. Supply network 6 represents the backward integration of b3 at the financial level, namely the acquisition. But the acquired manufacturer, c4, is not in the same region as b3. The probability of a1 being hit in supply networks 5 and 6 is $x[1-(1-y)(1-x)]$ where $y=[1-(1-x)^3][1-(1-x)^2]$and $x[1-(1-y)(1-x^2)]$ where $y=[1-(1-x)^3][1-(1-x)^2]$. It can be seen from Figure 15 that the reliability of a1 is higher in supply network 5 than in supply network 6. This means that if 3M is preparing for backward integration to cope with the impact of the pandemic, it will need to consider doing it within its own country, as different countries have different levels of emphasis on closing borders in their policies on COVID-19.

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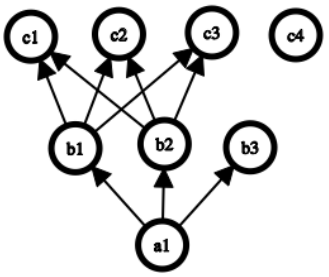

Figure 13: Supply network 5.

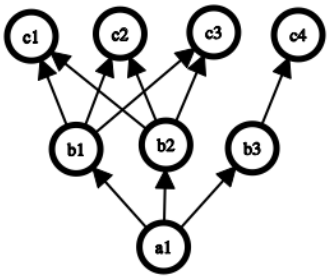

Figure 14: Supply network 6.

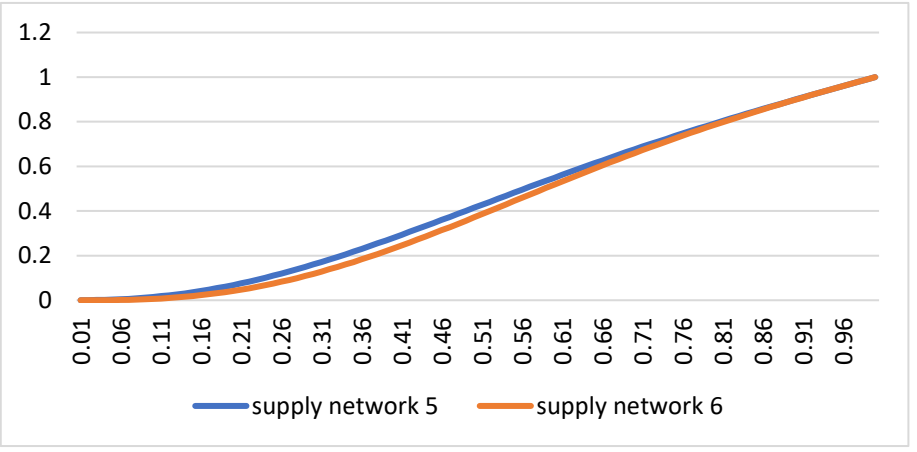

Figure 15: Comparison of 3M reliability in supply network 5 and supply network 6.

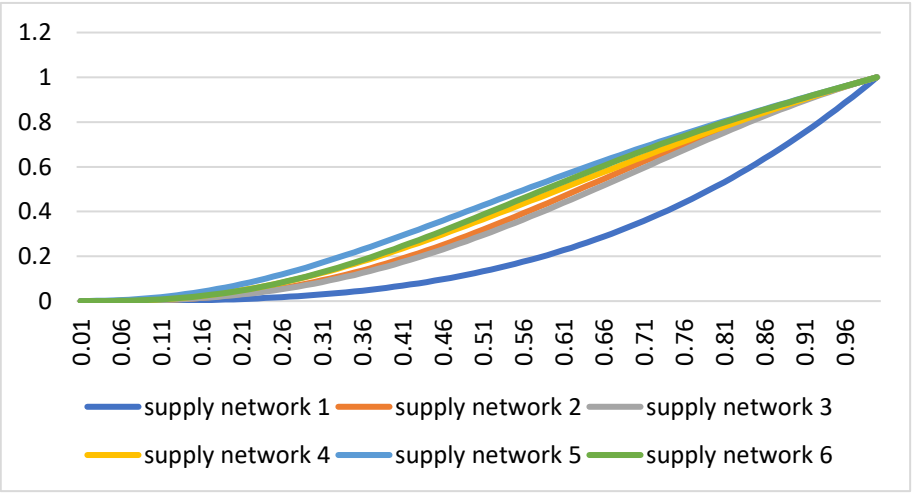

Figure 16: Reliability of 3M in each supply network.

In conclusion, backward integration at the geographic level is a strategy that can help 3M maximize its reliability during this pandemic. However, the backward integration strategy is effective only if there are enough upstream suppliers and suppliers must have enough upstream suppliers to cooperate with. This corresponds to the first and second parts of 3M's supply chain management strategy respectively. In other words, 3M needs to consider these three strategies together to improve the robustness of its supply chain.

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6. Conclusion

This paper studies the impact of COVID-19 on the manufacturing industry. By analysing the data of the total output of the world manufacturing industry from 2017 to 2020, this paper draws the conclusion that the output of the manufacturing industry declined significantly in Q2 2020 due to the influence of government intervention policies. The paper also finds that the manufacturing sector and the banking sector are in the same network, and the risks will be contagious to each other. During the pandemic, bank credit contracted while manufacturing credit demand increased. That will cause the manufacturing sector to suffer financial problems. In addition, supply chain disruptions are a key factor in manufacturing's woes amid the coronavirus pandemic. Through the analysis of the financial statements of 3M company, it is found that large-scale manufacturing enterprises like 3M have enough ability to internalize part of the impact and then adjust quickly. Moreover, 3M's supply chain management strategy adjusted for COVID-19 is worth thinking about and learning for other companies. However, this paper analyses the data of supply chain management through the data of financial statements, and does not find the publicly available data directly related to supply chain management, such as the increase or decrease of order volume, the expenses involved in inventory management and delivery, and the IT costs related to supply chain management. Therefore, this paper still has limitations in the dimension of 3M's supply chain management cost analysis. In addition, this paper does not use the quantitative analysis method to study the impact of financial contagion on the manufacturing industry, because there is no suitable model to embed the manufacturing industry into the risk contagion mechanism of the banking sector, but this is a field worth studying in the future.

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