Supply chain and Covid-19: does it matter for the financial markets?

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Abstract
Supply chain risk represent one of the main issues for the companies during the pandemic and for some firms the risk of default is significantly increased due to the disruptions in the supply chain and their impact of the productivity and profitability of the enterprise. Literature has shown that in the last years companies are reacting to the new scenario by constructing less global and more resilient supply chains but there is no evidence of the impact on the stock market performance.
The paper considers a twelve years time period and evaluates the changes in the customers' and suppliers' network for a representative sample of companies listed in Europe. Results show that the attention given by the market to the supply chain features is growing and, differently with respect to the pre-covid period, the abnormal performance with respect to standard pricing models is better explained by the choices in selecting the most relevant suppliers and customers.

Keywords: Supply chain, Covid-19, Stock performance, Supply chain disruption

EFM codes: 380, 240, 330, 350

1. Introduction

Successful supply chains, characterized by effective sourcing strategies, the usage of information technology, integration and external relationships are associated with lower default risk of the members (D'avanzo, Lewinski, H., V. and Wassenhove, 2003) that, in turn, ensures the resiliency in the long run. (Gibilaro and Mattarocci, 2019). Day-to-day disturbances in the supply chains operations affecting the financial performance are attributed to industry-specific risk, organizational risk, internal business process risk, and demand risk (Chen,2018). The financial performance of the members of the supply chain can be determined by disruption events can affect the wealth and the profitability for members' investors (Yu, 2013). Disruption risks belong to low-frequency-high-impact events characterized by a very strong and immediate impact on the network structure since some factories, suppliers, and transportation links become temporarily unavailable, determining the performance degradation in terms of revenue, service level and productivity (Ivanov et al., 2014). Among disruptions events, Covid-19 outbreak represents one of the major disruptions encountered during the last decades (Araz et al., 2020) caused by a viral pandemic that abruptly and severely constricted global economic activity (Bernanke, 2020) determining long periods of self-isolation (Niblett, 2020) whose duration would determine the intensity of the losses (Guan et al.,2020) . In light of the emphasis on efficiency in the operation, the spreading of the pandemic has found much of the world to relying upon complex, nested, and interconnected systems to deliver goods and services around the globe, showing a reduced resilience of key systems to shocks and allowing failures to cascade from one system to others (OECD, 2020). As a consequence, more than 94% of the Fortune 1000 companies have been reported seeing coronavirus-driven supply chain disruptions (Fortune, 2020) therefore global supply chains showed a strong vulnerability in managing a bullwhip effect to due reduced transparency (Zhou, Chou and Tsai, 2020) generating dramatic multilevel effects due to the

role of central nervous system of the economy and society (Ivanov, 2020). As a consequence, Covid-19 represented a weak up call for managers to build supply chain resilience to future shocks (Shih, 2020).
Despite the importance, only few empirical studies have investigated empirically the relationships between supply chain risk and performance (Colicchia and Strozzi, 2012) and the filling of this gap is of vital importance after the COVID-19 outbreak to build resilient supply chains. The paper analyzes a representative sample of the European companies listed in the eurostoxx and evaluated their supply chain features on a twelve years time horizon (2010-2021) and point out an higher relevant of the supply chain changes in the pandemic period. The analysis of the abnormal performance with respect to standard pricing models point out that the choice of modifying the network has an impact especially if the new customers or suppliers are from the same country, have a lower risk.
The originality of the paper lies in the analysis of the supply chain risk on the financial performance under different periods of the COVID-19 outbreak. The results obtained contribute in different directions to the existing literature: empirical evidences are offered to assess responses on the designing and structure of global supply chains after the outbreak (Ivanov et al., 2014); in light of the importance of default risk along the supply chain (Gibilaro and Mattarocci, 2019), the paper shows how it is affected by COVID-19 responses on the design and the structure of supply chains; through the analisys of financial markets reactions short term valuations of resilience strategies is provided.

2. Literature review

COVID-19 has generated great uncertainty and dramatically affected, among the others, supply chains (Chang, McAleer and Wong, 2020). Indeed, due to the global character of supply chains based on a very strong amalgamation of China across sectors (Free and Hecimovic, 2020) and on complex interconnected networks (Ivanov and Dolgui, 2021), Covid-19 has severely affected the ability to absorb and respond to supply shortage of inputs' to businesses (Gereffi, 2020) and demand shocks due to increased variability in demand caused by panic buying (Arafat, Kar and Kabir, 2020). Therefore, since the spreading of the pandemic, literature has raised the attention on resilience building in the post COVID-19 world (Golan, Jenergan, Linkov, 2020) intended like the capacity for an enterprise to survive, adapt, and grow in a turbulent environment (Fiksel, 2020) and to recover to normal functions (Visser, 2020). Building resilience is a crucial feature to ensure viability of supply chains and requires taking actions in different directions. After many decades of overreliance on China across many economic sectors, balanced diversification of supply chains has become an imperative to mitigate supply risks (Zhu, Chou and Tsai, 2020), localizing supply chain base near home and improving the regional production capacity for essential products primarily (van Hoeck, 2020). Recent evidence shows that US companies have already started to realign and diversify their supply chain operations to reduce risks associated with potential future disruptive events moving from Asia in favor of the relocation in South America (Oxford Business Group, 2020). Localization of supply chains determines benefits, but it can disclose also new threats. From the environmental sustainability perspective, benefits can derive from the provision for the potential risk posed by climate change and other natural and human-caused disasters (Farrell et al., 2020). Conversely, the localization of supply chains can challenge the operational efficiency due to the time requested to fulfill the process and the possibility that supply normalizes before reshoring can be completed (van Hoek. and Dobrzykowski, 2021).

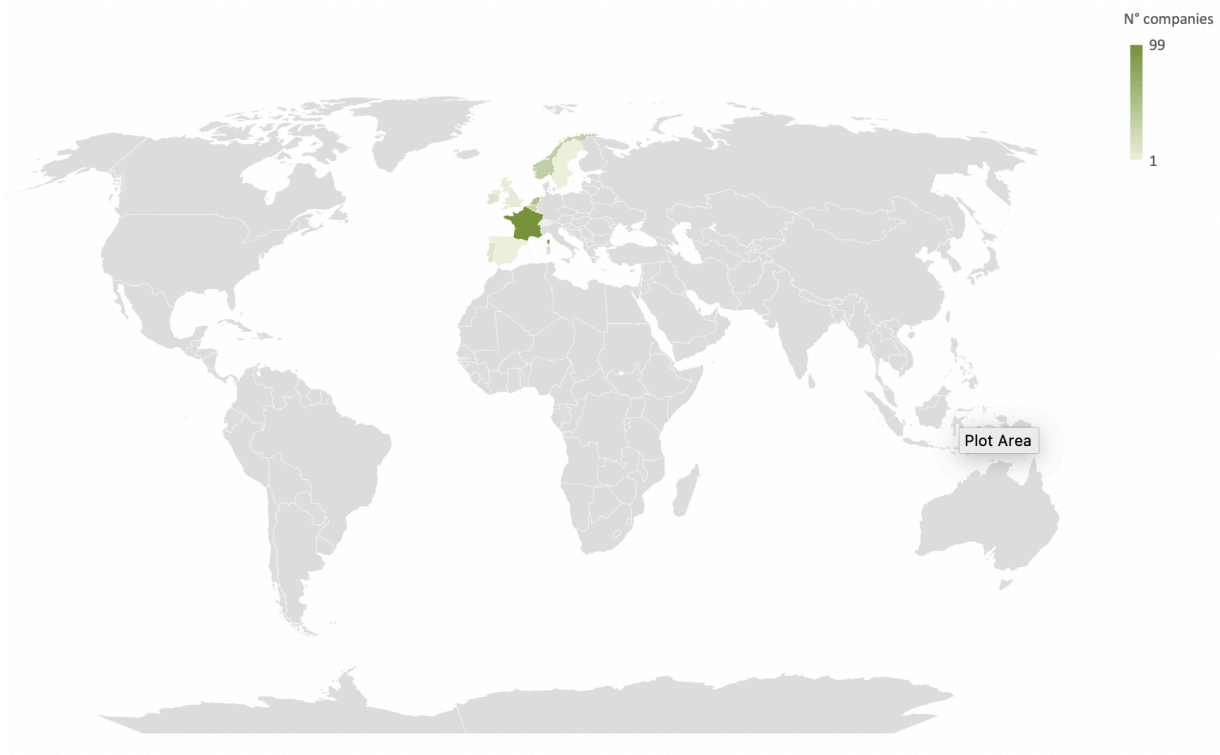
The search for silled employees to hire and of an alternative manufacturing market to replace China and the entrenched nature of supply chains (Zhu et. Al. 2020), with a potential effect of price increases for firms and consumers that can be accepted because of logistical challenges and growth in demand (Hahovirta and Denuwara, 2020). As a consequence, resilience capability building can come at the cost of lower operation efficiency to pursue survivability of supply chains (Ivanov and Dolgui, 2021). As a side effect, redundancy in inventories is necessary to maintain supply chains viable global supply chain (Miroudot, 2020) networks and the short term tradeoff between efficiency and resilience and efficiency is expected to solve in the long term (Golgeci, 2020). Facilitating factors in the transition of supply chains toward viability are the digital technology that should help to enhance visibility in the supply chain among suppliers and customers (Acioli, Scavarda and Reis, 2021) and collaboration among entities in the supply chain to foster inter-learning to deliver sustainable results (Blome, Paulraj, and Schuetz, 2020).
More than the real market, the spreading of COVID-19 impacted the stock market (Baker et al., 2020), determining connectedness between commodities and financial market. As a matter of fact, supply chain disruption events are found to affect stock prices in light of increased risk of the firm for members' investors in both the short term (Hendrick and Singhal, 2003) long term (Hendrick and Singhal, 2005). Empirical evidence shows that the COVID-19 disruption event affected the stock prices of the members of global supply chain during the first pandemic wave, showing differences among the subphases (Hoehler and Lansik, 2020) and that the firms exposed internationally due to either the belonging to global supply chains or selling to foreign customers showed a remarkable drop in the stock prices (Ding et al., 2021)

3. Empirical analysis

3.1 Sample

The sample considered the top 250 companies listed in the Euronext market at the end of 2021 and considers companies based in France (99), Netherlands (49), Norway (34), Belgium (30), Ireland (12), Portugal (10), Luxembourg (6), UK (3), Bermuda Islands (2), Faroe Islands (1), Spain (1), Sweden (1), and Switzerland (1) (Graph 1).

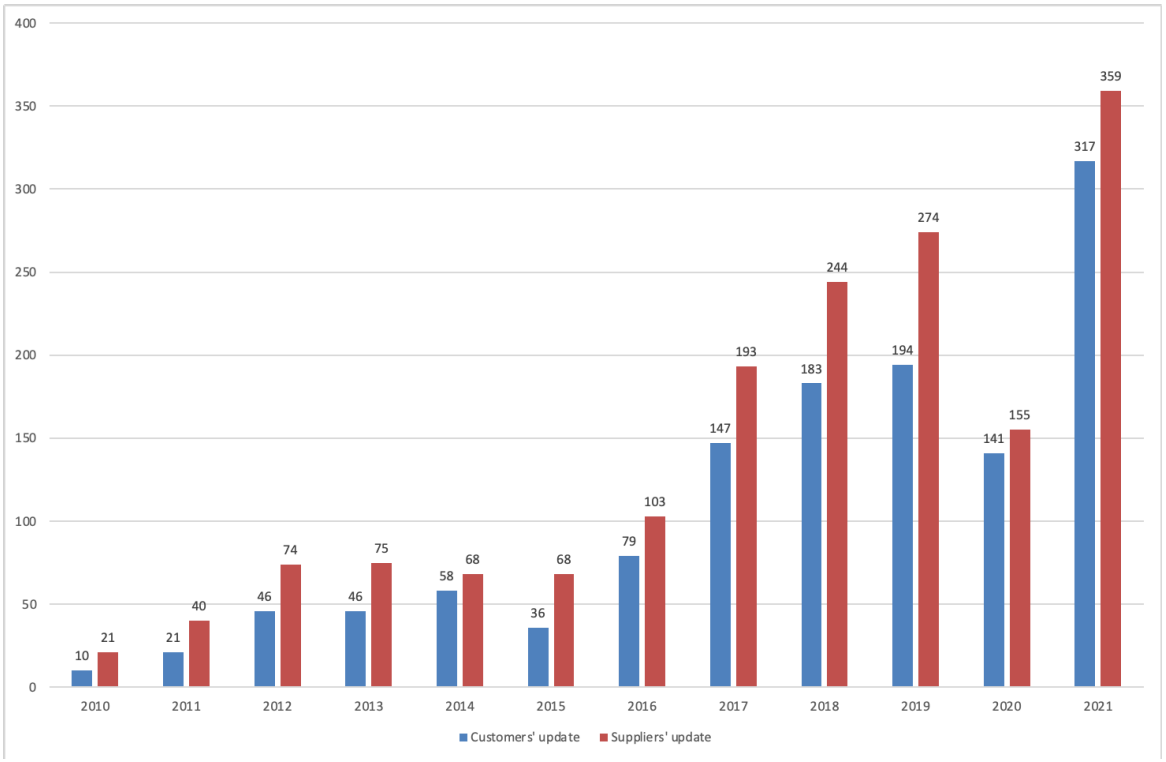
Graph 1. Companies classified by country of domicile



Source: Eikon Refinitiv data processed by the authors

For each company we collected all the information related to the supply chain for both the relevant customers and supplier that allow to understand the frequency in the changes of the supply chain structure year by year. The classification of the supplier and customer is based on a confidence score computed by Eikon Refinitiv using a proprietary algorithm that analyses News, Filings and other documents published by company that allows to assign a probability of a valid supplier-customer relationship between two companies. Relevant customers and suppliers are classified as the companies that have a probability of a valid supplier-customer relationship higher than 20% (Graph 2).

Graph 2. Supply chain updates



Source: Eikon Refinitiv data processed by the authors

Over the time period 2010-2021, the 250 companies have added to their supply chain 1278 new customers and 1678 new suppliers and the 2021 is the year characterized by the higher increase of new relevant customers and suppliers (respectively 317 and 359).
The analysis will consider the stock price of the shares listed in the Euronext on weekly basis and will compute the abnormal returns with respect to standard models used in literature and the role of the supply chain proxies in explaining the extra-performance achieved.

3.2 Methodology

The stock performance is computed by considering weekly data and computing for each company in the market by using the following formula:

$$r_{it} = \ln\left(\frac{P_{it}}{P_{it-1}}\right) \tag{1}$$

where P_{it} and P_{it-1} are respectively the closing price at the end of the year t and the year t-1. The performance measure is studied by considering separately companies that are experiencing at least one change in the yearly time horizon of a relevant suppliers or customers and the others.
We construct unexpected performance measure looking at the excess return with respect to standard pricing models (CAPM, Fama & French and Carhart Model). The extra performance achieved by each company is computed on the basis of the following formulas:

$$AR_{it}^{CAPM} = r_{it} - rf_t - \beta_{it}^{M}\left(R_{M,t} - rf_t\right) \tag{2a}$$

$$AR_{it}^{F\&F} = r_{it} - rf_t - \beta_{it}^{M}\left(R_{M,t} - rf_t\right) - \beta_{it}^{SMB}\left(R_{SC,t} - R_{LC,t}\right) - \beta_{it}^{HML}\left(R_{HBM,t} - R_{HBM,t}\right) \quad (2b)$$

$$AR_{it}^{Carhart} = r_{it} - rf_t - \beta_{it}^{M}\left(R_{M,t} - rf_t\right) - \beta_{it}^{SMB}\left(R_{SC,t} - R_{LC,t}\right) - \beta_{it}^{HML}\left(R_{HBM,t} - R_{HBM,t}\right) - \beta_{it}^{M}\left(R_{HPY,t} - R_{LPY,t}\right) \quad (2c)$$

Formula (2a) is the normal return with respect to the CAPM theoretical model (Sharpe, 1964). On the basis of the characteristics of the sample analysed we consider as a proxy of the risk free rate (rf_t) the return of a three months German Treasury bill and for market benchmark $\left(R_{M,t}\right)$ the value weighted average performance of the top 250 companies listed in the Euronext. The β_{it}^{M} is computed on weekly data considering the companies' return with respect to the index return two years before.

Formula (2b) is the abnormal return with respect to the Fama & French theoretical model (Fama and French, 1993). The two new factors included in the model with respect to the CAPM are the performance difference of small and large capitalized firms $\left(R_{SC,t} - R_{LC,t}\right)$ and the performance difference of high and low Book to market value companies $\left(R_{HBM,t} - R_{LBM,t}\right)$. Both β_{it}^{SMB} and β_{it}^{HML} are computed on weekly data considering the firms' return with respect to the two return gap measures in the two years before.

Formula (6) is the abnormal return with respect to the Carhart theoretical model (Carhart, 1997). The new factor added with respect to the F&F model is the performance difference of high and low past performance firms $\left(R_{HPY,t} - R_{LPY,t}\right)$. The β_{it}^{M} is computed on weekly data considering the company's return with respect to the difference in the two years before.

The abnormal performance is studied by considering the overall market and the two subsamples constructed on the basis of the supply chain yearly turnover.

A more detailed analysis of the supply chain features will consider the number of customers and suppliers classified on the basis of the country of domicile, the geographical area e balance sheet rating. The analysis of the geographical choice of main suppliers and customers is released as follows:

$$HB(C)_{it}^{C} = \frac{N^{\circ}\ new\ customers_{it}^{Country}}{N^{\circ}\ new\ customers_{it}} \quad (3a)$$

$$HB(S)_{it}^{C} = \frac{N^{\circ}\ new\ Suppliers_{it}^{Country}}{N^{\circ}\ new\ Suppliers_{it}} \quad (3b)$$

$$HB(C)_{it}^{A} = \frac{N^{\circ}\ new\ customers_{it}^{Area}}{N^{\circ}\ new\ customers_{it}} \quad (4a)$$

$$HB(S)_{it}^{A} = \frac{N^{\circ}\ new\ Suppliers_{it}^{Area}}{N^{\circ}\ new\ Suppliers_{it}} \quad (4b)$$

where the formulas consider the role of new customers and suppliers from the same country (3a, and 3b) or the same geographical area (4a and 4b) of the company with respect to the overall number of new supplier-customer relationships in the year t.

In order to evaluate the risk profile of the main customers and the main suppliers we consider a scoring model based on balance sheet data that allows to replicate the rating assigned by the main rating agencies developed by Eikon Refinitiv. Each supplier or customer will be assigned in a rating class from AAA to C- on the basis of its probability of default if all the data

necessary for the analysis are available[1]. Once computed the risk proxies for each supplier-customer relationship, for each of the companies in the Euronext index we computed:

$$Rating(C)_{it}^{New} = \frac{1}{n}\sum_{j=1}^{n} New\ rating(Customers)_{it}^{j} \quad (5a)$$

$$Rating(S)_{it}^{New} = \frac{1}{n}\sum_{j=1}^{n} New\ rating(Suppliers)_{it}^{j} \quad (5b)$$

$$P(C)_{it}^{New} = \frac{N°\ new\ customers\ rated_{it}}{N°\ new\ customers_{it}} \quad (6a)$$

$$P(S)_{it}^{New} = \frac{N°\ new\ suppliers\ rated_{it}}{N°\ new\ suppliers_{it}} \quad (6b)$$

Where formulas 5a) and 5b) compute the average rating of the new customers and suppliers for the company and allow to measure if the new supplier-customer relationships are characterized by a better or worse rating with respect to the existing ones. Formulas 6a) and 6b) allow measuring the role of unratable counterparties in the supply chain and they may be considered a proxy for the unexpected supply chain risk related to a lack or limited information available on business counterparties.
Supply chain measures are considered jointly with the stock market performances in order to measure if it matters for the return of the share and if during the pandemic has changed the role of the supply chain features for the stock market. In formulas:

$$AR_{it}^{Type}(C) = \alpha + \beta_1 D(C)_{it}^{New} + \beta_2 HB(C)_{it}^{C} + \beta_3 Rating(C)_{it}^{New} + \beta_4 P(C)_{it}^{New} + \varepsilon_{it} \quad (7)$$

$$AR_{it}^{Type}(S) = \alpha + \beta_1 D(S)_{it}^{New} + \beta_2 HB(S)_{it}^{C} + \beta_3 Rating(S)_{it}^{New} + \beta_4 P(S)_{it}^{New} + \varepsilon_{it} \quad (8)$$

$$AR_{it}^{Type}(S\&C) = \alpha + \beta_1 D(S\&C)_{it}^{New} + \beta_2 HB(S\&C)_{it}^{C} + \beta_3 Rating(S\&C)_{it}^{New} + \beta_4 P(S\&C)_{it}^{New} + \varepsilon_{it} \quad (9)$$

Where the abnormal return related to the different pricing models computed with the different pricing models (AR_{it}^{Type}) is studied with respect to the changes in the supply chain considering both the changes related only to the customers (C) and suppliers (S) and the overall changes in the supply chain (S&C). Independent variables are a dummy that assumes value one when there is a change in the relevant parties of a supply chain (D_{it}^{New}), the ratio between new parties involved with the same Country of domicile of the company (HB_{it}^{C}), the average rating of the member of the supply chain, ($Rating_{it}^{New}$), and the percentage of rated entities among those that are entering in the supply chain (P_{it}^{New}).

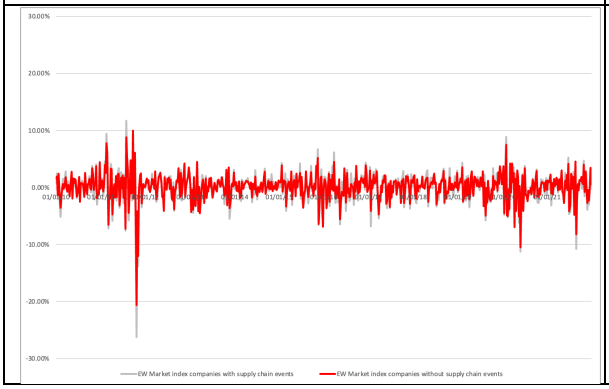
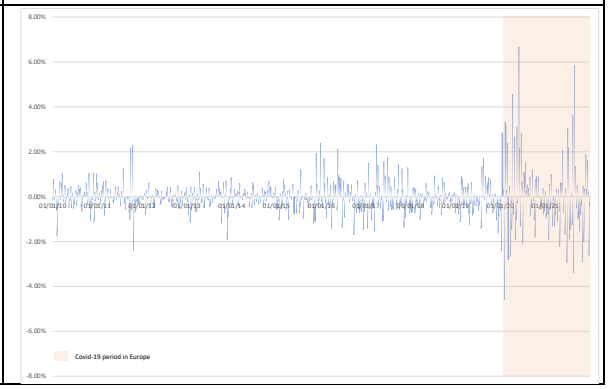
[1] The probability of default cannot be computed if the company is a private entity and not a corporation and if there are not enough historical data available.

The analysis will be performed by using a multiple cross section analysis in order to underline the differences in the role of the supply drivers over time and to highlight how the pandemic is making some strategic choices in the business network of the company more important.

3.3 Results

The analysis of the stock market performance of companies that are experiencing a change in supply chain and the others allow to point out some interesting differences in the performance in the pandemic period (Graph 3).

Graph 3. Stock market performance and supply chain events

Average performance of companies classified by supply chain events	Gap of gross average companies performance on the basis of the supply chain events
	

Source: Eikon Refinitiv data processed by the authors

On average companies that are affected by a supply chain change (customer or supplier) are suffering of a lower variability of the stock weekly performance with respect to the rest of the market but on average the return is lower with respect to the rest of the market. The Covid-19 has increased significantly the difference in the performances for the two type of companies and the effect seems to be long-lasting and not related only to the disclosure of the first cases of infection in Europe (February 2020) or the national lockdown measures (March -May 2020).

Results on the yearly return and abnormal return confirm a different average behavior for companies for which the supply chain has changed (Table 1).

The supply chain is affecting the companies' performance and a change in the suppliers or the customers has on average a negative impact on the ex-post return with respect to the ex-ante forecast realized by using the CAPM, the Fama and French, or the Carhart model (Table 1).

Table 1. Abnormal performance and supply chain change

	Abnormal return - CAPM model			Abnormal return - Fama & French model			Abnormal return - Carhart model		
	Overall	With supply chain change	Without supply chain change	Overall	With supply chain change	Without supply chain change	Overall	With supply chain change	Without supply chain change
2010	-2.59%	-10.84%**	-3.18%	-19.91%	-26.55%**	-20.70%*	-21.37%	-27.88%**	-22.28%*
2011	14.45%	4.23%**	15.35%	24.79%	14.23%**	25.80%*	27.11%	16.46%**	28.14%*
2012	2.95%	1.10%**	4.41%**	-18.39%	-21.71%**	-18.33%*	-20.92%	-24.37%**	-21.04%*
2013	-1.59%	1.20%**	-1.08%*	15.57%	19.96%**	16.99%**	17.82%	22.41%**	19.29%**
2014	6.03%	3.31%**	6.05%*	-7.74%	-13.55%**	-8.23%**	-7.30%	-13.01%**	-7.77%*
2015	4.35%	1.25%**	6.39%**	-1.21%	-5.43%**	0.61%**	0.55%	-3.41%**	2.46%**
2016	3.78%	4.71%**	-1.02%**	-4.68%	-4.73%*	-9.81%**	-0.89%	-0.47%*	-5.74%**
2017	0.54%	-3.33%**	2.51%**	-3.75%	-7.95%**	-1.79%**	-5.49%	-9.77%**	-3.57%**
2018	3.46%	2.52%*	0.53%**	-11.24%	-13.76%*	-13.46%*	-8.23%	-10.44%**	-10.57%**
2019	-0.73%	-3.86%**	2.22%**	-13.67%	-17.33%**	-11.12%*	-16.41%	-20.16%**	-13.97%**
2021	1.48%	1.69%*	3.09%**	-8.92%	-9.13%*	-7.37%**	-11.02%	-11.29%	-9.50%**
2020	-17.66%	-11.42%**	-16.90%	4.96%	11.00%**	7.20%**	2.30%	8.36%**	4.38%**
Overall	1.47%	-0.80%**	2.39%**	-3.49%	-6.24%**	-2.75%**	-3.40%	-6.32%**	-2.54%*

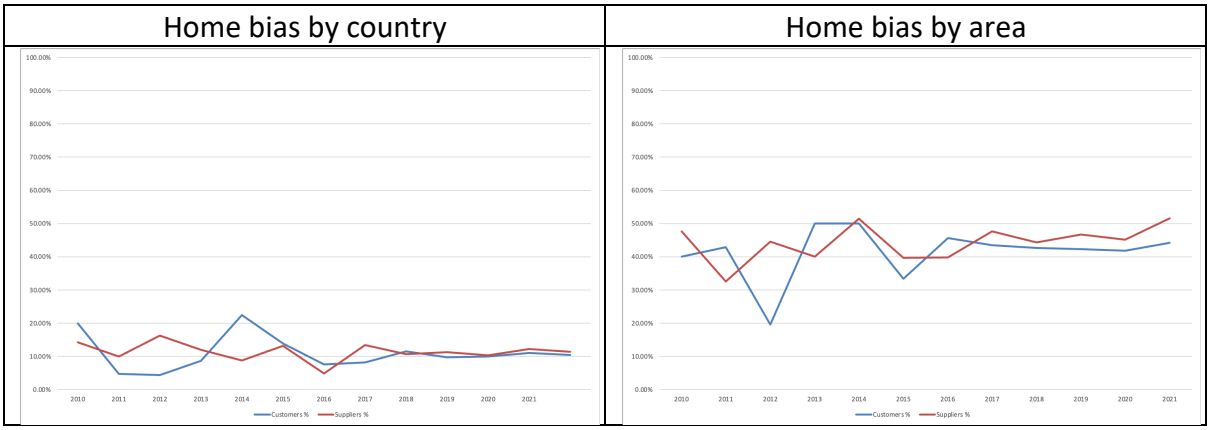
*Notes: *Difference with respect to the overall average with a t-test statistically significant at 95%.*

***Difference with respect to the overall average with a t-test statistically significant at 99%*

Source: Eikon Refinitiv data processed by the authors

The average abnormal return for companies experiencing supply chain changes is normally lower than the average of the market because the market reacts negatively to the higher uncertainty related to develop new long term customer-supplier relationship and the difference is more economically significant for the Fama & French and Carhart model models.
In order to analyze more in detail the impact of the supply chain changes on the performance, we construct proxies related to the geographical concentration of owners and suppliers and measures about the risk of the new members added to the supply chain.
The analysis of the country of domicile of suppliers and customers in the supply chain allows to identify some interesting results in the years of the pandemic (Graph 4).

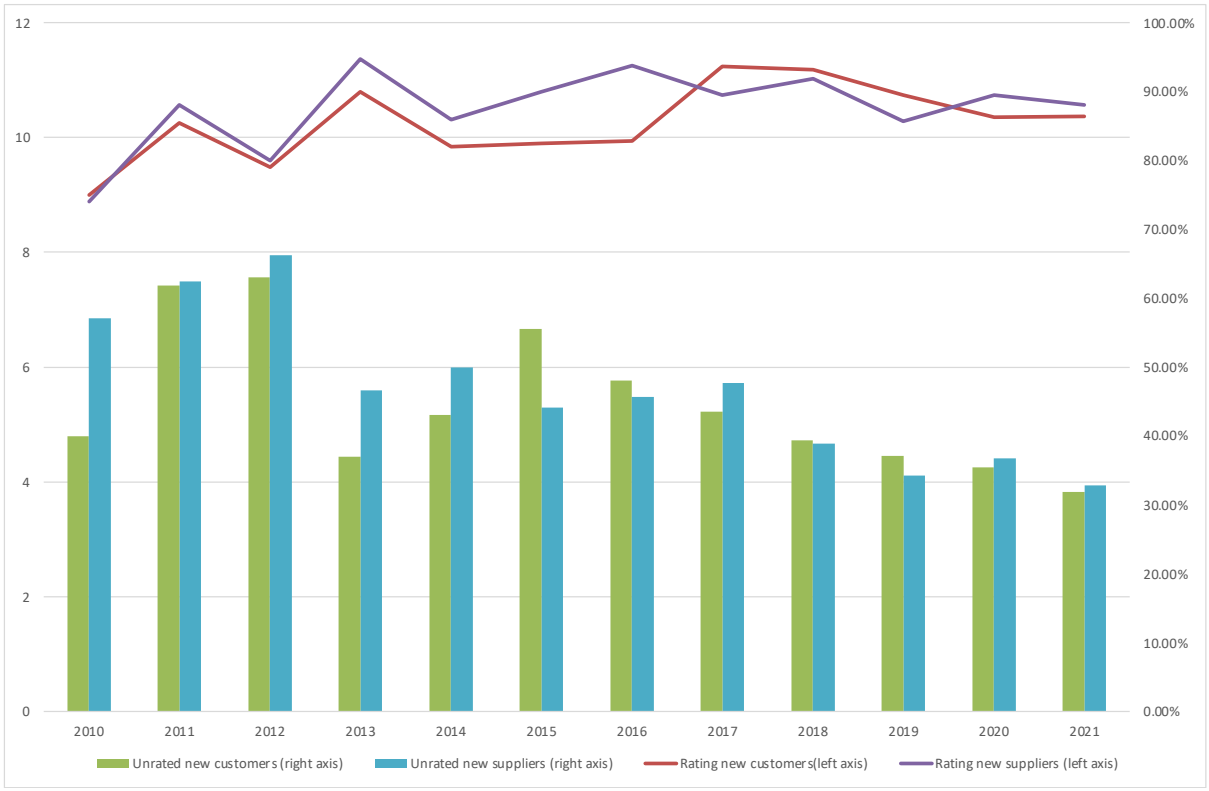
Graph 4. Home bias for suppliers and customers on basis of Country of domicile



Source: Eikon Refinitiv data processed by the authors

The role of suppliers or customers has not changed significantly during the health crisis and the role of home biased customers and suppliers in 2021 are respectively 11% and 12, just above the average of the twelve years time horizon. The role of suppliers and customer from the same geographical area is increased significantly reaching the 44% of the new customers and the 52% of the new suppliers.
The risk profile of companies involved in the supply chain is changing in the period analyzed (Graph 4) and the current average risk of the main suppliers and the customers is currently different with respect to the beginning of the time period (Graph 5).

Graph 5. Rating and risk of new customers and suppliers



Source: Eikon Refinitiv data processed by the authors

Customers and Suppliers that are working with the companies since the 2010 are safe and their average scores are respectively 9 and 8.9 equivalented to a BBB+ rating. In 2021, even if the current market scenario is significantly worse than the pre-covid period, the average scores are 10.4 for customers and 10,6 suppliers equivalent to a rating of BBB. The percentage of small and private companies among the main customers and suppliers is significantly decrease moving from 40% of new customers and 57.1% of new suppliers to respectively 31.8% and 32.87%.

The analysis of the role of the supply chain features in explaining the abnormal performance of the companies allows to identify some interesting difference of the pre-pandemic and the the covid-19 period (Table 2, 3, and 4).

Table 2. Abnormal performance and supply chain features – CAPM model

Customers	***2010***	***2011***	***2012***	***2013***	***2014***	***2015***	***2016***	***2017***	***2018***	***2019***	***2020***	***2021***
$D(C)_{it}^{New}$	-0.17	-0.11	0.50*	0.09	-0.08	0.09	-0.15	0.18*	-0.11	-0.18	-0.03	0.34*
$HB(C)_{it}^{C}$	0.17	0.27	-0.06	-0.22	0.03	0.1	-0.2	0.28*	-0.03	0.05	0.16	-0.05*
$Rating(C)_{it}^{New}$	0.02	0.02	0.04*	-0.01	-0.01	-0.01	0.01	-0.02*	0.01	0.01	-0.01	-0.04*
$P(C)_{it}^{New}$	0.06	0.20	0.39*	-0.06	0.01	-0.15	0.16	0.03	0.19	0.23*	0.02	-0.32*
α	0.03	-0.16*	0.01	0.02	0.02	0.03	0.07*	0.03	-0.03	0.06*	0.17*	-0.02
Obs.	239	239	239	239	239	239	239	239	239	239	239	239
Adj R2	0.81%	2.63%	5.22%	1.22%	2.00%	0.36%	2.78%	7.96%	1.53%	2.93%	1.05%	7.72%
Suppliers	***2010***	***2011***	***2012***	***2013***	***2014***	***2015***	***2016***	***2017***	***2018***	***2019***	***2020***	***2021***
$D(S)_{it}^{New}$	-0.47*	-0.01	0.22	0.20	0.10	0.10	-0.12*	0.16	-0.04	-0.18*	-0.10	0.02
$HB(S)_{it}^{C}$	-0.1	0.18	0.12	-0.01	0.35*	-0.13	0.09	-0.06	0.01	0.06	0.11	-0.07*
$Rating(S)_{it}^{New}$	0.03	0.01	-0.03	-0.03	-0.02	-0.02	0.01	-0.01	0.01	0.01	-0.01	-0.02
$P(S)_{it}^{New}$	0.26	0.07	-0.26	-0.15	-0.09	-0.08	0.05	-0.15	0.05	0.04	0.07	-0.06
α	0.05*	-0.16*	-0.01	0.03	-0.01	0.03	0.08*	0.05*	-0.01	0.11*	0.18*	0.02
Obs.	239	239	239	239	239	239	239	239	239	239	239	239
Adj R2	6.68%	1.83%	1.93%	2.38%	3.12%	0.84%	1.59%	1.86%	0.23%	6.63%	1.78%	4.06%
Customers and Suppliers	***2010***	***2011***	***2012***	***2013***	***2014***	***2015***	***2016***	***2017***	***2018***	***2019***	***2020***	***2021***
$D(C\&S)_{it}^{New}$	-0.32*	-0.06	-0.14	-0.07	0.05	0.1	-0.08	0.16*	-0.08	-0.19*	-0.09	0.21*
$HB(C\&S)_{it}^{C}$	-0.05	0.26	-0.01	-0.1	0.05	-0.07	-0.28	-0.06	0.12	0.08	0.14	-0.08*
$Rating(C\&S)_{it}^{New}$	0.04	0.03	0.01	-0.01	-0.02	-0.02	-0.01	-0.02*	0.01	0.01	-0.01	-0.03*
$P(C\&S)_{it}^{New}$	0.1	0.12	0.08	0.08	-0.05	-0.1	0.03	-0.08	0.08	0.09	0.04	-0.15
α	0.05*	-0.17*	0.02	0.04	0.01	0.03	0.08*	0.02	-0.01	0.12*	0.19*	-0.02
Obs.	239	240	239	239	239	239	239	239	239	239	239	239
Adj R2	6.25%	3.16%	1.33%	1.48%	1.25%	0.84%	4.17%	3.69%	1.45%	6.02%	2.14%	7.50%

Source: Eikon Refinitiv data processed by the authors

Table 3. Abnormal performance and supply chain features – Fama & French model

Customers	***2010***	***2011***	***2012***	***2013***	***2014***	***2015***	***2016***	***2017***	***2018***	***2019***	***2020***	***2021***
$D(C)_{it}^{New}$	-0.18	-0.08	0.53*	0.06	-0.11	0.06	-0.16	0.19*	-0.05	-0.16	-0.05	0.35*
$HB(C)_{it}^{C}$	0.23	0.27	-0.12	-0.23	0.02	0.13	-0.19	0.27	-0.05	0.09	0.13	-0.08
$Rating(C)_{it}^{New}$	0.03	0.02	0.04*	-0.01	-0.01	-0.01	0.01	-0.02*	0.01	0.01	-0.01	-0.04*
$P(C)_{it}^{New}$	0.03	0.15	0.43*	-0.05	0.03	-0.12	0.16	0.03	0.15	0.22	0.04	-0.3*
α	-0.09*	0.09*	-0.13*	-0.14*	-0.04	-0.07*	-0.01	-0.13*	0.16*	-0.17*	0.27*	-0.19*
Obs.	239	239	239	239	239	239	239	239	239	239	239	239
Adj R2	1.00%	2.33%	5.41%	1.36%	2.09%	0.40%	2.48%	7.83%	1.61%	2.38%	0.80%	7.57%
Suppliers	***2010***	***2011***	***2012***	***2013***	***2014***	***2015***	***2016***	***2017***	***2018***	***2019***	***2020***	***2021***
$D(S)_{it}^{New}$	-0.44	-0.11	0.24	0.26	0.09	0.08	-0.13	0.15	-0.07	-0.18	-0.08	0.04
$HB(S)_{it}^{C}$	-0.13	0.17	0.1	-0.06	0.34	-0.14	0.09	-0.07	0.02	0.05	0.08	-0.12
$Rating(S)_{it}^{New}$	0.03	0.02	-0.03	-0.03	-0.02	-0.01	0.01	-0.02	0.01	0.01	-0.01	-0.02
$P(S)_{it}^{New}$	0.22	0.16	-0.26	-0.23	-0.09	-0.07	0.05	-0.14	0.04	0.07	0.07	-0.07
α	-0.06*	0.09*	-0.14*	-0.14*	-0.05*	-0.06*	0.01	-0.1*	0.19*	-0.13*	0.28*	-0.16*
Obs.	239	239	239	239	239	239	239	239	239	239	239	239
Adj R2	6.16%	1.43%	1.42%	2.09%	2.82%	0.91%	1.65%	2.09%	0.43%	4.46%	1.97%	4.50%
Customers and Suppliers	***2010***	***2011***	***2012***	***2013***	***2014***	***2015***	***2016***	***2017***	***2018***	***2019***	***2020***	***2021***
$D(C\&S)_{it}^{New}$	-0.31*	-0.09	-0.14	-0.05	0.04	0.07	-0.1	0.15*	-0.08	-0.18*	-0.1	0.22*
$HB(C\&S)_{it}^{C}$	-0.06	0.23	-0.04	-0.12	0.05	-0.05	-0.26	-0.08	0.11	0.1	0.14	-0.16
$Rating(C\&S)_{it}^{New}$	0.04	0.03	0.01	0.01	-0.02	-0.02	0.01	-0.02	0.01	0.01	-0.01	-0.03*
$P(C\&S)_{it}^{New}$	0.08	0.13	0.09	0.03	-0.05	-0.08	0.04	-0.07	0.06	0.09	0.06	-0.14
α	-0.06*	0.08*	-0.13*	-0.12*	-0.05*	-0.06	0.02	-0.13*	0.18*	-0.12*	0.3*	-0.19*
Obs.	239	240	239	239	239	239	239	239	239	239	239	239
Adj R2	5.84%	2.49%	1.01%	1.31%	1.10%	0.70%	4.00%	3.15%	1.28%	4.64%	2.27%	8.12%

Source: Eikon Refinitiv data processed by the authors

Table 4. Abnormal performance and supply chain features – Carhart model

Customers	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**
$D(C)_{it}^{New}$	-0.18	-0.09	0.54*	0.06	-0.12	0.08	-0.15	0.19*	-0.05	-0.16	-0.06	0.35*
$HB(C)_{it}^{C}$	0.24	0.27	-0.13	-0.23	0.02	0.12	-0.19*	0.27	-0.05	0.09	0.13	-0.08*
$Rating(C)_{it}^{New}$	0.03	0.02	0.04*	-0.01	0.01	-0.01	0.01	-0.02*	0.01	0.01	-0.01	-0.04*
$P(C)_{it}^{New}$	0.02	0.15	0.44*	-0.05	0.04	-0.13	0.16	0.03	0.15	0.22	0.04	-0.3*
α	-0.11*	0.06*	-0.16*	-0.11*	-0.06*	-0.03	0.02	-0.13*	0.18*	-0.19*	0.29*	-0.21*
Obs.	239	239	239	239	239	239	239	239	239	239	239	239
Adj R2	1.04%	2.39%	5.43%	1.32%	2.16%	0.37%	2.56%	7.85%	1.61%	2.31%	0.78%	7.53%
Suppliers	***2010***	***2011***	***2012***	***2013***	***2014***	***2015***	***2016***	***2017***	***2018***	***2019***	***2020***	***2021***
$D(S)_{it}^{New}$	-0.43	-0.1	0.24	0.25	0.08	0.07	-0.12	0.15	-0.08	-0.19	-0.07	0.04
$HB(S)_{it}^{C}$	-0.13	0.17	0.1	-0.05	0.34	-0.13	0.09	-0.07	0.02	0.05	0.08	-0.12
$Rating(S)_{it}^{New}$	0.03	0.02	-0.03	-0.03	-0.01	-0.01	0.01	-0.02	0.01	0.01	-0.01	-0.02
$P(S)_{it}^{New}$	0.22	0.15	-0.27	-0.22	-0.09	-0.06	0.05	-0.14	0.04	0.08	0.07	-0.07
α	-0.09*	0.06*	-0.17*	-0.1*	-0.07*	-0.02	0.03	-0.1*	0.21*	-0.16*	0.31*	-0.18*
Obs.	239	239	239	239	239	239	239	239	239	239	239	239
Adj R2	6.04%	1.49%	1.34%	2.09%	2.70%	0.83%	1.62%	2.10%	0.50%	4.18%	2.01%	4.52%
Customers and Suppliers	***2010***	***2011***	***2012***	***2013***	***2014***	***2015***	***2016***	***2017***	***2018***	***2019***	***2020***	***2021***
$D(C\&S)_{it}^{New}$	-0.31*	-0.09	-0.14	-0.06	0.04	0.07	-0.09	0.15*	-0.08	-0.17*	-0.10	0.22*
$HB(C\&S)_{it}^{C}$	-0.06	0.23	-0.04	-0.12	0.05	-0.06	-0.26*	-0.08	0.11	0.10	0.14	-0.16*
$Rating(C\&S)_{it}^{New}$	0.04	0.03	0.01	0.01	-0.02	-0.02	0.01	-0.02	0.01	0.01	-0.01	-0.03*
$P(C\&S)_{it}^{New}$	0.07	0.12	0.09	0.04	-0.05	-0.08	0.04	-0.07	0.06	0.09	0.07	-0.13
α	-0.09*	0.05*	-0.16*	-0.09*	-0.07*	-0.02	0.04	-0.13*	0.2*	-0.15*	0.32*	-0.20*
Obs.	239	240	239	239	239	239	239	239	239	239	239	239
Adj R2	5.75%	2.59%	0.91%	1.27%	1.06%	0.70%	4.03%	3.18%	1.27%	4.43%	2.30%	8.14%

Source: Eikon Refinitiv data processed by the authors

The CAPM model allows to identify active performance measures that are easier to be explained through the supply chain features because the other two models already assigned a different weight to the performance of the large companies that are normally those for which the construction for the supply chain matters the most.
Among the supply chain features, the change of strategic customer when significant has a positive impact on the performance of the company because it will represent a new source of income in the medium long term. On the opposite a suppliers' change implies an higher risk and (frequently) an higher cost for the company that may have a negative effect on the stock performance.
The strategy of selecting main customers and main suppliers from the home country reduces significantly the risk of supply chain disruptions but reduces the competition among member of supply chain with an expected negative effect on bargaining power of the company. The net effect on the performance when statistically significant is, as expected, negative.
The choice to select safer customers or suppliers has a negative effect on the performance of the stock because the risk of the business and the profitability margin of the company will decrease and so the return requested by the investors will be lower. The negative impact is even stronger when the company increases the number of suppliers or customers that have a rating increases in the supply chain network.
Independently with respect to the approach selected (CAPM, Fama & French, or Carhart) the role of the supply chain features in explain the abnormal performance is maximized in the 2021 showing an higher interest of the financial markets on the supply chain issues and their possible impact on the company performance.

4. Conclusion

Supply chain is a key factor for the success of the company in the medium long term and Covid-19 has shown its relevance for the survival of companies exposed in foreign markets for the procurement and the selling strategy. Empirical evidence has shown that in the last two years markets are evaluating differently companies that are creating a better a more resilient supply chain with respect to the others and there could also a pricing implication for the shares traded in the stock market. The abnormal performance analysis has shown that the choice of modifying the network in which the company is operating may be relevant especially in the year when there is the turnover of customers and/or suppliers and if the company is changing the risk profile of the parties involved in the supply chain.
Evidence provided focused only on the first two years of the pandemic and may related to irrational behavior that is currently affecting all the main stock markets (Vasileiou, 2021). An analysis on a longer time analysis may clarify if the higher relevance highlighted of the supply chain issues for investment purpose is only a consequence of the high relevance of such type of news in the newspapers and media since the first lockdown measures. An analysis sectors (i.a. energy) or markets (i.a. developing economies) that are characterized by structural dependence from international exports and imports may also be useful for testing if the role of supply chain features increases with the complexity and degree of globalization of the companies' business model (Guan et al., 2020).

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