The impact of risk conditions and postponement on upstream supply chain vulnerability

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Several contributions have tried to evaluate supply risk sources but none of them empirically investigates the effectiveness of supply chain risk management in reducing the perceived upstream vulnerability. We aim to increase the understanding of which factors influence the firm perception of supply risk by exploring the relationships among risk conditions, postponement and perceived upstream risks. To achieve our objective we conducted a survey analysis on 54 Italian manufacturing companies. Results show that risk conditions influence the perceived upstream vulnerability. Furthermore, we provide evidence of the effectiveness of postponement in mitigating the effect of technological turbulence on companies perception of supply risks.

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Keywords: supply chain vulnerability, upstream risk mitigation, postponement

Introduction

In the last decades companies have seen an increase in the dependence from external parties (i.e., suppliers) in managing their operations. Attention has thus been paid on how to properly manage the supply network in order to be efficient and effective. One major issue for companies that rely on suppliers is supply risk, i.e. the potential vulnerability due to the behaviour of external suppliers.

Several contributions have tried to effectively identify and evaluate upstream vulnerability drivers (e.g., Peck, 2005; Sodhi, and Chopra, 2004; Svennson, 2000; Wagner and Bode, 2006) but just few of these studies focused on how managerial perceptions of supply risk are formed (e.g., Ellis et al., 2010; Zsidisin, 2003). Furthermore, contributions provided by literature focused on identification and assessment of risk sources but none of them empirically investigates the current corporate response and the effectiveness of supply chain risk management practices in reducing the perceived vulnerability. This is partially due to the difficulty companies have in understanding which practices relate to supply chain resiliency.

According to Zsidisin (2003) supply risk can be defined as "the potential occurrence of an incident associated with inbound supply from supplier failure or the supply market, in which its outcomes result in the inability of the purchasing firm to meet customer demand or cause threats to customer life and safety". More in general, companies are exposed to numerous operational upstream risks associated with their supply network. Among the most studied we can find risks associated to the uncertainty that characterises suppliers reliability (Wagner and Bode, 2006), the availability of purchases (Kraljic, 1983), the fluctuations in exchange rates and raw material prices (Speckman and Davis, 2004; Kleindorfer and Saad, 2005), and intellectual property risks related to the difficulty of protecting the intellectual property that goods represent during outsourcing (Sodhi and Chopra, 2004).

Trying to address the risk assessment issue many authors (Ellis et al., 2010; March and Shapira, 1987; Mitchel, 1999) point out the importance of the subjective judgement of risk as the significant determinant of managerial and customer choice. Understanding perceptions of risk is essential because appraisals of risk are subjective and actions regarding risks are based on perceptions (Yates and Stone, 1992). From the perspective of purchasing and supply management, there are numerous factors that influence the perception of supply risks. Previous contributions (e.g., Ellis et al., 2010; Giunipero and Eltantawy, 2010; Harland et al., 2003; Hopkins, 2005; Kraljic, 1983; Lee, 2004; Peck, 2005; Trkman and Mc Cormack, 2009; Zsidisin, 2003; Zsidisin and Ellram, 2003) have provided evidence that influencing factors can be associated to two main sources: risk conditions and supply chain risk management (SCRM). In this work attention is going to be paid on one specific SCRM practice i.e. postponement. In particular this paper aims to respond to the need of simultaneously examine both the environmental factors in which companies operate and that influence risk perception and postponement as a driver to manage supply risk.

Literature review

Risk Conditions

On the basis of previous contributions (Ellis et al., 2010; Kraljic, 1983; Wagner and Bode, 2006; Zsidisin, 2003), we can define risk conditions as risk sources or the antecedents influencing the exposition of companies to the supply risk. Among the most studied risk conditions we can find the criticality of purchases (related to the degree of customization and complexity of purchased components and to the relative impact of purchases on the performance of the final product), the difficulty of the supply markets (i.e., supply markets concentration and capacity constraints) and the technological turbulence (i.e., product and process technology innovation, degree of product obsolescence, frequency of new product introduction). Several publications (e.g., Ellis et al., 2010; Peck, 2005; Trkman and Mc

Cormack, 2009; Zsidisin, 2003; Zsidisin and Ellram, 2003) mention that the more critical the reported risk conditions, the higher the perceived relevance of supply risks.
First, considering the case in which purchases are characterized by a high degree of customization and complexity, and have significant influence on the performance of the firm's final product (e.g., quality, reliability). In those circumstances companies strongly depend on suppliers because the transaction-specific investment have increased switching costs. As a result a vendor failure to delivery will have significant consequences on the firm's ability to stay on the market (Giunipero and Eltantawy, 2010; Kraljic, 1983).
Then, many authors have dealt with the study of the peculiarities of supply markets on the robustness of companies (e.g., Kraljic, 1983; Trkman and McCormack, 2009; Wagner et al., 2009; Zsidisin, 2003). In case of high supply market concentration and capacity constraint, firms will experience significant problems in substituting the supply with a contingency source. Thus, when the difficulty of the supply market is critical the supply risk is perceived as relevant because firm's room for manoeuvre is reduced (Ellis et al., 2010).
Finally, literature has considered technological turbulence as a important element to define risk perception. This risk condition is significantly influenced by the endogenous uncertainty coming from changes in underlying technologies of a purchased product. In presence of a higher technological turbulence, the likelihood related to the inability of suppliers to adapt to technological or product design changes may be higher. Also, this may have detrimental effects on the costs and competitiveness of customer (Zsidisin and Ellram, 2003).

Postponement

To cope with supply risks and mitigate the effect of the discussed risk conditions, firms have to adopt supply chain risk management and consequently generate alignment, adaptability and agility (Lee, 2004). In order to do that, firms can implement both practices that allow an effective identification and management of the risk sources, and practices able to improve reaction capabilities (i.e., agility and flexibility) that are helpful in reducing impacts of risk.
Harland et al. (2003) discusses and summarises various sources of supply network stability within the following supply risk management cycle:

1. choosing the appropriate type of relationship with suppliers by adopting the strategic sourcing practice;
2. developing and using vendor rating programs;
3. designing supply contracts;
4. designing and using a system of information-sharing and integration practices;
5. using tools to monitoring suppliers and control any possible opportunistic tendencies.

By leveraging on the five practices reported above, companies are able to effectively manage the sources of supply risk (e.g., Cohen and Agrawal, 1999; Kraljic, 1983; Tang, 2006; Torres and Mahmoodi, 2005; Wagner et al., 2009).
Furthermore, literature paid attention on two reactive strategy: Buffer-based Strategies and Postponement. By developing this two SCRM practices companies are able to properly react when supply risk occurs reducing its negative potential effect. Buffer-based Strategies are so called because they leveraging on buffers or slack resources (Galbraith, 1977) in order to mitigate the negative effect related to supply risk. The use of slack resources (i.e., inventory buffer at bottleneck station, additional production capacity by means of external workforce, precautionary lead time, etc.) is a common approach in managing supply uncertainty, regardless of the level of perceived upstream vulnerability (Kaipia, 2008).
Last but not least, postponement is a proactive strategy allowing firms to enhance their agility in order to properly manage supply chain risks. Specifically, the term postponement refers to the flexible strategy by which firms enhance their ability to manage point of differentiation along their production lines. Lee and Tang (1997) describe how delayed differentiation can be achieved via standardization of components, product modularity and re-sequencing of

modular processes. Many contributions collected by Tang (2006) provide evidence of the effectiveness of these postponement tactics in generating inventory savings and in improving the ability of the firms to cope with the variability of demand: in this sense postponement was defined by Tang (2006) as a robust lever of resiliency through agility. Tang and Tomlin (2008) describe how flexible process and flexible product via postponement can be effective ways to reduce the expected negative effects coming from process and demand risks (i.e., reduced capability of specific production lines, overstocking, unpredictable demand). As manufacturing processes become more flexible (i.e., different production lines are capable of producing all products because of standardized and modularized components and processes), different kinds of products can be manufactured in the same production line. As a result companies can shift production quantities across internal resources reducing process risks significantly.

Supply chain agility via postponement also enables firms to reduce the impact of demand risks. For example, to reduce the overstock and under-stock costs of different version of DeskJet Printers, HP redesigned its product by delaying the point of differentiation. HP first manufactures according to a make-to-stock system and then ships generic printers to the distribution centres where are customized in a make-to-order manner. This postponement strategy allow HP to became more efficient and simultaneously to quickly respond to the demand changes (see Lee and Tang (1997) for details on the HP case)

Literature mainly addresses postponement to cope with process and demand risks, however postponement can also be adopted in order to manage supply risks. Hopkins (2005) describes that the adoption of the tactics underlying the postponement approach (i.e., standardizations of components, product/process modularity) allows companies to adopt new configurations of the production process, typically by postponing the operations involving unavailable components, so to manage those situations where purchases are temporally unavailable. For example, after Philip's semiconductor plant was damaged in a fire in 2000, Nokia was facing a serious supply disruption of radio frequency chips. Since Nokia's cell phones are designed according to the modular design concept, Nokia was able to postpone the insertion of the unavailable components until the end of the assembly process. Due to this postponement strategy, Nokia was able to reconfigure the design of their basic phones so that the modified phones could accept slightly different chips from other suppliers. Consequently, Nokia satisfied customer demand smoothly and obtained a stronger market position (Hopkins, 2005)

Even if the literature on postponement is rather diffused some limitations can be highlighted.

First of all, most contributions lack empirical evidence of what companies are actually doing in order to increase their ability to react when supply risk occurs.

Second, there is limited evidence regarding the influence of risk conditions on the company's decision concerning the development of postponement: specifically there is no evidence whether postponement are adopted in specific contexts.

In the end, limited contributions are provided regarding the effectiveness of postponement in reducing perceived upstream vulnerability.

Objectives and methodology

This paper aims at contributing to the understanding of the impact of risk conditions and postponement on the perceived upstream vulnerability. Specifically attention is here paid on the relationships among three sets of variables:

1. Risk conditions: contingent drivers increasing vulnerability and its perception;
2. Postponement: the extent to which companies are adopting the underlying practices;
3. Perceived supply risk: in this work attention has been paid on two of the most discussed and studied supply risks (i.e., supplier default, purchase unavailability).

Based on the previous literature review we can argue about the relationships between these variables but no contribution has evaluated them on an empirical basis.
Previous contributions (e.g., Ellis et al., 2010; Peck, 2005; Trkman and Mc Cormack, 2009; Zsidisin, 2003; Zsidisin and Ellram, 2003) provide evidence that the more risk conditions are critical, the higher the perceived relevance of supply risks. Thus we formulate the following research proposition:

RP1. Risk conditions are correlated with a higher perception of supply risks.

In order to manage supply risk, firms operating in risky conditions tend to react by adopting postponement for generating agility (Lee, 2004). As a result, companies investing in postponement become more capable to cope with risk, thus we expect that they will reduce the perception of supply risk (Tang, 2006; Torres and Mahmoodi, 2005). For these reasons we formulate the following research proposition:

RP2. Postponement is correlated with a lower perception of supply risk.

Figure 1 describes the theoretical model underpinning our research propositions. In particular we can highlight that the relationship between risk conditions and the perceived supply risk is made of a direct path and an indirect path through postponement:

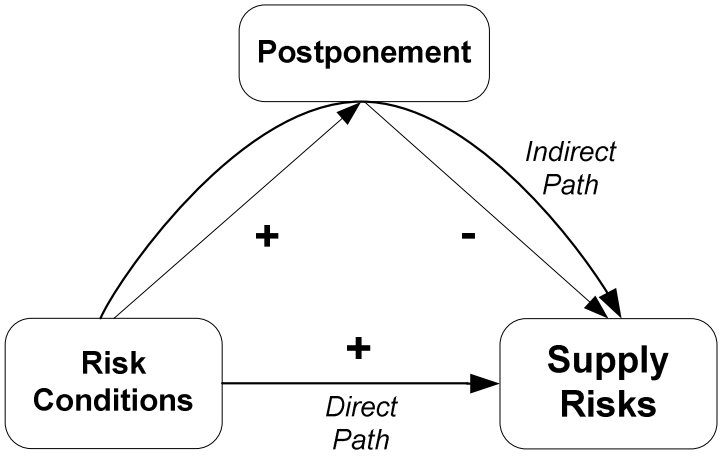

Figure 1. Theoretical model

In order to test our research propositions we adopted a survey approach. In particular, based on an extensive literature review a questionnaire was designed in order to operationalise the mentioned variables. The questionnaire was refined by means of five pilot cases in order to determine the validity of the model and test the discriminant ability of the questionnaire. In appendix the last release of relevant questionnaire metrics is provided.
Once the questionnaire was refined and its thoroughness verified, we managed a survey analysis on a sample of Italian companies. 300 Italian companies were selected according to following criteria:

i. Medium-size company. This is due to the need to limit the complexity of the organizations being evaluated.
ii. Manufacturing companies. We focus on the machinery manufacturing industry.
iii. Upstream supply chain relevance. We selected firms by considering the importance of the supply chain to their operations in order to obtain an heterogeneous sample. This selection were made based on the purchasing costs.

Companies were contacted by phone calls in order to identify a reference person (i.e., purchasing manager, supply chain manager or who are in charge to manage the supply

network) and to describe the research. Participants were provided with an electronic version of the questionnaire and support was given in order to guarantee full understanding of the questionnaire. Data were collected between the firsts of May and the end of August 2010. We run ANOVA on collected data in order to identify influences of time factor on risk conditions, postponement adoptions and supply risk perceptions. Time factor are measured on a 1-4 scale where 1 equals to "data were collected in May", 2 "data were collected in June", 3 "data were collected in July", and 4 "data were collected in August". Analysis shows that influences do not exist (P-values higher than 0.29).
Finally, 54 companies provided useful and complete information for this research (thus with a response rate of 18%). The sample is described in table 1. Companies are mainly small (48.2 of the sample) but also medium and large are represented. Different industrial sectors from the assembly industry are considered, mainly from the manufacturing of machinery and equipment not classified elsewhere. Concerning the incidence of the purchasing cost on revenues, the sample is heterogeneous.

Table 1 Descriptive statistics in terms of (a) size, (b) industrial sector (ATECO 2007), (c) purchasing cost.

(a)

Size*	**N**	**%**
Small	22	40.7
Medium	26	48.2
Large	6	11.1
Total	**54**	**100**

(b)

Ateco**	**N**	**%**
Ateco 22	10	18.5
Ateco 26	3	5.6
Ateco 27	6	11.1
Ateco 28	29	53.7
Ateco 29	5	9.3
Ateco 31	1	1.8
Total	**54**	**100**

(c)

$\frac{\text{Purchases}}{\text{Total Sales}}$	**N**	**%**
>= 70%	9	16.7
60% - 69%	16	29.6
50% - 59%	11	20.4
40% - 49%	8	14.8
<40%	10	18.5
Total	**54**	**100**

Table 1. Sample description

* Size: Small: less than 250 employees, Medium: 251-500 employees, Large: over 501 employees;
** ATECO 2007 Code: 22: manufacture of rubber and plastics; 26: manufacture of computers and electronic products, optical, medical electrical equipment, apparatus for measuring and watches; 27: manufacture of electrical appliances and electrical equipment for non-domestic; 28: Manufacture of machinery and equipment not classified elsewhere; 29: Manufacture of motor vehicles, trailers and semi-trailers; 31: furniture manufacture

In order to measure the model's variables we applied Principal Component Analysis (PCA)to build specific constructs. Reliability of constructs was checked by means of Cronbach's Alpha and by checking the theoretical validity of the constructs (Nunnally, 1994). Variables and Measures of Supply Risks, Risk Conditions and Postponement are discussed below.

Supply Risk

In this work we decided to focus our attention on two supply risks: Supplier Failure risk (SF) and Purchases Unavailability risk (PU). The first one is related to the cases in which a supplier becomes unavailable as a consequence of the vendor financial instability (Wagner and Johnson, 2004) or of the vendor's vertical integration by a direct competitor of the customer firm, forcing the termination of the relationship (Sodhi and Chopra, 2004). The second supply risk is related to the cases in which there's no possibility to supply a specific components because of capacity constraints or shortages in the supply markets. In both cases supply risk can leads to a strong reduction of the firm's efficiency and ability to cope with the needs of the final market (Wagner and Bode, 2006). Hence, Supplier Failure risk and Purchases Unavailability risk can be considered two of the most relevant forms of upstream vulnerability (Thun and Hoenig, 2009).

In order to measure the relevance of this two supply risks, we collected information about the managers perception regarding both the probability the risk has to occur, and its potential negative effects on company's performance. Specifically, probability and impact of supply risks were measured on a 1-5 Likert scale where 1 represents poor and 5 high. As suggested by Mitchell (1995), we evaluated the perceived risk relevance as the product between the occurrence probability and the negative expected impact of risk.

Risk Conditions

In this study we focused on three risk conditions: Criticality of Purchases (CP), Difficulty of Supply Markets (DSM) and Technological Turbulence (TT). Consistent with the literature described in the previous section, we focused on these three contingent factors because they influence both to the perceived probability and the perceived impact of upstream risks.

In order to measure these variables we built latent factors based on items available from the questionnaire. Specifically companies were asked to provide an evaluation based on a 1-5 Likert scale (where 1 represents poor and 5 represents high). Table 2 summarizes the results of PCA and reliability tests (Cronbach's Alpha), and descriptive statistics on risk conditions.

Construct	Items	Average	Std. Dev	Factor Loading
Criticality of Purchases Eigenvalue: 1.76 R^2: 0.59 Alpha: 0.64	Degree of item customization	3.74	1.06	0.74
	Purchases complexity	3.69	1.11	0.75
	Purchases Importance	4.28	0.77	0.8
Difficulty of Supply Markets Eigenvalue:1.63 R^2: 0.81 Alpha: 0.77	Supply markets concentration	3.44	0.83	0.9
	Capacity constraints of supply markets	3.36	0.92	0.9
Technological Turbulence Eigenvalue:1.97 R^2: 0.49 Alpha: 0.66	Product technology innovation	3.25	0.96	0.73
	Process technology innovation	3.00	1.00	0.76
	Degree of product/service obsolescence	2.57	0.92	0.65
	Frequency of new product introduction	3.00	0.87	0.66

Table 2. Risk conditions constructs

Identified factors are consistent with previous works (e.g., Droge et al., 2003; Chen et al., 2004; Ellis et al., 2010).

Postponement

Referring to the agility principle, in this paper we investigate postponement practice that enable companies to become more flexible so as to reduce the negative implications of the occurrence of supply risks (e.g., Hopkins, 2005; Lee, 2004; Tang, 2006). Specifically, adopting a modular based manufacturing process companies improve their capabilities to shift production quantities across internal resources and across different products (e.g., Lee and Tang, 1997; Tang and Tomlin, 2008).

We measured Postponement by means of 8 items all deriving from the flexible manufacturing literature (e.g., Graves and Tomlin, 2003; Lee and Tang, 1997; Swaminathan and Lee, 2003; Tu et al., 2004; Yang et al., 2004). Also in this case, items were measured on a 1-5 Likert scale where 1 equals to "no use" and 5 represents "high level of adoption". Table 3 shows results of principal component factor analysis, reliability test (Cronbach's Alpha) and descriptive statistics on postponement.

Construct	Items	Average	Std. Dev	Factor Loading
Postponement Eigenvalue: 4.55 R^2: 0.57 Alpha: 0.88	Products used modularized design	2.76	1.36	0.62
	Product modules could be assembled by different sequences	2.50	1.20	0.60
	Different modules as Different features	3.04	1.27	0.68
	Production process used modularized design	3.36	1.03	0.65
	Subprocess could be added or removed	3.14	1.13	0.88
	The Production process modules can be adjusted for changing in production needs	2.88	1.19	0.85
	The Production process can be broken down into standard and customization sub-processes	3.04	1.10	0.83
	The Production process modules can be rearranged so that customization sub-process occur last	2.78	1.19	0.85

Table 3. Postponement construct

As in the case of risk conditions, results are coherent with contributions of previous work (Tu et al., 2004).

Analysis and findings

In order to test our model and achieve our objectives we proceeded as follows.

First we applied correlation analysis to assess the relationships among risk conditions, postponement and firm perception of supply risks. Then, only when correlations are significant, we applied path analysis in order to evaluate the mediation impact of postponement. Specifically, path analysis is conducted by means of two subsequent OLS regression models: in the first one postponement is regressed for risk conditions, in the second one perceived supply risk is regressed by both postponement and risk conditions (Holland, 1988).

Correlation Analysis

Table 4 provides pairwise correlation analysis between risk conditions and firm's perception of supply risks.

	Supplier Default			Purchases unavailability		
	R	**P**	**I**	**R**	**P**	**I**
Criticality of Purchases	-	-	-	-	-	-
Difficulty of Supply Markets	+0.36**	-	+0.38***	+0.37**	+0.38***	-
Technological Turbulence	-	-	-	-	+0.25*	-

Table 4. Pairwise correlation between risk conditions and perceived supply risks

Results show that the difficulty of supply markets is the only one risk condition influencing the firm's perception of supply risks. In this sense it could be considered a supply chain vulnerability driver. Quite interestingly companies with different criticality of purchases don't perceive different risks in terms of supply. Similarly technological turbulence seems to be correlated only with the perceived risk of purchase unavailability.

Table 5 provided the pairwise correlation between postponement and firm's perception of supply risks.

	Supplier Default			Purchases Unavailability		
	R	**P**	**I**	**R**	**P**	**I**
Adopt **Postponement**	-0.38***	-	-0.49***	-	-	-0.43***

Table 5. Pairwise correlation between postponement and perceived supply risks

Results show that the adoption of postponement is negatively correlated with the two considered risks. Thus companies that are leveraging on postponement declare a lower perception of risk compared to those that aren't adopting this practice.
Third, we evaluate the relation between postponement adoption and risk conditions (see table 6).

	Criticality of Purchases	Difficulty of Supply Markets	Technological Turbulence
Adopt **Postponement**	-	-	+0.39***

Table 6. Pairwise correlation between postponement and risk conditions

Results show that only technological turbulence is correlated with postponement adoption, thus companies that operate in turbulent contexts tend to adopt postponement more than those operating in stable contexts.

Path Analysis
Based on the previous results, we limited the application of the path analysis only to those cases where preliminary conditions are verified (i.e., significant correlation among the three groups of variables considered). Specifically only Technological Turbulence can be considered. Table 7 provides the final results of the analysis. In particular standardized estimates are shown for each relationship and R^2 is provided. The two considered paths are also shown, thus the indirect path from risk conditions to risk perception through postponement and the direct path between risk conditions and risk perception.

Indirect path					Direct path		
Risk condition	--->	*Postponement*	--->	*Risk Perception*	*Risk Condition*	--->	*Risk Perception*
TT	**+0.30** **R^2= 0.092**	**P**	**-0.43*** **R^2= 0.187**	**SF-R**	**TT**	**+0.26*** **R^2= 0.187**	**SF-R**
TT	**+0.30**** **R^2=0.092**	**P**	**-0.59*** **R^2= 0.297**	**SF-I**	**TT**	**+0.29**** **R^2= 0.297**	**SF-I**
TT	**+0.30**** **R^2=0.092**	**P**	**-0.46*** **R^2=0.190**	**PU-I**	TT	+0.12 R^2=0.190	PU-I

Table 7. Path analysis

Results show that all indirect paths are significant: companies operating in a turbulent environment are pushed to adopt postponement tactics, which decrease their perceived upstream vulnerability.
Furthermore, a significant direct path exists between technological turbulence and managerial perception of the supplier failure risk. This means that the adoption of postponement is able to mitigate the effect of technological turbulence both on perceived relevance and impact of the supplier failure risk.
Finally, results do not prove any significant influence of technological turbulence on the perceived impact of the purchases unavailability risk. Indeed, after controlling for the adoption of postponement, the direct influence of technological turbulence remains not significant.

Discussion and Conclusion

This work provides evidence of the effectiveness of postponement in reducing the perceived supply risk.

Standards for product, price and quality performance may be difficult to establish in presence of technological turbulence, making it hard to identify attractive suppliers and to adopt safeguarding tactics to reduce supply risks (e.g., Stump and Heide, 1996). Furthermore, when context is turbulent, a more intensive interaction between buyer and supplier is needed in order to build a value-added relationship (Lazzarini et al., 2008). Therefore, in presence of contingent turbulence, companies facing a supplier failure may face higher switching costs and greater difficulties to effectively react. Indeed, they have to put in place a lot of effort in identifying a new available and consistent supplier and spend more time in laying the foundations for a competitive relationship. Interestingly, we show that postponement can be an effective weapon in mitigating the influence of technological turbulence on the perceived impact of the supplier default risk. Specifically, the adoption of postponement allows companies to gain time by re-sequencing operations and increase the probability to find consistent suppliers by modifying the final product design (Hopkins, 2005). We also find a significant indirect path among technological turbulence, postponement and purchases unavailability risk. However, in this case the adoption of flexible manufacturing and modular design are not able to mitigate the influence of the contingent turbulence on the perceived impact of risk.

On the contrary we didn't find any significant relationship between the use of postponement and the criticality of purchases. Nevertheless the influence of this risk condition on the perceived upstream vulnerability could be mitigated by the adoption of others SCRM practices on which future studies should focus (e.g., strategic sourcing,).

Finally, we found that companies operating with difficult supply markets tend to perceive higher risks from the supply side but they do not rely on postponement to cope with this risk. This result is intuitive and supported by previous contributions (e.g., Ellis et al., 2010; Zsidisin, 2003). Future works should examine if other practices are adopted e.g., supplier integration, vendor rating, etc.

This paper thus contributes to the literature on supply chain risk management by providing empirical evidence of the impact of risk mitigation practices (i.e., postponement) in reducing supply risks. We argue that this contribution, even if limited to a small sample of companies, can stimulate empirical research on this topic.

In the end we would like also to address some of the limitations of this work. First of all the sample is limited to only 54 companies. Thus future work should refer to wider datasets so to ensure statistical validity of the mentioned relationships. Second, attention here was paid only to postponement while other practices can be adopted in order to keep risks under control. Future works should address also other SCRM practices.

Appendix

1. How would you describe the following characteristic of your purchases portfolio?

Product Characteristics	Poor				high
Degree of personalization of the purchased good	1	2	3	4	5
Complexity of the purchased good (e.g. Number of shares, Number of interfaces with the finished goods, technological level)	1	2	3	4	5
Contribution to the availability, quality of the finished product	1	2	3	4	5
Supply Market characteristics	Poor				high
Concentration of supply markets	1	2	3	4	5
Capacity constraints of supply markets (Suppliers' capacity utilization and suppliers' breakeven stability)	1	2	3	4	5

2. How would you describe the following characteristics of your business context?

Degree of Technological Turbulence	Poor				high
Degree of product technology innovation	1	2	3	4	5
Degree of process technology innovation	1	2	3	4	5
Degree of product/service obsolescence	1	2	3	4	5
Frequency of new product introduction	1	2	3	4	5

3. How much do you agree with the following claims?

Product and Process Modularity	Strongly disagree				Strongly agree
Products used modularized design	1	2	3	4	5
Product modules could be assembled by different sequences	1	2	3	4	5
Different modules as Different features	1	2	3	4	5
Production process used modularized design	1	2	3	4	5
Sub-process could be added or removed to the production process	1	2	3	4	5
The Production process modules can be adjusted for changing in production needs	1	2	3	4	5
The Production process can be broken down into standard and customization sub-processes	1	2	3	4	5
The Production process modules can be rearranged so that customization sub-process occur last	1	2	3	4	5

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