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Evaluación de la resiliencia empresarial: Marco de categorización de disrupciones
Enterprise resilience assessment: a categorisation framework of disruptions

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Resumen: Las empresas están cada vez más expuestas a vulnerabilidades debido a la gran incertidumbre del contexto actual, y por ello necesitan estar preparadas para hacer frente a disrupciones. Si una disrupción impacta en una empresa, ésta tendrá que adaptarse a la nueva situación y recuperarse rápidamente para alcanzar su estado normal de operación. Esta capacidad se define como resiliencia empresarial. Con el fin de evaluar cuán resiliente es una empresa, es necesario analizar qué provoca la falta de resiliencia: las disrupciones. Este trabajo propone un marco de categorización de disrupciones, como punto de partida para evaluar la resiliencia empresarial.

Palabras Claves: Resiliencia Empresarial, Disrupción, Fuente, Consecuencias, Marco de Categorización

Abstract: Currently, enterprises are more exposed to vulnerabilities and threats due to the recent and uncertain context and this makes enterprises need the capacity to be ready and prepared to face up to more and more expected and unexpected events. If a disruption impacts on an enterprise, the company will have to adapt to this new situation and try to recover as soon as possible to its normal state of operation. This ability has been defined as Enterprise Resilience. The topic of enterprise resilience is an under-researched concept since there are few studies in the literature, which focus on evaluating and assessing this business capacity. Moreover, enterprise resilience is a new innovative research area that evolves from the traditional risk management to a more operational vision of how to manage disruptions.

In order to assess how resilient an enterprise is, it is necessary to understand, assess and analyse the factors that affect enterprise resilience. Therefore, the first step is to focus on the trigger that causes this lack of enterprise resilience: the disruptions. This will lead to: (i) support enterprises to be aware of the potential disruptions in which the company has less adaptative ability and (ii) take appropriate decisions to avoid the occurrence of disruptions and/or to mitigate the impact of them once that already happened.

To do so, disruptions should be categorized to provide an organized structure that will be the input for further research. This paper proposes a categorisation framework of disruptions which is the starting point to evaluate the resilience capacity of enterprises.

Key words: Enterprise Resilience, Disruption, Source, Consequences, Categorization Framework.

1. Introduction

In this turbulent and changing environment, enterprises are exposed to a high number of disruptions that alter its normal and daily operations. In order to face up to this unstable context, enterprises and Supply Chains (SCs) should be resilient. Enterprise resilience is the capacity to decrease the level of vulnerability to expected and unexpected disruptions, its ability to change itself and adapt to its changing environment, and its ability to recover in the least possible time (Erol et al., 2010). However, (i) how do enterprises manage their level of vulnerability to disruptions? (ii) Do enterprises have methods / tools to prevent such disruptions? (iii) If a disruption shocks an enterprise, will it be able to recover? (iv) And will it learn from past disruptions already happened?

Few studies that guide enterprises to measure and analyse their enterprise resilience capacity have been found in the literature review performed. The current status of the world economy is one of the main drivers to focus on enterprise resilience research. During the last 5-6 years, the number of studies addressed to improve enterprise resilience (and related areas) to mitigate the consequences of disruptions has increased as it can be seen in Figure 1. However, it is still a subject under-researched and enterprises are more and more aware of the importance to be ready for continuous turbulences to which they are permanently exposed.

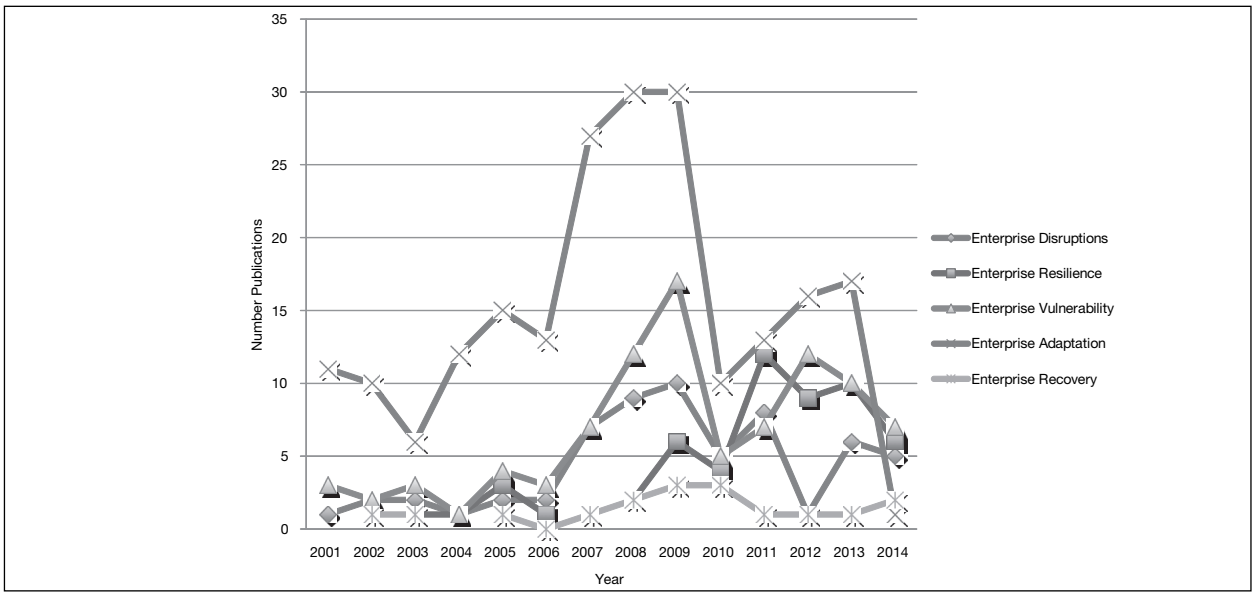

Figure 1
Number of publications by keywords related to Enterprise Resilience in the area of Engineering (ISI Web of Knowledge℠, 2014).

Therefore, the global objective of the research (as described in Figure 2) is to propose a tool that supports enterprises to firstly, measure and analyse their enterprise resilience capacity and secondly, provide them with valuable information about which actions are the most appropriate to take preventive measures against disruptions, minimize their effects in case of occurrence, to recover in the least possible time and cost, and be constantly adapted to potential expected and unexpected events.

Disruptions are the triggers that cause enterprises weakness. In order to assess how resilient an enterprise or its SC is, it should be studied in detail what generates the lack of enterprise resilience: the disruptions.

The objective of this paper is to provide the categorisation framework of disruptions (research element of Disruptions of Figure 2) to catalogue the most common events to which enterprises have to face up to subsequently estimate their probability of occurrence and severity. The categorization framework and the estimation of the frequency and impact of disruptions are the inputs to the research elements of Prevention, Recovery and Adaptation. The results of the global framework will be the assessment of the resilience capacity of enterprises and a summary of the most suitable preventive, recovery and adaptative actions that enterprises should perform in order to be enough resilient to survive in this turbulent context.

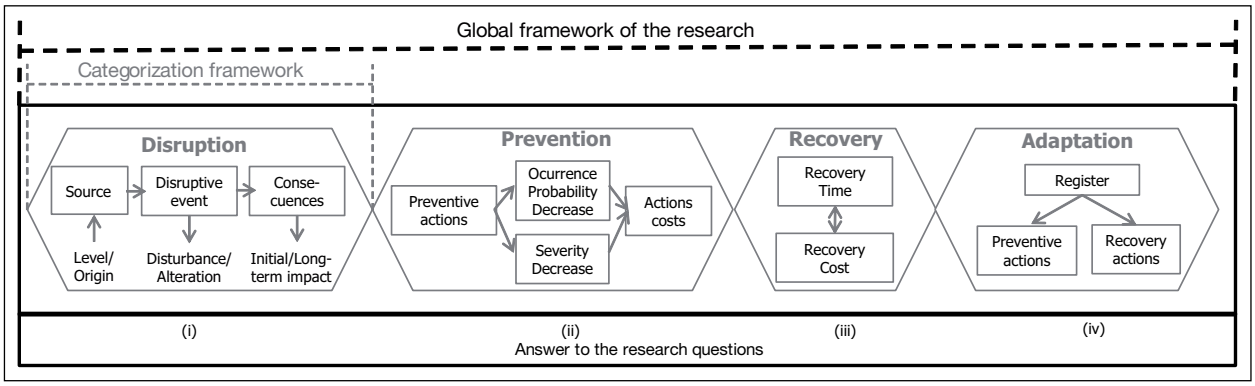

Figure 2
Global framework of the research

The paper is organized as follows: Section 2 reviews the literature about disruptions and describes its main elements. Section 3 describes the research methodology used to define the categorisation framework of disruptions. Section 4 proposes the categorisation framework of disruptions as the starting point to evaluate the resilience capacity of enterprises. Finally, section 5 highlights the main conclusions and further research.

2. Disruptions

In the literature, there is no consensus on the term 'disruption'. Some authors use 'perturbance' (Svensson, 2000 and Kleindorfer and Saad, 2005), others prefer to use 'risk' (Chopra and Sodhi, 2004), 'uncertainty' (Mason-Jones and Towill, 1998), 'disturbance' (Barroso et al., 2008) and 'crisis' (Natarajarathinam et al., 2009) to denote the term disruption.

Svensson (2000) and Kleindorfer and Saad (2005) define perturbance, what is considered in this work as disruption, as an unexpected event that interrupts the normal flow of products and materials in a SC. Barroso et al. (2008) define disturbance as a foreseeable or unforeseeable event, which affects directly the usual operation and stability of an enterprise or its SC.

In this work, a disruption is considered to be composed by 3 elements (Figure 3):

- Source: the trigger that causes and originates the disruption.
- Disruptive event: incident that causes an expected or unexpected disturbance that have negative effects on the enterprise and its SC.
- Consequence: Alteration of the normal enterprise operation.

2.1. Disruptions' sources

Mason-Jones and Towill (1998) classify uncertainty sources into 4 categories: (i) process uncertainty (affecting the internal processes of an enterprise to fulfil the planned objectives); (ii) supply uncertainty (the supplier cannot provide the required products with the requirements specified by the focal company); (iii) demand uncertainty (it is related to customers' requirements, demand volatility, products' customization, etc.); and (iv) control uncertainty (it is related to the flows of information, materials and/or finance and how an enterprise manage these flows to provide products).

Christopher and Peck (2004) consider the same categories than Mason-Jones and Towill (1998), however they subdivide these categories into three classes: i) within an enterprise, ii) outside an enterprise but internal to the SC or iii) external to the SC.

Cranfield (2002) explain that disruptions could arise from a number of sources, such as: natural disasters, terrorist incidents, industrial or direct action and operational difficulties. They also consider that these sources could be also classified into two types: those disruptions arising within the SC and those ones external to it (Cucchiella and Gastaldi, 2006).

Kleindorfer and Saad (2005) differentiate uncertainty sources between internal or external to the enterprise. Moreover, they consider three sources of disruption: operational contingencies; natural hazards and terrorism; and political instability.

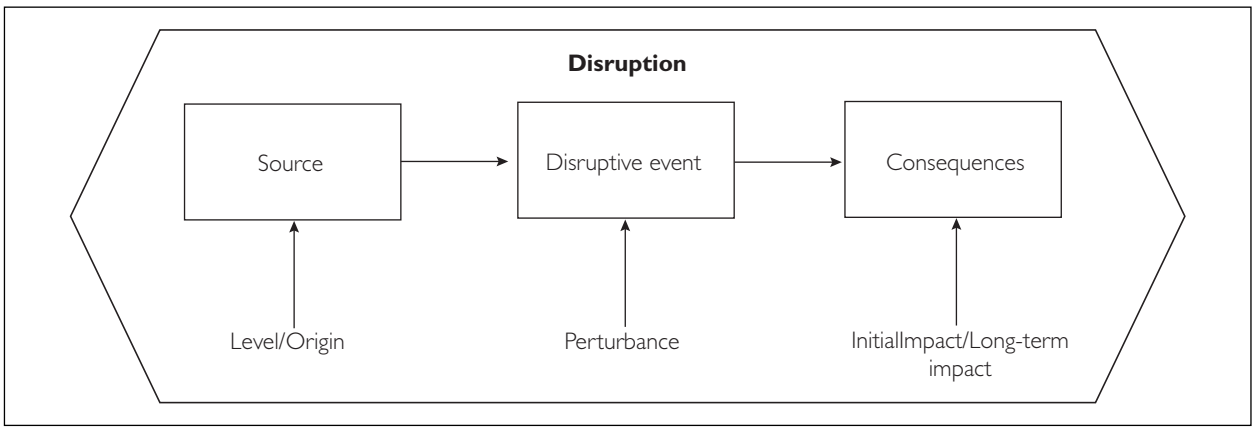

Figure 3
Summary of the disruptions' elements

Wager and Bode (2006 and 2009) group the SC risk sources in demand; supply; catastrophic; regulatory; legal and bureaucratic; and infrastructure risk.

Hu et al. (2008) state that the disruptive events could range from natural events, to accidents, transportation disruptions, or to man-made events. Barroso et al., (2008) explain that an enterprise could be affected by disturbances derived from internal or external sources. And they classify human, equipment, energetic and financial aspects as internal disturbance sources and supply, man made, nature and customers as external disturbance sources.

Wagner and Neshat (2010) categorize SC vulnerability drivers into three groups: supply side, demand side, and SC structure vulnerabilities.

After this literature review about disruptions' sources, it has been confirmed that there is a high degree of confusion with regards to the use of different terminology to classify the disruptions sources: uncertainties, risks, disturbances, perturbances, vulnerability drivers, etc. Moreover, the literature does not differentiate between the "what" causes the disruptive event and 'the level' in which the disruptions have its origin.

2.2. Disruptive event

Based on the definition of disruptive event of this study, a literature review has been performed. As in the previous case, few references have been found that enumerate the most common, regular and usual disruptive events that have occurred in the last years in enterprises and SCs. Most of the resources found in the bibliography are related to risk management and do not consider the enterprise resilience management perspective.

In the empirical study performed by Wagner and Bode (2006 and 2009), besides identifying the disruption sources, they also list some habitual disruptive events. However, as aforementioned, it is has been a complex task to find the most universal and regular disruptive events. Different institutions related to risk management publish yearly reports that show a list of the most important and top risks that enterprises and their SC have to face up to. Nevertheless, risk is a general term that is sometimes referred to disruptions' sources, disruptive events and disruptions' consequences interchangeably. The typical definition of risk commonly accepted in the literature is 'variation in the distribution of possible outcomes, their likelihoods, and their subjective values' (March and Shapira, 1987). For example, Aon Risk Solutions's (2011) yearly report classifies damage to reputation/brand of an enterprise as a risk. However, based on the framework defined in Figure 3, damage to reputation/brand of an enterprise is a consequence of a disruptive event (e.g. due to quality problems of products delivered).

Therefore, these enumerations of risks should be analyzed carefully in order to separate what a disruptive event is and what has to be considered as consequences in order to provide a consistent and clear framework of disruptions, which will be the starting point to assess the capacity of enterprise resilience.

2.3. Disruptions' consequences

A disruptive event affects directly the usual operation and stability of an enterprise or SC. Therefore, in this study, the consequences of a disruptive event always have a negative effect on an enterprise and for this reason it is considered to be associated with undesired consequences. Sheffi and Rice (2005) point out that any significant disruptive event has an effect on enterprise performance, whether that performance is measured by sales, production level, profits, customer service or another metric.

Dalziell and McManus (2004) explain that the point at which a disruptive event occurs is when a system, in this case, an enterprise, is pushed from one state of relative stability or equilibrium into another.

Figure 4 shows an example of two enterprises A and B, which have been impacted by a disruptive event. The negative consequences of enterprise B are higher than in enterprise A, because the performance of B decreases more abruptly although it seems that enterprise B will recover sooner than A. Therefore, the consequences of a disruptive event should be analyzed in detail taking into account not only the negative effect, also other factors such as the recovery capacity. Due to the fact that assessing enterprise resilience is a very complex task, the starting point of enterprise resilience, which are the disruptions, have to be frameworked.

3. Research Methodology

The research methodology used in this paper (Figure 5) is based on an exhaustive literature review (CRC

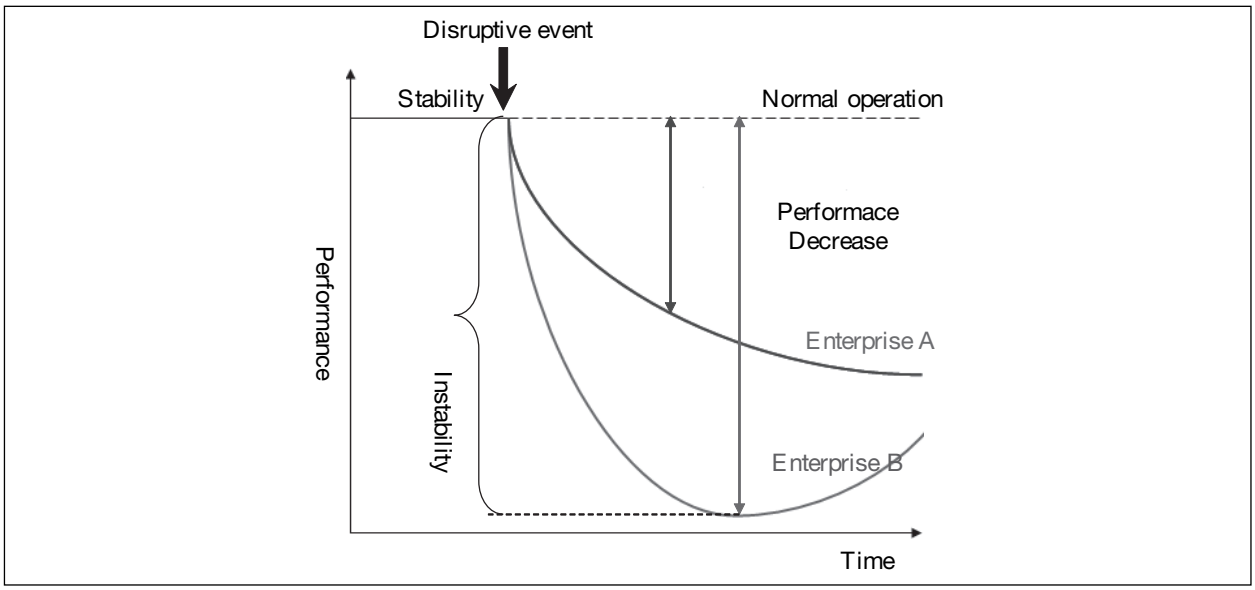

Figure 4
Disruptions' consequences (based on Sheffi and Rice, 2005 and Erol et al., 2010)

ENGnetBASE, DIALNET, Emerald ScienceDirect, ISI Web of Knowledge, SciELO, Scirus, Scopus and Uspto) with keywords related to disruptions to identify the most mentioned and studied disruption sources, disruptive events and consequences of such events.

80 references have been identified and analyzed and among them, 15 key references have been selected as relevant. The research performed to categorize disruptions is based on these key references and complementary sources as risks rankings studies (Cranfield, 2002; The Council on Competitiveness, 2007 based on Executive Risk Rankings, 2007; Insurance Risk Rankings, 2007 and Mayors' Risk Rankings, 2007; Ernst & Young Strategic Business, 2010; Aon Risk Solutions, 2011, World Economic Forum, 2012 and Deloitte, 2013); occupational risk prevention publications (Miñambres et al., 2004; Brío González et al., 2004; Fernández et al., 2007 and Escanciano García-Miranda et al., 2010); European Projects (SHAPE-RISK, 2007; REMPLANET, 2012; INTEG-RISK, 2013 and RMAC, 2014) and case studies (Sheffi and Rice, 2005 and Stolker; 2008).

The categorisation framework of disruptions will be further improved and validated with a Delphi study performed by experts in enterprise resilience. Moreover, it will also be enhanced by piloting it in real industrial cases with the feedback and experience of industrial professionals as it is shown in Figure 5.

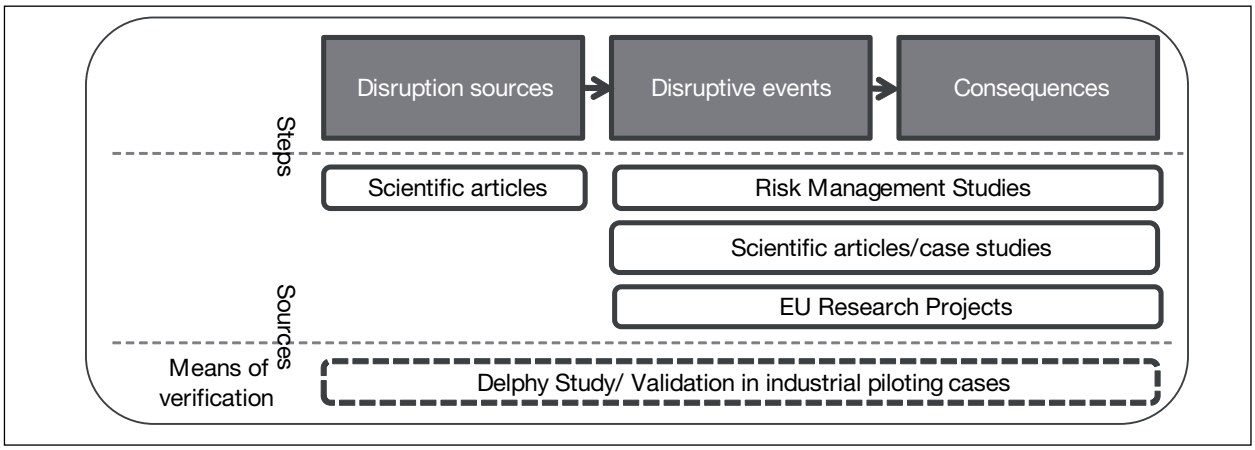

Figure 5
Research Methodology used to define the Categorization Framework of Disruptions

4. Framework to categorise disruptions

The categorisation framework of disruptions is defined based on three steps.

Categorisation of the disruptions sources.

This step is focused on distinguishing the different disruptions sources. Two different disruptions sources have been defined:

- The level in which the disruption have its origin. This type considers: (i) within an enterprise, (ii) outside an enterprise but internal to the SC and (iii) external to the SC.
- The origin that causes the disruptive event. In this case, the different alternatives are: accidental, customer, energetic, equipments, financial, Information and Communications Technologies (ICT), infrastructure, man-made, natural, political, product, regulatory, supplier and terrorism.

Categorisation of the disruptive events.

An enumeration of the top disruptive events identified is developed. This is based on yearly reports developed by risk management institutions and occupational risk prevention publications.

Moreover, the list of disruptive events is constantly being updated according to the current characteristics of the surrounding environment.

Categorisation of consequences.

In the literature, a high amount of case studies related to disruptive events and its consequences exists. These case studies provide a collection of the main consequences: (I) Business interruption; (II) Damage to reputation/brand; (III) Delays and failure of due dates; (IV) Failure to attract or retain top talent; (V) Failure to meet customer needs; (VI) High inventories; (VII) Impossibility to pay personnel, suppliers, taxes; (VIII) Increase of final products price; (IX) Increase of production costs; (X) Injury to end customers; (XI) Injury to workers; (XII) Loss of intellectual property/data; (XIII) Loss of networked communication; (XIV) Physical damage; (XV) Sales decrease; (XVI) Understaffing; (XVII) Unfulfilled orders. Sheffi and Rice (2005) divide a disruption into 8 different phases: preparation, disruptive event, first response, initial impact, time of full impact, preparation for recovery, recovery and long-term impact. The categorisation framework of disruptions also distinguishes between initial impact and long-term impact.

Table 1 shows a small piece of the categorization framework. It is the initial skeleton to develop methods and tools to assess, analyse and propose actions to improve the resilience capacity of enterprises. For example, the disruptive event of absenteeism/strikes has its origin in the human resources, for this reason it has been categorized as man-made. This disruptive event could happen in a focal enterprise if the strike is sector-focused but it also can occur in the whole SC or external to it if the strike is national. The initial impact will be understaffing. However, this also could have more consequences such as: delays and failure of due dates and even though business interruption due to the lack of workers. These consequences can be also translated into failure to meet customer needs and damage to reputation/brand because of customers do not receive the right products at the right time.

5. Conclusions and further research

The categorisation framework of disruptions marks the beginning of the process to assess enterprise resilience. In order to evaluate how resilient an enterprise is, it is necessary to have a clear understanding and deep knowledge of the origin/s, characteristics and consequences that disruptions cause to focus the subsequent analysis. Therefore, the first version of this categorisation framework attempts to provide an understandable and easy scheme to support enterprises to identify resilience gaps.

In general terms, further research will be focused on extending the framework. This is possible because the framework is an open structure that could be updated in any moment with new sources, disruptive events and consequences. To do so, it is important to take into account the relationships and the different transactions among the focal enterprise analyzed and its SC partners. Moreover, the extension of this framework will also include in the consequences element, the main components affected by the negative effects of the different disruptions (e.g. human resources, product, processes, …). As next step to improve and validate the framework, a Delphi study with experts in enterprise resilience will be launched. After this, it will be sent to industrial professionals, who daily have to face up to disruptive events, to receive feedback and refine the framework. This categorization framework will be linked to the prevention, recovery and adaptation frameworks to achieve the global enterprise resilience assessment framework, with which an enterprise will be able to study

	Sources			Consequences		
	Level	Primary origin	Disruptive event	Initial impact	Long-term impact	References
1	i, ii, iii	Accidental	Fire, gas leak, explosions…	Injury to workers	I, III, V, XI, XII, XIII, XIV, XVII	Stolker (2008); CC(2007)
2	i, ii	Customer	Unanticipated or very volatile demand	High inventories / Delays and failure of due dates	V, IX, XV, XVII	Deloitte (2013); Wagner et al. (2006)
3	i, ii	Customer	Insuficient or distorted information from the customer about product commitments	Failure to meet customer needs	II, III, V, VIII, IX	Wagner et al. (2006)
4	i, ii	Customer	Bad payment behaviour or payment defaults of customers	Impossibility to pay personnel, supliers, taxes…	I, II	Wagner et al. (2006)
5	i, ii	Customer	Product demand changes/customization	Failure to meet customer needs	II, III, VIII, IX, XVI	Deloitte (2013); EY(2010); Cranfield (2002)
6	i, ii, iii	Energetic	Energy/water interruption (electricity, gas…)	Business interruption	II, III, V, XIII, XVI	CC (2007); EY (2010)
7	i, ii, iii	Energetic	Changes in the prices of energy	Increase of final products price	IX	CC (2007); EY (2010)
8	i, ii, iii	Equipments	Breakdown of machinery	Delays and failure of due dates	I, II	Deloitte (2013)
9	i, ii, iii	Equipments	Production technological changes	Increase of production costs	I, III, V, VIII, XV, XVII	EY (2010)
10	i, ii, iii	Financial	Economic slowdown	Sales decrease	I, IV, VII	AON (2011); EY (2010)
11	i, ii, iii	Financial	Increase of commodity price	Increase of final products price	XV	AON (2011); EY(2010)
12	i, ii, iii	Financial	Innaccessibility of capital/credit	Impossibility to pay personnel, supliers, taxes…	II, VIII, XV	AON (2011), EY (2010)
13	i, ii, iii	Financial	Interest rate fluctuation	Impossibility to pay personnel, supliers, taxes…	II, VIII, XV	AON (2011)
14	i, ii, iii	ICT	Lack of technology infrastructure to support business needs	Failure to meet customer needs	XIII	AON (2011); EY (2010)
15	i, ii, iii	ICT	Perturbation or breakdown of IT systems	Loss of networked communication	II, V, XII	Deloitte (2013); AON (2011); Jütner (2005)
16	i, ii, iii	Infrastructure	Transportation infrastructure failure (e.g.rail disruptions)	Delays and failure of due dates	II	Cranfield (2003)
17	i, ii, iii	Man-made	Crime/Theft/Fraud/Employee Dishonesty	Loss of intellectual property/data	II, III, V, XVI	AON (2011)
18	i, ii, iii	Man-made	Sabotage	Business interruption	II, III, V, XI, XII, XIII, XVI	AON (2011); CC(2007)
19	i, ii, iii	Man-made	Kidnap and ransom/extorsion	Understaffing	IV, XI	AON (2011)
20	i, ii, iii	Man-made	Absenteeism/Strikes	Understaffing	I, II, III, V	AON (2011)
21	i, ii, iii	Natural	Pandemic/diseases/health crises	Understaffing	I, II, III, V	WEF (2012); AON (2011); CC(2007); Wagner et al. (2006)
22	i, ii, iii	Natural	Natural disasters (e.g. earthquake, flooding, tsunami, tornados…)	Business interruption	III, V, XI, XIII, XIV, XVI	AON (2011); CC(2007); Wagner et al. (2006)
23	i, ii, iii	Political	Political instability or other socio-political crises	Business interruption	I, III, V, X, XI, XIII, XIV, XVI, XVII	Wagner et al. (2006); EY (2010)
24	i, ii, iii	Political	War	Business interruption	I, III, V, X, XI, XIII, XIV, XVI, XVII	Wagner et al. (2006)
25	i, ii, iii	Product	Products quality	Damage to reputation/brand	V, XV	CC (2007)
26	i, ii, iii	Product	Nocive substances in products	Damage to reputation/brand / Injury to end customers	II, V, X, XV	Deloitte (2013); AON (2011); CC(2007)
27	i, ii, iii	Regulatory	Regulatory and legislative changes	Injury to end customers	V, VIII, IX, XV	Deloitte (2013); AON (2011); CC(2007)
28	i, ii, iii	Regulatory	Introduction of road pricing schemes	Increase of final products price	XV	Wagner et al. (2006)
29	i, ii	Supplier	Natural resource scarcity/unavailability of raw materials	Delays and failure of due dates	I, II, V, VIII, XVII	AON (2011)
30	i, ii	Supplier	Supplier quality problems	Business interruption	III, V, XVIII	Wagner et al. (2006)
31	i, ii	Supplier	Sudden demise of a supplier (e.g due to bankruptcy)	Business interruption	III, V, XVIII	Wagner et al. (2006); Zsidisin et al. (2000)
32	i, ii	Supplier	Capacity fluctuations or shortages on the supply markets	Delays and failure of due dates	I, V, XVIII	Zsidisin et al. (2000)
33	i, ii, iii	Supplier	Supplier capacity constrains	Delays and failure of due dates	I, V, XVIII	Zsidisin et al. (2000)
34	i, ii, iii	Terrorism	Computer Crime/Hacking/Viruses/Malicious Codes	Loss of networked communication	II, V, XII	AON (2011); CC(2007)
35	i, ii, iii	Terrorism	International terror attacks	Business interruption	II, III, V, XI, XII, XIII, XIV, XV, XVI, XVII	CC (2007); Sheffi et al. (2005)

Table 1
Categorisation framework of disruptions.

its degree of vulnerability to take the proper decisions with regard to its preventive, recovery and adaptative capacity if a disruption hits it in order to be more resilient.

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