Enterprise Resilience Assessment: A Categorisation Framework of Disruptions

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Abstract Currently, enterprises are more exposed to vulnerabilities and threats due to the recent context and this makes enterprises need the capacity to be ready and prepared to face up to more and more disruptions. If a disruption impact on an enterprise, it will have to adapt to this new situation and try to recover as soon as possible to its normal state of operations. This ability has been defined as Enterprise Resilience. In order to assess how resilient an enterprise is, it is necessary to firstly focus on the trigger that causes this lack of enterprise resilience: the disruptions. This paper proposes a categorisation framework of disruptions which is the starting point to evaluate the resilience capacity of enterprises.

Keywords: Enterprise Resilience, Disruption, Source, Consequences, 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). Disruptions appear in the definition of enterprise resilience as the trigger that causes enterprises weakness. In order to assess how resilient an enterprise

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or its SC is, it should be studied in detail what generates the lack of enterprise resilience: the disruptions. Section 2 reviews the literature about disruptions and describes its main elements. Section 3 proposes a categorisation framework of disruptions which is the starting point to evaluate the resilience capacity of enterprises. Finally, section 4 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 y Saad, 2005), others prefer to use ‘risk’ (Chopra y 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 (Fig. 1):

- **Source**: source that causes and originate the disruption.
- **Disruptive event**: event that causes an expected or unexpected perturbance that have negative effects on the enterprise and its SC.
- **Consequence**: Alteration of the normal flow of products and materials.

![Fig. 1 Summary of the disruptions' elements](image)

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 re-
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.

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.

\[ \text{2.2 Disruptive Event} \]

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 y 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 it 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 Fig. 1, 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 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.

The studies analyzed in this work are: 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) and World Economic Forum (2012) and several cases studies found in the literature.

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.

Dalziel 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.

Fig. 2 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 framed.

![Disruptions' consequences](image)

**Fig. 2** Disruptions’ consequences (based on Sheffi and Rice, 2005 and Erol et al., 2010)

### 3 Framework to Categorise Disruptions

The research methodology used in this paper is based on an exhaustive literature review (*CRC ENGnetBASE, DIALNET, Emerald ScienceDirect, ISI Web of Knowledge, SciELO, Scirus, Scopus and Uspto*) to identify the most mentioned and studied disruption sources, disruptive events and consequences of such events. Moreover, other sources as risks rankings developed by insurance companies have been taken into account. On the other hand, the categorisation methodology is based on cases studies found in the literature, which are the inputs to develop the categorisation framework of 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.

<table>
<thead>
<tr>
<th>Level</th>
<th>Primary origin</th>
<th>Disruptive event</th>
<th>Initial impact</th>
<th>Consequences</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Accidental</td>
<td>Fire, gas leak, explosions, ...</td>
<td>Injury to workers</td>
<td>III, V, XI, XII, XIII, XIV, XVII</td>
</tr>
<tr>
<td>2</td>
<td>Customer</td>
<td>Unanticipated or very low demand</td>
<td>Failure to meet customer needs, ...</td>
<td>V, IX, XV, XVIII</td>
</tr>
<tr>
<td>3</td>
<td>Customer</td>
<td>Bad payment behavior or payment defaults of customers</td>
<td>Failure to meet customer needs, ...</td>
<td>I, V, VIII, IX, XVI</td>
</tr>
<tr>
<td>4</td>
<td>Customer</td>
<td>Producers demand changes/destabilization</td>
<td>Failure to meet customer needs, ...</td>
<td>II, III, V, VIII, XVI</td>
</tr>
<tr>
<td>5</td>
<td>Equipment</td>
<td>Changes in the prices of energy</td>
<td>Increase of final products price</td>
<td>IX, XV</td>
</tr>
<tr>
<td>6</td>
<td>Equipment</td>
<td>Breakdown of machinery</td>
<td>Delays and failure of due dates</td>
<td>I, II</td>
</tr>
<tr>
<td>7</td>
<td>Equipment</td>
<td>Production technological changes</td>
<td>Increase of production costs</td>
<td>III, V, VIII, XVII</td>
</tr>
<tr>
<td>8</td>
<td>Equipment</td>
<td>Inventory or commitment price</td>
<td>Increase of final products price</td>
<td>XV</td>
</tr>
<tr>
<td>9</td>
<td>Equipment</td>
<td>Inaccessibility of capital/credit</td>
<td>Impossibility to pay personnel, suppliers, taxes...</td>
<td>III, V, VIII, XV</td>
</tr>
<tr>
<td>10</td>
<td>Equipment</td>
<td>Lack of technology to support business needs</td>
<td>Failure to meet customer needs</td>
<td>XI</td>
</tr>
<tr>
<td>11</td>
<td>Equipment</td>
<td>Proliferation of defects in IT systems</td>
<td>Loss of networked communication</td>
<td>I, V, XII</td>
</tr>
<tr>
<td>12</td>
<td>Equipment</td>
<td>Transportation induced/natural failure (e.g. rail disruptions)</td>
<td>Delays and failure of due dates</td>
<td>I, V, VIII, XIV</td>
</tr>
<tr>
<td>13</td>
<td>Equipment</td>
<td>Sabotage</td>
<td>Business interruption</td>
<td>I, III, V, VIII, XI, XII, XIII, XIV, XV, XVI, XVII</td>
</tr>
<tr>
<td>14</td>
<td>Equipment</td>
<td>Kidnap and ransom/extortion</td>
<td>Understaffing</td>
<td>V, XI</td>
</tr>
<tr>
<td>15</td>
<td>Equipment</td>
<td>Absenteeism/strikes</td>
<td>Understaffing</td>
<td>III, V, XI, XII, XIII, XIV, XV, XVI, XVII</td>
</tr>
<tr>
<td>16</td>
<td>Equipment</td>
<td>Pandemic/diseases/health crises</td>
<td>Understaffing</td>
<td>I, III, V</td>
</tr>
<tr>
<td>17</td>
<td>Natural</td>
<td>Natural disasters (e.g. earthquakes, flooding, tsunamis, etc.)</td>
<td>Business interruption</td>
<td>III, V, XI, XII, XIII, XIV, XV, XVI, XVII</td>
</tr>
<tr>
<td>18</td>
<td>Natural</td>
<td>Political instability or other socio-political crisis</td>
<td>Business interruption</td>
<td>III, V, XI, XII, XIII, XIV, XV, XVI, XVII</td>
</tr>
<tr>
<td>19</td>
<td>Natural</td>
<td>War</td>
<td>Business interruption</td>
<td>V, III, V, XI, XII, XIII, XIV, XV, XVI, XVII</td>
</tr>
<tr>
<td>20</td>
<td>Product</td>
<td>Product quality</td>
<td>Damage to reputation/brand</td>
<td>I, II, III, V, XI, XII, XIII, XIV, XV, XVI, XVII</td>
</tr>
<tr>
<td>21</td>
<td>Product</td>
<td>Nocive substances in products</td>
<td>Damage to reputation/brand</td>
<td>I, V, XV, X, XV</td>
</tr>
<tr>
<td>22</td>
<td>Regulatory</td>
<td>Regulatory and legislative changes</td>
<td>Delays and failure of due dates</td>
<td>V, VIII, IX, XV, XVII</td>
</tr>
<tr>
<td>23</td>
<td>Regulatory</td>
<td>Introduction of road pricing schemes</td>
<td>Increase of final products price</td>
<td>V, IX, XV, XVII</td>
</tr>
<tr>
<td>24</td>
<td>Supplier</td>
<td>Natural resource scarcity/unavailability of raw materials</td>
<td>Delays and failure of due dates</td>
<td>I, II, III, V, VIII, X, XVII</td>
</tr>
<tr>
<td>25</td>
<td>Supplier</td>
<td>Supplier quality problems</td>
<td>Business interruption</td>
<td>I, V, X, XV, XVI, XVII</td>
</tr>
<tr>
<td>26</td>
<td>Supplier</td>
<td>Supplier capacity constraints, shortages</td>
<td>Business interruption</td>
<td>V, XV, X, XVII</td>
</tr>
<tr>
<td>27</td>
<td>Supplier</td>
<td>Supplier capacity constraints, shortages</td>
<td>Business interruption</td>
<td>V, XV, X, XVII</td>
</tr>
<tr>
<td>28</td>
<td>Supplier</td>
<td>Supply chain breakdown due to supplier (e.g., bankruptcy)</td>
<td>Business interruption</td>
<td>V, XV, X, XVII</td>
</tr>
<tr>
<td>29</td>
<td>Terrorism</td>
<td>International terror attacks</td>
<td>Business interruption</td>
<td>I, III, V, XI, XII, XIII, XIV, XV, XVI, XVII</td>
</tr>
<tr>
<td>30</td>
<td>Terrorism</td>
<td>Computer Crime/Hacking/Virus/Malware/Codes</td>
<td>Loss of networked communication</td>
<td>I, II, VII</td>
</tr>
</tbody>
</table>

**Fig. 3 Categorisation framework of disruptions.**
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.

The categorisation framework of disruptions is the skeleton that structures and relates the 3 elements (sources, disruptive events and consequences) of disruptions. and will be used to support the assessment of enterprise resilience capacity. Fig. 3 shows a small part of the proposed categorisation framework of disruptions.

### 4 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 a deep knowledge of the origin/s, characteristics and consequences that disruptions cause. 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 risk management will be launched. After this, an enterprise will be able to study its degree of vulnerability to take the proper decisions to improve its adaptative and recovery capacity if a disruption hits it.
5 References