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Origins of Disruptions Sources Framework to Support the Enterprise Resilience Analysis

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Abstract: The business environment is increasingly unstable and enterprises have to face more frequently threats that put the business continuity at risk. In light of this, enterprises need to be resilient enough to manage these undesired situations. The analysis of enterprise resilience is a very difficult task, and since the beginning supporting approaches to guide this task are required. Based on the Categorisation Framework of Disruptions developed by Sanchis and Poler (2014), the present research aims at defining and characterizing the origins of disruptions sources to classify the potential disruptive events. To do so, the origins of the disruptions sources framework is defined as a supporting mechanism to make available to both, companies and researchers, valuable information in an organised manner to facilitate the retrieval of the necessary data to assess the enterprise resilience capacity and focus the research on the most critical origins of disruptions sources.

Keywords: Origins, Disruption Sources, Enterprise Resilience, Disruptive Events, Framework

1. INTRODUCTION

The business environment is increasingly unstable and companies have to efficiently manage their processes with transparency, so that they are able to respond to the inherent risk presented by their activities and their relationships with the environment. Enterprise resilience is presented as the capacity to decrease the level of its vulnerability to expected and unexpected threats, its ability to change itself and adapt to its changing environment, and its ability to recover in the least possible time in case of a disruptive event occurrence (Erol, Sauser, and Mansouri, 2010).

Many companies manage risk and business continuity, but do not take into account the global and aggregate perspective of enterprise resilience. In addition, risk management and business continuity are usually left to security and insurance professionals. However, it is necessary to build a resilient company to change the way in which the company operates to increase its preparation and recovery abilities in order to give an efficient response in adverse situations.

Resilience has been extensively studied in the literature from strategic, tactical and operative perspectives in light of numerous severe disruptions such as tsunami, fires, and floods (Ivanov, 2018). However, at first glance, it seems that there are no universal patterns that ensure the continuity or the stoppage of enterprises in the face of disruptive events occurrence.

Companies are usually more reactive than proactive from a resilient viewpoint. They often do not anticipate the disruptive events and nor take the appropriate decisions to minimize their impact.

The concept of resilience has been applied to a large number of disciplines, including, of course, the business and industrial world. Hollnagel (2006) defines enterprise resilience as the ability of a system to predict, recognize, anticipate and face disruptions before adverse consequences occur. The ability to foresee, recognize and anticipate disruptions requires preparedness capacity for the disruptive events. Comfort, Sungu, Johnson and Dunn (2001) suggest that a system must create a balance between anticipation or preparedness and resilience. However, companies do not only require preparedness capacity but, to face the imminent occurrence of a disruptive event, Hollnagel (2006) also emphasizes defence, to give a response to the disruptive event, through their recovery ability. Sanchis and Poler (2013) state that enterprise resilience is function of the enterprise vulnerability, adaptative capacity and recovery ability.

The analysis of enterprise resilience is a very complex task. In the literature, there are few attempts to analyse this enterprise capacity, and besides this, the approaches are complicated and enterprises usually find difficult its implementation. For this reason, it is necessary an easy-to-implement mechanism to research and analyse enterprise resilience. As aforementioned, the analysis of enterprise resilience is a very difficult task, so the data should be framed to offer the information in a structured way. Goble, Fields and Cocchiara (2002) explain that to reach an appropriate level of enterprise resilience and evaluate disruptions, it is necessary to understand the interrelationships and interdependencies between business processes, information and technologies within companies. Sanchis and Poler (2014) explain that the assessment of enterprise resilience capacity should focus on the element that causes the lack of enterprise resilience capacity, the disruptions; taking into account that disruptions encompasses the disruptive events, the source

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where the event is originated and the negative consequences and all these components should be studied carefully.

Therefore, the main objective of this paper is to characterize, based on the Categorisation Framework of Disruptions developed by Sanchis and Poler (2014), the origins of disruptions sources in order to delimit and establish the boundaries of the enterprise resilience research (from an investigation point of view) and analysis (from a company point of view). This characterisation is the first step to define the overall enterprise resilience research framework to support enterprises in the assessment of this capacity. This second framework will consist of three main elements: (i) the characterisation of disruptions, taking into account the different origins analysed in this paper; (ii) the constituent capacities of the enterprise resilience (preparedness and recovery) and (iii) the transition elements (preventive and knowledge registration actions) that will allow the transition from the AS IS model of a company to a future one (TO BE).

The paper is structured as follows. Section 2 shows the foundations of the categorisation framework of disruptions developed by Sanchis and Poler (2014) which will serve as the basis for the characterisation of the origins of disruptions sources. Section 3 presents the research methodology performed to obtain the characterisation of the origins of disruptions sources. Finally, section 4 highlights the main conclusions and further research.

2. THE CATEGORISATION FRAMEWOK OF DISRUPTIONS

Companies are very complex dynamic entities and this complexity increases every day due to the amount and density of relationships between companies and the entities of their supply network. Current companies have to face a greater amount and more serious threats. Sanchis and Poler (2014) explain that at present the lack of enterprise resilience capacity is triggered by the disruptions manifestation. The authors state that a disruption encompasses the occurrence of a disruptive event, the source where the event is originated and its negative consequences as it is shown in Fig. 1.

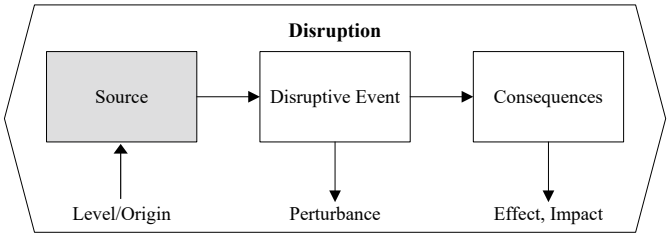

Fig 1. Categorisation Framework of Disruptions (Sanchis and Poler, 2014)

The categorisation framework of disruptions proposed by Sanchis and Poler (2014) is composed by the following elements:

- Source: the trigger that causes and originates the disruption. This element is, in turn, divided into two components: (i) the level in which the disruptive event occurs that could be: inside the enterprise (-intra), outside the enterprise but inside the supply network (-inter) or outside the supply network (-extra); and (ii) the origin in which the disruptive event is initiated. This second component, the origin of the disruption sources, is the one that will be characterised in detail in this paper.
- Disruptive event: any foreseeable or unpredictable situation that affects the normal operation and stability of a company (Barroso, Machado and Machado, 2011). At the moment in which a disruptive event occurs, a company is pushed from a state of relative equilibrium to another state characterised by instability. The ease with which the company is moved to this new unstable state is a measure of vulnerability, understood as the preparedness capacity to face the disruptive event, while the degree to which the company responds to such an event is a measure of the recovery ability.
- Consequence: Effects and impact of the perturbance in the normal operation of an enterprise. Sheffi and Rice (2005) point out that any significant disruptive event has a consequence on enterprise performance, whether that performance is measured by sales, production level, profits, customer service or another metric.

The categorisation framework of disruptions proposed by Sanchis and Poler (2014) is the initial step to analyse enterprise resilience and offers only an initial overview. However, in order to evaluate how resilient an enterprise is, and to investigate this area, it is necessary to have a clear understanding and deep knowledge of the origin/s where the different disruptive events could occur. For this reason, this paper goes beyond the former framework by detailing the origins of the disruptions sources. This analysis will provide valuable information to focus on the most vulnerable origins and implement actions addressed to the disruptions instantiated in such origins to make enterprises more resilient.

3. CHARACTERISATION OF THE ORIGINS OF DISRUPTIONS SOURCES

The research methodology used to characterize the origins of the disruptions sources is focused on the following activities and pursues the following objective (Fig. 2):

Activity 1. Literature review with two main sub-steps:

- Sub-activity 1.1. Identification in the literature of existing classifications related to the origins of disruptions sources. The main objective of this activity is to detect the main classifications published in the literature to select the identified origins as a first and preliminary list. This enumeration will serve as a basis, including more origins that are not considered in the existing classifications, for classifying the most common and troublesome disruptive events also analysed in the literature that is the sub-activity 1.2. The literature review is focused on analysing scientific papers related to enterprise resilience
- Sub-activity 1.2. Identification of the most worrying disruptive events based on surveys and questionnaires performed by prestigious consultancy firms that annually analysis which the top disruptive events and risks are. The main objective of this search is to classify the disruptive

events according to the preliminary list of origins of disruptions sources done in the previous sub-activity.

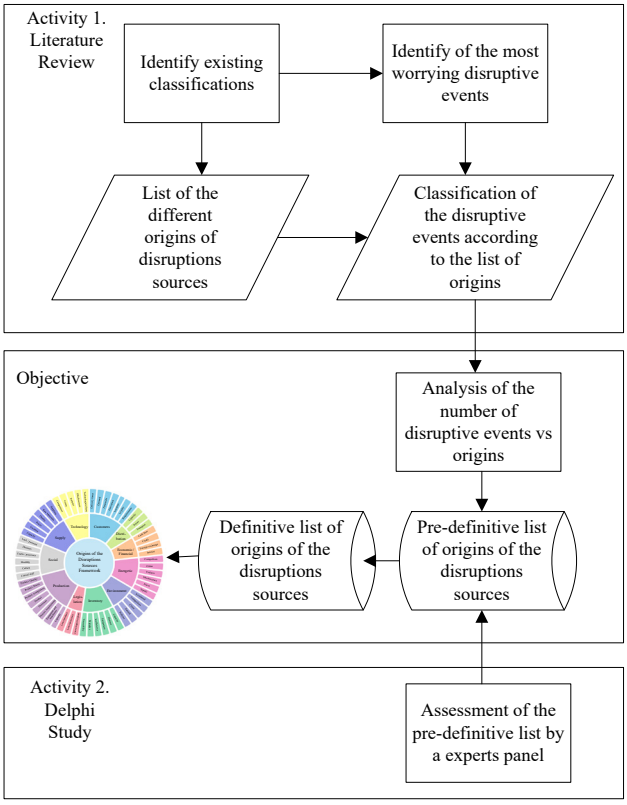

Fig 2. Summary of the Research Methodology used to define the Origins of Disruptions Sources Framework

Objective. The objective of the research methodology used in this paper is to match the origins of disruption sources identified in the sub-activity 1.1 with the disruptive events found in sub-activity 1.2. With this matching, we aim at shaping a pre-definitive list of origins of disruptions sources according to the number and frequency of the analysed disruptive events found in the literature. The definitive list of origins of disruptions sources will be achieved through the validation of the Delphi study performed in the activity 2. It is worth mentioning that although the main objective is to define a definitive version of the origins of disruptions sources framework, the framework is not a closed system, as enterprise resilience capacity is a lively capability that depends extremely on the intrinsic conditions of enterprises and the dynamism of the environment in which enterprises operate. For this reason, it is mandatory to leave the framework open for the inclusion, at any time, more origins of disruptions sources depending on the existing needs at that time.

Activity 2. Validation of the origins of disruptions sources selection through a Delphi study. Besides the literature review analysis, the pre-definitive list of the origins of disruptions sources is validated by a panel of 11 experts that, with their deep knowledge, assess the number and type of origins selected in Activity 1.

3.1 Literature Review

As aforementioned, a literature review is performed in order to identify current and existing disruptions sources classifications. Table 1 shows a summary of the most relevant disruptions sources found in the literature.

Table 1. Overview of different origins of disruptions sources according to the literature review.

	Control	Customers, Demand	Energetic	Environment, Nature, Catastrophes	Equipment	Financials	Infrastructure	Legislation	Processes/ Production	Social, Man-made	Structure	Supply	Transportation
Mason-Jones and Towill (1998)	✓	✓							✓			✓	
Cranfield (2002)				✓					✓	✓			
Van der Vorst and Beulens (2002)	✓	✓		✓					✓				
Christopher and Peck (2004)	✓	✓							✓			✓	
Jüttner (2005)		✓		✓								✓	
Barroso, Machado and Machado (2008)		✓	✓	✓	✓	✓				✓		✓	
Hu, Li and Holloway (2008)				✓						✓			✓
Wagner and Bode (2009)		✓		✓			✓	✓				✓	
Wagner and Neshat (2010)		✓									✓	✓	
Ivanov et al., (2017)								✓				✓	✓

Other origins of disruptions sources such as terrorism and political instability (Kleindorfer and Saad, 2005) have been also identified in the literature.

Based on the existing disruptions sources classifications (Table 1) the literature review is also focused on identifying the most alarming disruptive events to detect the most critical origins of disruptions sources. This review is based on the annual reports developed by important consulting firms with the rankings of the risk situations that most concern the business world (AON Risk Solutions, 2017; Control Risks, 2017; Price Waterhouse Cooper, 2017, Business Continuity Institute, 2018; World Economic Forum, 2019). As all the disruptive events identified do not match with the existing disruptions sources classifications, new sources are defined.

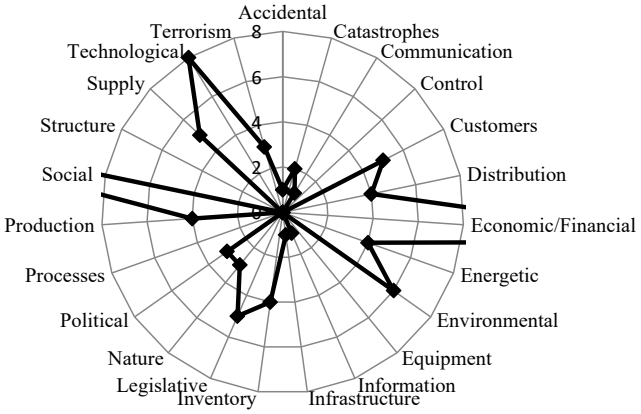

Fig 3. Number of disruptive events classified according to different origins of disruption sources

In total 103 disruptive events are classified according to the origin of disruptions sources and the results obtained are shown in Fig. 3. The disruptive events most found are related to social (24 disruptive events), economic and financial (19 disruptive events) and technological issues (8 disruptive events). Environmental, legislative, customers, supply, distribution, energetic, inventory, and production are the

origins of disruptions sources that follow the top 3 disruptive events.

Based on these results, the more significant origins of disruptions sources are identified and with this piece of information, the Delphi study is performed. The Delphi study consisted of 11 professionals and academic scholars in the area of enterprise resilience who, with two iterations, complete the analysis. And with such information, the origins of the disruptions sources framework is proposed.

3.2 Origins of the Disruptions Sources Framework

The origins of the disruptions sources framework is a first attempt to define the most significant origins in which the different disruptive events could be initiated. From a research point of view, this framework is a supporting mechanism to delimit the field in which the enterprise resilience capacity should be investigated. From a business point of view, this proposal offers an initial outline to set the limits of the different areas in which the disruptive events could be originated, in order to focus, the enterprise resilience analysis, on the most critical ones (where the highest number of disruptive events occur or where their probability and/or severity of occurrence is higher).Based on the literature review performed in section 3.1, the origins of the disruptions sources framework is presented in Fig. 4.

Fig 4. Origins of the Disruptions Sources Framework.

The framework proposed is composed by 11 origins: customers, distribution, economic/financial, energetic, environment, inventory, legislation, production, social, supply and technology. Each origin is divided into sub-origins depending on the nature of the previously identified disruptive events. The framework presents an open structure where more sub-origins, even origins, could be added depending on the requirements of the enterprise resilience study. However, this proposal offers a first approach as a supporting mechanism to classify and focus the scope of the enterprise resilience analysis. In order to guide companies and researchers with the use of this proposal, it is important to detail what each origin covers. Each origin is described as follows:

- **Customers**. Person/s or company/es that acquire goods or services (it is not necessarily that customers are final consumers, they may be entities of the supply network that acquire goods to continue with their productive process). This origin is related to aspects such as demand, requirements, delivery times, financial problems, loyalty, location, etc.
- **Distribution**. Process by which the products are physically delivered to the final customer or to other intermediate entities of the supply network to continue with other additional productive processes until the overall completion of the product. This origin is related to aspects such as transport capacity, means and/or distribution channels, fuel prices, etc.
- **Economic/financial**. Process that manages the financial resources of the company, with two main functions: investment and financing. This origin includes factors related to currencies, prices, margins, credits, liquidity ...
- **Energetic**. It includes the resources and energy capacity to perform the daily operations of the company. This origin is related to supply aspects of electricity, water, gas ... and the necessary resources to guarantee the normal operation of the company.
- **Environment.** The environment origin includes various elements according to its perspective. The natural environment is characterised by different climatic, meteorological, orographic conditions ... according to the geographical location of the company. The political environment is characterised by a set of governmental events based on recent history according to geographic zones and their future effects. The environment of the threats is related to the systematic use of terror, to coerce companies in order to claim and promote certain objectives, usually political and/or religious.
- **Inventory.** Organisation of the inputs (raw materials) and outputs (work in progress and final product stock) for their maintenance and storage. This origin covers the inventories management including aspects such as warehouse capacities, delivery times, commodity rotation, etc.
- **Legislation**. Set of legal rules, laws, regulations, ... that govern the daily operation of the company and whose breach may carry a penalty. This origin is associated with aspects of environmental regulations, safety, prevention of occupational hazards, etc.
- **Production**. Process through which a material, either natural or with some degree of elaboration, becomes a final product or a sub-product to start another productive process. This origin is related to aspects such as the machinery and equipment necessary to carry out the manufacturing process, as well as their capacity, quality of manufactured products, among others.
- **Social**. This origin designates the group of individuals that intervene directly or indirectly in the production of goods and services of the company to be delivered to customers effectively and efficiently. This origin includes factors

related to the human resources of the company, such as absenteeism, strikes, etc.

- **Supply**. Acquisition of raw materials and/or components necessary for the production of goods or the delivery of services. This origin also includes suppliers, since they are the entities that supply the necessary inputs for manufacturing.
- **Technology**. Tools, software, hardware and methods used to collect, retain, manipulate or distribute information. This origin is related to systems, equipment and tools (software) that allow the management of the necessary information for the proper operation of the company.

With the proposal of the origins of disruptions sources framework, 11 origins are identified. Using this framework, both, companies and researchers, are able to classify the different disruptive events according to "where" the perturbance is originated. This classification allows to converge all the information related to the disruptive events following the same criteria.

For example, a company that has suffered reiteratively the occurrence of these three disruptive events: *DisEvent1.* Workforce shortage; *DisEvent2.* Natural resource scarcity/availability of raw materials; and *DisEvent3.* Crime/theft/fraud/employee dishonesty. Using the origins of disruptions sources framework, the company is able to classify the three previous disruptive events. The origin of the first and third ones is social while the origin of the second one is supply. With this information, the company can: (i) register the information related to the occurrence of such disruptive events according to their origins to make the information retrieval easier and quicker, and (ii) pay attention on the critical origins (in this case social and supply) to search potential solutions.

In the case of the social origin, the department of human resources should be informed by the responsible of the enterprise resilience analysis about the problems that the company has with the personnel. And the same applies to the supply department with the DisEvent2. Potential solutions cover two perspectives, the proactive one, by the implementation of mitigation policies, and a reactive one, through the implementation of contingency strategies. In the case of the supply origin, the enterprise, particularly the supply/purchase department should study potential options such as searching alternative raw materials or components, definition of products' new compositions, implementation of reverse logistics and recycling systems as mitigation policies to enhance the preparedness capability against the disruptive event DisEvent2, what will also improve the enterprise resilience capacity.

The use of the origins of disruption sources framework will serve, among others, to register the information in a way that allows the retrieval of such information when necessary, e.g. when the same or a similar disruptive event occurs through case-based reasoning principles and its associated tools (Jcolibri, myCBR, and CBR Shell) (Thakur et al., 2016). In addition, the framework has two levels of detail. The first level composed by the 11 origins previously described. The second level covers the sub-origins. In total the frameworks presents 59 sub-origins. This two-level framework allows companies to register the information based on the depth of the information classification.

Following with the previous example, disruptive events DisEvent1 and 3 are classified as lack / personal and hostility sub-origins, respectively, whereas the disruptive event DisEvent2 sub-origin is raw materials.

The use of this proposal is suitable to standardise the procedures related to the enterprise resilience analysis as the framework offers the scope for the classification of the disruptive events what normalize the study.

Finally, this framework is also useful to obtain statics about the most worrisome and critical origins to focus efforts on such critical areas.

4. CONCLUSION AND FURTHER RESEARCH

The origins of the disruptions sources framework is the first approximation, based on the categorisation framework of disruptions defined by Sanchis and Poler (2014), to classify the potential disruptive events that could impact on an enterprise, according to the different origins where they are initiated. With this classification, enterprises but also researchers, are able to consolidate the information in a structured way according to the different origins identified in this research. This origins classification provides a supporting framework to make available both, companies and researchers, valuable information in an organised manner to facilitate the retrieval of the necessary data to assess the enterprise resilience capacity and focus the research on the most critical origins of disruptions sources.

- The framework proposed also presents the characteristic that has an open structure, so that can be updated with new origins and sub-origins when necessary. This up-to-date process will depend on how the variables that impact on the enterprise resilience capacity evolve. Any company or researcher, depending on their own business or investigation requirements, could extend the framework with new origins or sub-origins, in order to confer to the framework the characteristics of a living tool. The present version of the framework has been defined from an industrial company viewpoint belonging to any industrial sector. In case that, a company that offers services wishes to use this framework, the proposal should be customised with the particular requirements of this type of companies.
- As this framework covers a first approximation, further research is advisable to focus on:
- The identification of other interesting and needed origins of disruptions sources (due to the rapidity with which enterprise systems evolve) through the use of the 5M Ishikawa diagram and of 5 why's method to provide strong guidelines to the current status of the framework.
- The complete characterisation of the other two elements of the Categorisation Framework of Disruptions: disruptive events and consequences, to offer the complete outline to assess the enterprise resilience capacity through the analysis of secondary data mainly based on multiple case studies.
- The implementation of the origins of disruptions sources in a company piloting real case, to classify and structure the information related to disruptive events according to

the different origins based on a self-assessment through questionnaire mechanisms.

- The implementation of the origins of disruptions sources in further investigation to focus the research on the most interesting origins or those which are under-researched based on descriptive statistics, more concretely frequency analysis.
- Based on the results obtained in the previous steps, mitigation policies or recovery strategies will be analysed and proposed according to the each origin of disruptions sources to improve the capacity of enterprise resilience. A mixed integer linear programming model will be defined in order to provide the optimal solution about which policies are the most adequate to be implemented for the assessment and enhancement of enterprises resilience.

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