[ANTI]FRAGILITY OF TECHNOLOGICAL AND INNOVATION PARKS TOWARDS EXTREME EVENTS: AN ASSESSMENT AND ANALYSIS MODEL

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[Anti]fragility of technological and innovation parks towards extreme events: an assessment and analysis model

Abstract

Innovation centers, such as technological and innovation parks, have become widely used by both startup companies and governments to boost and sustain growth and implement public innovation policies, respectively. In this regard, complexity of such innovation centers, which can be seen as systems of systems, has grown exponentially. The four helix concept, comprising governments, the academy (universities), society and the market adds to the complexity that exposes innovation parks to exogenous and endogenous unpredicted extreme events that stress the system and could even collapse it. Recent research has explored the subject under the concept of antifragility which translates into a system's capacity of improving from disorder or entropy. Systems can either be fragile (suffer and degrade), robust (unchanged by the stressor) or antifragile (improve when subjected to the stressor). This study, within this context, seeks to establish a quantitative empirical model for the assessment of the level of antifragility of technological and innovation parks. Early results include findings in the literature regarding antifragility assessment models for systems of systems.

Keywords: Antifragility; technological and Innovation park; extreme events; innovation

1 INTRODUCTION

Technological and innovation parks are part of the federal ministerial department of science, technology and innovation (MCTI) policy of stimuli and fostering of economic development and new business and enterprise creation, through the national business incubators and technology parks development program (MCTI, 2015).

As an innovation environment, technological and innovation parks usually develop according to the triple helix model: companies; academia; society and government. As such, the parks aim at fomenting innovation in business and academic environments, and can be seen as complex systems, capable of the development and deployment of businesses and policies that react and adapt to changing global and local challenges, such as emerging technologies and economic constraints, policies and variables.

This study, therefore, applies the antifragility concept, developed by Taleb (2012) to understand the consequences of the exposure of innovation parks complex systems to unpredicted and unforeseen extreme events. An assessment method, developed by Johnson and Gheorghe (2013), of the antifragility of systems of systems in a generic manner, is used as a starting point to tailor an antifragility assessment model to technological and innovation parks.

2 ANTIFRAGILITY

Antifragility is an emergent concept used to describe things that gain from disorder (Taleb, 2012). The term 'antifragility' was proposed by Nassim Nicholas Taleb in 2012 in a homonymous book. The concept states that, in an increasingly complex world, predictions have little use and opacity permeates what we know. Unforeseen extreme events (such as the world economic crisis of 2008) are largely unavoidable and cannot be detected a priori, with widespread and ample consequences that affect those exposed to them (individuals, things, organizations, institutions and other complex systems) (Taleb, 2012). Such unexpected events are called black swans (Taleb, 2010).

Black swans carry high levels of volatility and stress that may affect a system in three different manners: a) its degradation or even complete failure or halt - what is called fragility; b) the continuation of its normal operation, largely unaffected by the stress and volatility derived from the black swan – labelled robustness or resilience; and c) the improvement of the system, that emerges better and stronger and benefits from volatility, stress and disorder – hence, antifragile (Taleb, 2012).

Antifragility, therefore, refers to the ability of a system of benefiting from disorder, chaos, stress and volatility, up to a certain point. Antifragility differs from resilience or robustness in the sense that resilient or robust systems don't degrade or suffer when subjected to high levels of volatility, and can handle certain amounts of stress; nonetheless, these systems, opposite to the antifragile ones, do not improve or get better under stress.

Although the terminology and context related to antifragility are relatively new, underlying concepts, aspects and characteristics of antifragile systems have been discussed by several authors.

3 TECHNOLOGICAL AND INNOVATION PARKS

To Vedovello (2006), technological parks act supporting the integration between companies and universities, as a mechanism of regional development that stimulates competitiveness, generating growth and economic development where they are located. Like

Vedovello (2006), many articles in the scientific literature consider technological parks as mechanisms that promote innovation and sustained economic development.

According to the International Association of Science Parks (Schiavone et al, 2014), a technological park is considered an organization managed by specialized professionals, formed to increase the overall wealth and welfare of the community it belongs to, promoting the innovation culture and competitiveness. To achieve these goals, the park foments the flow of knowledge between its companies, universities and research and development (R&D) facilities and their respective markets. It also fosters the creation and development of knowledge and innovation based companies through incubation processes and the creation of spin-offs, providing physical spaces in forms of offices and labs and high level services to its companies, such as consultancies, IT and human resources services and others.

Innovation parks, therefore, must possess adequate infrastructure and services to meet its innovative companies' demands and concerns, contributing to their overall competitiveness and ultimately, their success. Innovation parks can be understood as systems that promote the culture of innovation, competitiveness, and knowledge and technologies sharing (Silva et al, 2014).

Durão et al (2005) highlights that the different existent concepts defining technological parks share a set of common aspects: be self-sustainable; are linked to universities, R&D centers and other high level educational facilities; encourage and support the creation of startups through incubation processes; stimulate technological and knowledge transfer; and provide an environment for all these aspects to materialize.

4 ANTIFRAGILITY ASSESSMENT AND ANALYSIS MODEL DEVELOPMENT METHOD

The proposed study seeks to establish an assessment model regarding the antifragility of a technological and innovation parks. The research will use the generic framework developed by Johnson and Gheorghe (2013) as a starting point to tailor the assessment and analysis model of technological and innovation parks' antifragility.

Johnson and Gheorghe (2013) framework reduces the multidimensional concept of fragility into a two dimensional, continuous interval scale, that helps the assessment of the fragility of a system of systems, measuring in one dimension the impact suffered by a system and its correspondent classification in terms of antifragility (table 01).

Table 01 - Johnson's and Gheorghe's antifragility analytical criteria (2013)

Attribute	Theory
Entropy	Systems tend to increase in complexity over time. In doing so they lose the ability to use information to transform inputs into desired outputs; the number of potential system states relative to known system states increase (that is, disorder grows); and X-Events emerge (Chakrabarti and De 2000; Atkins 2003; Bradnick 2008).
Emergence	The relationship between the outputs of a system at the macro level and the actions of the micro level components in the system is either resultant or emergent (Goldstein 1999). When system outputs can be directly traced to activities or functions of its components and there are cause-effect relationships between micro level component activity and macro level results, then the system output is said to be resultant. However, when no such traceability can be constructed, the output is said to be emergent and X-Events are produced (Menzies 1988; Christen and Franklin 2002).
Efficiency vs. Risk	Efficiencies are gained at the expense of increased potential for harm due to stress. For example, redundant components may reduce the potential for system failure, but at the expense of more resources without more functionality or output. Less redundant systems designs are more efficient but are more fragile.
Balancing Constraints vs. Freedom	The optimum condition for a system is a balance of constraints and degrees of freedom. A system that is too open (that is, high degrees of freedom, minimum constraints, maximum interactions and dependencies with other systems, and so on) has increased exposure to X-Events.
Coupling (Loose/Tight)	Failures can reverberate through tightly coupled (that is, linked) systems increasing in amplitude and potentially leading to catastrophic failure. The greater the degree of coupling between systems and system components, the more fragile the system becomes.
Requisite Variety	There are regulators in a SOS that attempt to control the outcome and behaviors of the agents in the system. When the number of regulators is insufficient relative to the number of agents, the behavior of the system becomes unpredictable and extreme hazardous events emerge. In other words, a gap in complexity of the systems and its agents or subsystems causes X-Events to occur.
Stress Starvation	Withholding stress from systems or attempting to reduce uncertainty in them can cause weakness, fragility, and expose them to hazardous X-Events. Applying regular and controlled stress to a system can increase its robustness and potentially lead to antifragility.
Redundancy	Having duplicate components that are required for a function or duplicate functions to meet the same objective, are to create excess system capacity and are effective hazard defenses. This is good for building robustness to a degree, but falls short when it is based on estimates from historical worse case events. When X-Events reoccur, they can do so with an impact that is more or less than the historical levels. Redundancy tends to stabilize systems and make them more robust (that is, less fragile but not antifragile).
Non-Monotonicity	Learning from mistakes can be an effective defense against stressors. Mistakes and failures can lead to new information. As new information becomes available it defeats previous thinking, which can result in new practices and approaches (Augusto and Simari 2001; Nute 2003; Governtori and Terenziani 2007). In this case, stressors can actually cause the system to improve.
Absorption	Systems shall have design margins that can encompass (that is, absorb) the magnitude and duration of the potential stress it may encounter and continue in an intended state. The greater the absorption, the greater the robustness and the less the fragility. Absorption does not increase antifragility.

The proposed model foresees the building of a questionnaire, coupled with semi structured interviews, addressing the complexities involved in innovation parks' systems and management, as well as its readiness and robustness to respond to unpredicted extreme events of exogenous and also endogenous nature, comprising Johnson and Gheorghe (2013) analytical criteria, to be conducted among the stakeholders of technological innovation parks.

Next steps include the definition of the questions and structure of the interviews, and building an appropriate scale to quantitatively measure the antifragility level regarding each antifragility analytical criteria; the establishment of a formula and method of classification of innovation parks antifragility level; and the application of the framework in case studies to validate the results and consolidate the model.

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