What if you catch a black swan?
Public policy design for climate change adaptation

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EXTENDED ABSTRACT

What if you catch a black swan? So called black swans – unlikely but high impact unpredictable events – are now of particular concern for public management as their effects impact widely social and economic systems. As global climate change effects multiply, so does awareness of the black swans (unseen droughts, floods, fires, etc.) the new climate condition might carry and their consequences. Resilience thinking has been one of the main approaches used to frame climate change dynamics by aiming to enhance the capability of social systems to adapt to these new climate conditions. Thus, policymakers' agenda now includes resilience-based strategies oriented to protect preferred states of the system from unavoidable and unpredictable disturbances.

However, there is still a sizable amount of work needed before to transform these resilience-based strategies into policies. Particularly, there is a need for developing means to bridge the, so far, mechanistic concepts of resilience with the real world and to overcome current contradictions between resilience and the new public management approaches. Current paper addresses this need by exploring how to use a Dynamic Performance Management approach to support policymaking processes for climate change adaptation and to identify timely mechanisms to deal with the unexpected.

Effects of climate change are now hard to deny. In the past years, climate change has manifested in the rise of temperatures and changes in the rainfall seasonality around the glove. These effects of climate change have shocked our social and economic systems exacerbating water scarcity, hunger and even social conflicts in many parts of the world. Occurrence of unlikely events makes us aware that while black swans (Taleb, 2010) have low probabilities to happen, they are still possible. Moreover, the high impact of some of those unlikely events evidenced the dependence of social and economic systems on their natural counterparts and arose interest in identifying ways to reduce vulnerabilities and foster successfully manage adaptation.

Walker et al. (2004) define resilience as the capacity of a system to absorb disturbance while remaining its essential function. However, even resilience is widely applied, a defining characteristic of the resilience concept in SES literature is that "there is no single theoretical framework under which all resilience-related research is subordinated" (Duit, 2015, p. 5). Instead there is a diverse set of different definitions, concepts and descriptions of what resilience means (Berkers, Colding, & Folke, 2002; Chapin III et al., 2009; Folke, Carpenter, Walker, Scheffer, & Elmqvist, 2004; Walker, Gunderson, Knizig, Folke, & Carpenter, 2006; Walker, Holling,

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Carpenter, & Kinzig, 2004) and, hence, scholars usually refer to the research related to resilience that resilience thinking rather than resilience theory (Walker and Salt, 2006).

Resilience thinking has gained recognition in the context of climate change as a possible framework to analyse systems vulnerabilities and identify potential policies. Resilience has become a common objective of climate change adaptation across a whole range of systems and activities, and it is an overarching concept in many strategies (Heller & Zavaleta 2009; Mawdsley, O'Malley & Ojima 2009).

In the public policy administration domain the idea of resilience is not new, already in the late 1980s Wildavsky (1988) described resilience as a mean to manage risk in the modern societies. Nowadays, resiliance is a familiar concept in the crisis management literature (Aldrich, 2012; Boin, Comfort, & Demchak, 2010). For instance, many scholars in organizational studies aim to understand resilience and responsiveness of social structures (Crichton et al. 2009; Weick and Sutcliffe 2011; Donahue and O'Leary 2012; Boin and van Eeten 2013) and colleagues in the planning domain search for designs that help communities and societies to withstand disturbances (Paton and Johnston 2006; Goldstein 2012). How to translate resilience concept into effective policies, however, is still to a considerable extent unexplored in the public administration domain.

Current research on resilience policymaking is mainly found in the SES domain (Biggs et al., 2012; Chapin III et al., 2009). This literature focuses on the description of those social and natural properties of the system that are hypothesised to foster resilience, like "redundancy", "stakeholder participation" and "understanding of the system". The justification for these properties is found in case study research showing how SES theories enhanced the resilience of a particular outcome of the system to specific disturbances. Downsides in the current literature are: a) lack of quantification of resilience and the impact of the policies to enhance the system resilience, b) absence of a structured process to identify what are the properties of the system that need to be enhanced in each particular case, and c) the political process and power relations embedded in the development and management of public policies are underestimated.

Bianchi and Rivenbark (2012) describe a dynamic performance management (DPM) approach - the combination of system dynamics and performance management systems - as an alternative to output-based performance systems. The DPM approach supports policymaking process by modelling organizational systems (in system dynamics model) and using simulation techniques to understand the behaviour of the complex systems public policies deal with. The significant contribution of DPM is to help policymakers to assess middle and long-term impacts of their actions in the system outputs by placing the measure of performance in a broader context of the system (Bianchi, Winch and Tomaselli, 2008). Alternatively to traditional policymaking approaches, the main focus of DPM is the middle and long term implications of the potential policies in different parts of the system structure and the responses that the observed system's behaviour is likely to give.

To achieve this, DPM operationalizes the analysis of policies on framework grouping three inter-connected views of the system performance (Bianchi, 2012)

1. an “objective” view;
2. an “instrumental” view;
3. a “subjective” view.

The “objective” view opens the policy black-box and dissects the policy final outcomes into a sequence of products or services offered to internal and external clients. This view focuses on the actual activities and process that public bodies execute to implement the policy.

The “instrumental” view focuses on the dynamic structure and performance drivers producing the observed end-results. This view supports identification and understanding of a) the end-results, b) how strategic resources are built and depleted, c) relationships between strategic resources and performance, and d) the importance of these relationships over time.

Finally, the “subjective” view links the previous two views in the context of the pursued objectives by aligning actions and processes to strategic resources and drivers. This view comprehends the targets and explicit ways to measure them.

The combination of these three views supported by simulation techniques represents an ideal framework to operationalize resilience thinking into policymaking since it moves the discussion to practical settings. By using DPM as a framework, policymakers are encouraged to a) define resilience in terms of objective and measurable targets, b) describe the policies with regard to intermediate products and services related to concrete activities and process and c) analyse the system in terms of strategic resources and performance drivers.

Since DPM combines performance management framework with system dynamics methodology, the approach proposed by Herrera & Kopainsky (2015) to conceptualize resilience into SD models is used to measure and compare the policy results. Even though resilience is commonly used as a general property of the system, in practice resilience often refers to a particular outcome of the system that is able to withstand a particular disturbance the system is exposed to (Barker, Ramirez-Marquez, & Rocco, 2013; Henry & Emmanuel Ramirez-Marquez, 2012). These outcomes could be food, housing or safety, for example, and can be represented by a quantifiable and time dependent outcome function *F*(x) (Barker, Ramirez-Marquez, & Rocco, 2013; Henry & Emmanuel Ramirez-Marquez, 2012). Resilience, then, is measured by the ability of the system to maintain the normal behaviour of its outcome function, or bounce it back, after been shocked by a disruptive event. The policy objectives, then, are defined as how to maintain the normal behaviour of *F*(x) or, if it deviates from its normal behaviour, how to increase the system chances to bounce back to it once the disturbance ceases.

In order to measure resilience through the outcome function *F*(x), it is necessary to define a dynamic measure of the disturbance affecting the system. This measure of the disturbance (σ) should account for the magnitude of the disruptive event and for the time the disruptive event lasts (see Equation 1).

$$\sigma = \delta * (t_d - t_e) \qquad (1)$$

δ: magnitude of the disruptive event

t_d: time when the disruptive event ceases

t_e: time when the disruptive event starts

Since resilience is a dynamic and complex concept there is no one single generalized measure for it but rather a set of measures used to conceptualize different aspects of resilience (Frankenberger & Nelson, 2013). The five measures proposed by (Herrera & Kopainsky, 2015) are used in this paper as key indicators for the performance targets. These measures, combine concepts from engineering and ecological resilience paradigms in a system dynamics context. Table 1 presents the proposed measures and their mathematical definition.

Table 1: Measures of resilience in system dynamics models

Paradigm	Measure		Description	Mathematical definition
Engineering resilience	Hardness	σ_M	The ability of the system to withstand a disturbance σ without presenting change in the performance of the outcome function F(x)	$\sigma_M = \delta_M \times (t_d - t_e)$ (2)
	Recover Rapidity	$\bar{R}$	Average rapidity of the system's recover from a disturbance σ (Attoh-Okine et al. 2009)	$\bar{R} = \frac{D-C}{t_f - t_d}$ (3)
	Robustness	$\bar{\rho}$	The ability of the system to withstand big disturbances σ without significant loss of performance (Attoh-Okine et al. 2009)	$\bar{\rho} = \frac{\sigma}{D-C}$ (4)
Ecological resilience	Elasticity	σ_L	The ability of the system to withstand a disturbance σ without changing to a different steady state	$\sigma_L = \delta_L \times (t_d - t_e)$ (5)
	Index of Resilience	I_R	The probability of keeping the current steady state or regime.	$P(S_0 \parallel \sigma)$ (6)

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The case study analysed in this paper shows how resilience can be operationalized to design and evaluate climate change adaptation policies in the public sector. The case study shows that by using DPM, building resilience is not an abstract concept but a well-defined and logical process that helps policymakers to assess long-term perspective policies by shifting their focus from outputs to outcomes driven.

Bridging the instrumental analysis with the public administration practices, the case study shows how DPM can be used to combine the mechanistic approach of resilience thinking with public sector management practices by connecting the instrumental view with subjective and objective ones. The Figure 8 shows how DPM approach links the strategic resources and key performance drivers, through feedback loop mechanisms, with goals, activities, processes and products. The results of the structure analysis are smoothly moved to a performance control agenda. This agenda allows policymakers to plan and control the policy implementation and performance.

Furthermore, the case study shows that DPM can help to evaluate and compare the policies benefits and costs. Translation of the proposed policies into concrete activities and processes, supported by computer simulations, allows to evaluate policies in terms of their costs and benefits. The results of the case study show that resilience is not an absolute, but rather a relative term. Systems can be resilient in different ways and to a different extent. Comparison and selection of policies then requires clear measures to conceptualize their benefits in terms of resilience and understanding of how much benefits each policy delivers against the cost of those benefits. The NPV and value for money analysis are common and necessary in a public administration that deals with scarce funds and needs to prioritize them wisely. Moreover, identification and quantification of key drivers and strategic resources also support the implementation and performance management processes by helping to set targets for performance and clear deliverables.

The successful experience of applying the proposed framework raised the need for further steps in the research to complement it and to overcome some of the framework's current limitations. First, to supplement the results of this study case, more case study research is needed. Different contexts and problems should be assessed as well. Second, in order to draw conclusions about how DPM supports resilience policymaking, it is required to follow up the implementation process to see the policy results in the real system.

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