

# THE ROLE OF INSURANCE IN CRITICAL INFRASTRUCTURE RESILIENCE

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## ABSTRACT

Resilience enhances the traditional risk management toolkit in several aspects, and insurance is an effective risk transfer mechanism that can contribute to increasing resilience. However providing insurance to a CI based on its resilience level is a complicated matter. Resilience is for systems, whereas insurance policyholders are companies, not systems. Beyond the fact that insurance can strengthen resilience and the assumption that resilience can improve insurability, many of the 'needs' from insurance relating to resilience come back to understanding and calculating risk. The SmartResilience Horizon2020 project (2017-2019) considered the problem of how to assess the resilience of a CI and developed a series of indicators and methods for that purpose. Then it considered the problems currently faced by the insurance sector and explored whether such methods could reduce vulnerability to consequences of disruptions, and provide better insurance coverage.

This paper briefly presents some of the outcomes of the SmartResilience project, focusing on (1) the extent to which insurance can enhance resilience, (2) how resilience can improve the conditions of insurability of CI, and (3) how SmartResilience methods can be used for that purpose. There exists a positive feedback mechanism.

## INTRODUCTION

Critical infrastructure (CI) that operate in complex adaptive systems are affected by systemic risks, which are difficult to analyse via conventional risk assessment methodologies. CI and systems with inherent nested interdependencies with others, or that are prone to low-probability, high-consequence events that are difficult to accurately predict or model, must enhance their resilience, i.e. their ability to anticipate, rebound and recover from disruptions. Resilience-based approaches are thus needed to deal with the consequences of disruptions.

From an insurance point of view, the limitations of standard risk-based approaches are visible and increasingly problematic. The insurance sector is increasingly facing accumulation challenges, which requires a systems approach.

This paper comprises three parts: benefits and limitation of insurance to improving resilience, benefits and limitations of resilience to insurance, and contribution of the SmartResilience project. It concludes with a few recommendations for further research.

## 1 INSURANCE CAN ENHANCE RESILIENCE

The insurance industry is a centre of risk expertise in risk assessment. Through the design of insurance policies it can provide clear and well-defined risk and resilience requirements. It has therefore both the ability and the mandate to contribute to infrastructure resilience.

The first reason why insurance can enhance resilience is that insurance provides cash money for fast recovery when a disruption causes an insured damage. More broadly, the insurance industry supports in various ways the strengthening of systems towards increased resilience regarding all of the five resilience phases of the resilience curve (National Academy of Sciences, 2012; Øien, Bodsberg, & Jovanovic, 2018) described in Figure 1 below: (1) understand risk (e.g., increase transparency through better identification of precise risk, assess and price risk, and assess dependencies); (2)

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anticipate/prepare (e.g., enable anticipation through scenario development and emerging risk management, and avoid losses for instance through current innovations such as the use of sensor technology); (3) absorb/withstand (e.g., through increased insurance density as well as additional services); (4) respond/recover (e.g., through innovations such as parametric insurance that accelerate payments as well as through ex-ante financing); and (5) adapt/transform (e.g., establish public-private partnerships or incentivise investments in resilience). (Kunreuther et al., 2016; World Bank, 2017). There is a range of possible ways that insurance can contribute to resilience, yet the starting point is understanding risk.

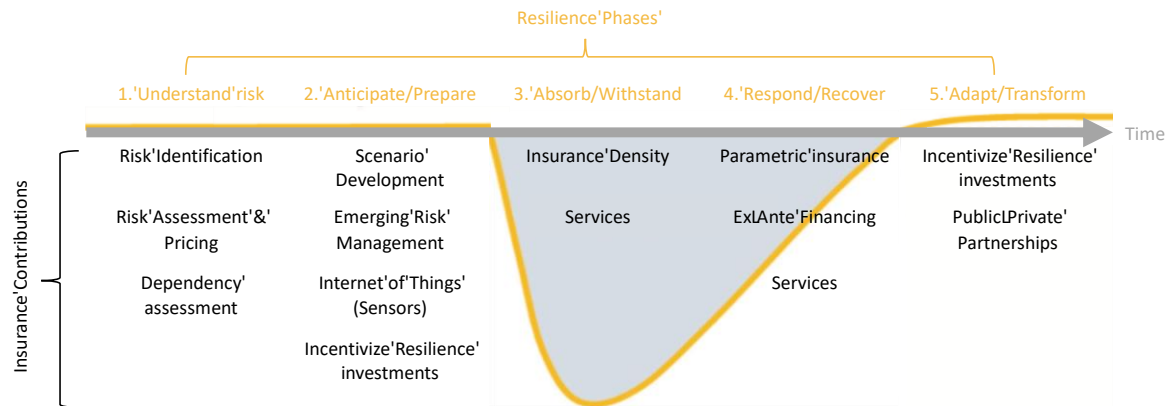


Figure 1: The five phases of functionality in a resilient system (Øien et al., 2018) and insurance contribution

However insurance contribution is constrained by a number of challenges that the insurance sector faces concerning critical infrastructure. This will reduce its capacity to support resilience building through better insurance products. We list some of them below:

- Risk identification. In the context of interconnected CIs, it is first difficult to identify the individual risks and weakest points in the chain. Insurance only covers damage from actual loss events, and only when those have been anticipated and therefore covered in the insurance contract. Second, the individual nodes of a system must be relatively independent of each other.
- Risk quantification. Insurers generally anticipate that quantifying resilience will remain a challenge, and their preference may be for solutions that do not require precise quantification (e.g. probability x severity), such as with parametric insurance. Parametric policies use indicators that are related to a hazard (e.g. wind speed, amount of rain, intensity of seismic activity) rather than the actual damage caused to a policyholder, i.e. a client who subscribes an insurance contract (Moteff, 2012; Cambridge Centre for Risk Studies, 2018).
- Identification of critical nodes in interconnected systems. Strengthening a system's resilience requires to consider the role of certain nodes and dependencies between the individual components. Modeling interdependencies is very complex, and accuracy and reliability may be difficult to prove.
- Incentivizing investment. Investments in resilience are generally difficult to fund, because high present-day expenses are faced with only potential future advantages. In addition, there is rarely one or several risk 'owners' in networks of CIs, so no obvious policyholders of insurance. Solutions similar to community insurance may have to be developed.
- Regulation. There is no overarching regulation that would require overall improvement of resilience levels in CIs. Yet the setting of principles or minimum legal requirement is important to constrain and incentivise the pursuit of socially desirable goals, which insurance can support.

## 2 RESILIENCE COULD IMPROVE THE CONDITIONS OF INSURABILITY OF CI

In a resilient CI the consequences of disruption in the delivery of services to its clients and community are reduced, which improves the attractiveness of the CI to insurers. Traditional infrastructure insurance products are of three types: property damage, business interruption, and third-party liability. In addition, examples for modern insurance products include financial income protection (e.g., protecting energy companies against the negative financial effects of a warm winter) and cyber insurance (e.g., in terms of both physical damage and third-party liability). Where and how can resilience help improve the conditions of insurability in these products or in new insurance products?

In section 1, we have listed a few basic, traditional principles that are required for any risk transfer through an insurance product. These principles remain valid even in a changing risk landscape and in the context of resilience. They need to be considered in any attempt to use resilience in the context of insurance. Furthermore, on-going approaches to resilience and contribution from the SmartResilience project (see section 3) are promising to provide a quantitative assessment of CI resilience, which insurance can use to offer better insurance conditions or new insurance products. So, how could resilience improve the conditions of insurability? What would that mean for resilience-based insurance? We list some elements below:

- Resilience measurement and quantification. Insurance provides compensation for experienced losses. The loss has to be measurable in financial terms. Loss frequency and severity need to be quantified, e.g. through probabilistic models and risk or resilience maps. If higher resilience leads to lower losses and fewer disruptions, this effect needs to be quantified as well.
- One of the factors of resilience is diversification, which is also needed in insurance, where it helps address the problem of systemic risk (IRGC, 2018b) and accumulation. Risks in the insurance portfolio need to be independent of each other to a certain degree to create the pooling effect (law of large numbers). In the insurance portfolio, there has to be a diversification benefit. So it is important to identify critical nodes in interconnected systems.
- Those who work on resilience try to develop and implement standardised methods to measure it, which is also needed in the insurance market. At some point in time, market standards have to be established for both the definition of resilience, for the methods of assessment and monitoring, and for the implementation of resilience frameworks in the market.
- In a resilient CI, interests between policyholder and insurer must be aligned. The loss needs to occur randomly and in particular without influence from the policyholder. This strengthens the positive feedback between resilience and insurance, or between investment in risk reduction and resilience improvement on the one side, and attractivity and business opportunity for insurance and the provision of good insurance conditions on the other side.
- To create incentives for continuous improvement.

### **3 SMARTRESILIENCE METHODS TO ASSESS THE RESILIENCE OF CI**

The SmartResilience project has developed a holistic methodology for the assessment and management of resilience of critical infrastructures, e.g., energy, water supply, and transportation networks (EU-VRi, 2018, Øien et al., 2017, Øien et al 2018).

The project has:

- Identified existing and new indicators suitable for assessing the resilience of critical infrastructures
- Developed a resilience assessment methodology based on the indicators
- Developed an interactive tool to assess the resilience of CIs and to support authorities and CI operators and owners in improving their resilience to disruptions (Jovanovic et al., 2019).
- Applied the methodology and tools in several case studies involving energy, transportation, health, and water infrastructures.

More concretely, the tools developed by SmartResilience provide:

- Two methods to measure resilience. The first method provides a 'resilience level assessment'. It measures each phase of the resilience curve (see Figure 1) indirectly through the selected indicators, without considering the shape of the resilience curve. The second method provides a 'functionality level assessment. It measures the loss of critical functionality directly, considering resilience as inversely proportional to the loss of critical functionality. In this case, the shape of the resilience curve is modelled. For both methods, a hierarchical indicator approach is used for assessing and managing resilience.
- Possibilities to analyze interdependencies within infrastructure systems. Interdependencies can be described with indicators (e.g., indicators of what issues may arise due to dependency from another CI). Then, interdependencies can be assessed at an 'infrastructure-of-infrastructure' level, to analyze the effect and consequences of an incident on several CIs by using agent-based-models.

Further work could be undertaken to use these methods for developing a market standard, which could be translated into specific expected loss assessments and thus insurance conditions to create investment incentives.

## 4 CONCLUDING REMARKS

The insurance industry is a well-established and respected centre of risk expertise. Therefore, to the extent that risk and resilience are linked (IRGC 2016 & 2018b), insurance has both the ability and the mandate to contribute to increasing resilience constructively. The insurance sector is challenged by the evolving risk landscape, that becomes systemic and interconnected, and is interested in participating in the development of innovations, tests, including through trials and errors.

For CIs, the external benefits of insurance to provide coverage around 'resilience' should not be underestimated. In addition to immediate benefits in case of disruption, insurance can also facilitate investment in CIs. Improving the capacity of CI to attract investments (problem of ageing and maintenance, long-term sustainability) is a common critical need. Investments can be from external investors, for example, insurance companies themselves (which are among the largest investors globally). Resilience methods may allow the measurement and mitigation of risks in long-term infrastructure projects and hence make these investments more attractive and sometimes even accessible for insurers. Quite often, long-term risks in infrastructure investments prevent regulated investors like insurance companies to provide funding.

Measurement of resilience through standardized methods for resilience assessment is at the core of all these opportunities and expected benefits. The SmartResilience assessment tools can be valuable methods for providing support to developing the concept of 'insuring resilience'. Key success factors for the adoption and application of resilience assessment tools include robustness, reliability and neutrality, but also practical implementation in the market, which raises issues of market standards, comparability, alignment of interest and trust.

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All SmartResilience public deliverables are available from <http://www.smartresilience.eu-vri.eu/Results>

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