D7.3 BC Models and Adaptation Strategies assessment report

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[1] **R**=Document, report; **DEM**=Demonstrator, pilot, prototype; **DEC**=website, patent fillings, videos, etc.; **OTHER**=other

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ACRONYMS AND ABBREVIATIONS

ARIO	Adaptive Regional Input-Output
BC	Business Continuity
BCP	Business Continuity Plan
BCS	Business Continuity Strategy
B2B	Business-to-business
CC	Climate Change
CH	Cultural Heritage
FDN	Final Demand Node
GDPR	General Data Protection Resources
GVA	Gross Value Added
HR	Human Resources
HRAP	Holistic Risk Assessment Platform
IT	Information Technology

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Executive Summary

Deliverable D7.3, namely “BC Models and Adaptation Strategies assessment report”, documents the work undertaken in Task 7.2 “Assessing Business Continuity Models and Adaptation Strategies”.

Five Business Continuity Strategies (BCSs) are proposed that aim to enable the critical processes of Cultural Heritage (CH) communities to continue operating at least to the minimum needed extent, when those are exposed to Climate Change (CC) or non-CC aggravated hazards severely impacting their critical infrastructure and/or supply chains. Initially, a brief literature review is undertaken on state-of-the-art aspects that are relevant to business resilience as well as to key Business Continuity Plan (BCP) elements. Thereafter, a detailed description of each of the considered BCS is given, along with the relevant advantages and limitations. The first BCS, namely the “do-nothing” strategy, corresponds to the absence of comprehensive risk mitigation planning and is used herein as a benchmark for assessing the performance of the other four strategies. The second BCS involves “reciprocal agreements”, which are deemed to be mutual actions signed between local businesses of similar size that operate within the same sectors to allow for a resilience load balancing. Suitable for service-based businesses, the third BCS is related to a “work-from-home” framework and essentially involves the orientation of several employees to work from their own premises. On the other hand, the fourth BCS, namely “business traffic redistribution” strategy, is more suitable for large organizations operating on a series of interchangeable physical assets, which can satisfy increased demand requests if needed. The fifth BCS is the insurance, a strategy that is always recommended for risk mitigation as it can reduce both the indirect and the direct losses of a disaster. Two insurance approaches are discussed in this deliverable, these being the “traditional indemnity” and the “innovative parametric” insurance. Finally, the deliverable deals with the development of several methods to integrate the aforementioned BCSs in the context of the socioeconomic tool that was developed before in Task 5.5. Through this process, the effect of each BCS to the production capacity of a business sector is demonstrated by realizing several hypothetical disaster scenarios in two HYPERION pilot sites, i.e., the city of Rhodes and the city of Tønsberg. Based on the estimated indirect losses that are predicted for these scenarios per pilot site by means of the socioeconomic analyses, a number of general yet informed guidelines are given for the application of the BCSs on either product- or service-based business sectors.

1 Introduction

1.1 Background

Deliverable D7.3 “BC Models and Adaptation Strategies assessment report” summarizes the work undertaken in Task 7.2, namely “Assessing Business Continuity Models and Adaptation Strategies”. The work in Task 7.2 proposes several comprehensive Business Continuity Strategies (BCSs) that could enhance the socioeconomic, community, and organizational resilience of Cultural Heritage (CH) sites when those are exposed to a spectrum of Climate Change (CC) or non-CC aggravated hazards. The efficiency of the proposed BCSs is evaluated on the basis of the socioeconomic model that was developed before in this project in Task 5.5, namely “Socioeconomic, Community and Organizational Resilience Framework/Engine” and was consequently integrated into the Holistic Risk Assessment Platform (HRAP) engine of HYPERION.

1.2 Scope and objective

The overall objective of Task 7.2 is to analyze a range of BCSs that could enable critical processes to continue operating a least to a minimum required degree even in those cases that the operation of the CH site has been severely affected. Depending on the particularities of each business sector, a specific BCS might be more suitable/efficient than the others. To assess the impact of each BCS, a quantitative approach is adopted, which explicitly exploits the HYPERION socioeconomic tool that is fully supported by the HRAP platform. This deliverable initially focuses on the development of the methodologies that will enable to model the BCS in the context of the aforementioned socioeconomic model. Consequently, each BCS is tested under a series of different CC or non-CC hazard scenarios, to eventually demonstrate their effect on the production capacity of the considered service or product-based business sectors. Ultimately, the proposed adaptation framework is anticipated to (a) support local businesses on finding the best practices to maximize BC and consequently minimize service disruptions and economic losses associated to them and (b) to allow CH operators and managers to define, examine, and undertake meaningful consistent comparisons of different risk mitigation strategies.

1.3 Definition of Business Continuity Strategies

Every company is susceptible to natural (e.g., hurricanes, floods) and man-made (e.g., cyber-attacks, fires) perils, that, in the absence of proper pre- and post-event mitigation planning, can result in severe direct and/or indirect losses. From an economic standpoint, the **direct cost** of an adverse event is the repair or replacement cost of the damaged or destroyed assets, respectively and it is commonly estimated by insurance companies following the occurrence of a disaster (Hallegatte, 2008). On the other hand, the **indirect cost** of an adverse event comprises the off-site business interruption, reduction in property values and stock market effects (Kaushalya et al., 2014). As not all hazards can be averted, enhancing business resilience by adopting efficient Business Continuity Plans (BCPs) currently comprises the state-of-the-art approach for risk mitigation.

BCPs are designed (a) to reduce the impact of a crisis and (b) to rapidly restore conditions to return to the so-called “Business as Usual” state. While for example ISO 22301 (ISO 22301, 2014) specifies some general requirements to implement, maintain and improve resilience, there is no single recommended plan for improving BC. Instead, every organization needs to develop its own dynamic BCP based on its unique characteristics. In this process, the identification of the major faced risks along with the development of the corresponding response procedures, the training and the testing of such steps are deemed to be crucial parameters that largely affect the effectiveness of a BCP. In particular, training and testing is an iterative optimization process that involves initially developing a test methodology, in which the simultaneous testing and training of the disaster recovery team is followed by a BCP revision to improve its efficiency, and consequently this is followed by a simultaneous testing and training phase (Cerullo V. and Cerullo M.J., 2004).

While BCPs are by default business-specific, common BC principles/practices can be adopted by the individual businesses composing a business sector, in order to withstand the faced crises as a group rather than as business units. When widely adopted, these sector-wide plans, that are herein called Business Continuity Strategies (BCS), can enhance business survivability and ultimately protect the economy of the entire CH community. Such strategic approaches can assist regional and local authorities to identify the critical components of their CH communities and prioritize the support to those business sectors during pre-event planning and decision-making.

2 Proposed Business Continuity Strategies

Five BCSs are proposed herein for supporting the economy of a CH site that is subjected to either CC or non-CC aggravated hazards, these being the: (a) do-nothing, (b) reciprocal agreement, (c) work-from-home, (d) business traffic redistribution, and (e) insurance strategies. The first strategy, namely do-nothing, essentially corresponds to the absence of comprehensive damage/risk mitigation planning, and it will be denoted from this point onwards as BCS0. BCS0 will be used as our benchmark to assess the performance of the remaining four BCS (BCS1, BCS2, BCS3 and BCS4, for b, c, d, and e respectively). A detailed description along with the pros and cons of each strategy is provided in the subsequent sections.

2.1 Reciprocal agreement (BCS1)

Reciprocal agreements (or actions) involve two individuals or groups with similar objectives who agree to assist each other (BCS1). Such agreements allow for a resilience load balancing between similar sized local businesses that operate within the same sectors, essentially offering faster business resumption and product/service availability to the CH site residents/visitors following the occurrence of an adverse event. Based on pre-approved mutual actions, reciprocal agreements facilitate rapid response to incidents/disasters affecting the local tourist traffic and revenue streams, thus assisting the survival of the local businesses and the reputation retention of the CH area. Moreover, they offer enhanced flexibility for the supply chain of the CH sites and higher product and service availability rate. However, they require a broad consensus among the local firms, to prevent competitors from seizing the opportunity to take advantage in the pertinent market.

For instance, the hotels operating in a CH area might sign reciprocal agreements to redistribute their traffic to other hotel partners in case one or more of them are experiencing service disruptions. Hence, in case of a disaster that forces several hotels to suspend their operation, the tourists will not have to leave the CH area, but will be directed to the remaining hotel partners of the agreement. A contract will be signed between the disrupted and non-disrupted hotels to share the turnover stemming from the transferred tourists (e.g., 50-50 or 30-70 sharing). Thus, the disrupted hotels will maintain a percentage of their profits, that will assist their survival and quick recovery from the shock. From a business sector standpoint this will retain, not only the Gross Value Added (GVA) of the “Accommodation” sector (assuming that all visitors will agree to be transferred to other hotels), but also the revenue streams of the other tourist-based sectors, such as the “Food and beverage” and the “Retail trade”.

2.2 Work-from-home (BCS2)

Self-explanatory, the work-from-home strategy (BCS2) involves the orientation of several employees to work from their own premises in case that the premises of an organization are adversely affected by a peril. To support BCS2, an organization should develop procedures to ensure data integrity and confidentially, for instance by means of complying with the EU General Data Protection Regulation (GDPR) (Regulation (EU) 2016/679, 2016). Moreover, the employees should be trained to be capable of working remotely or to effectively switch to remote if necessary. Managers and Human Resources (HR) officers should also consider obstacles associated with the transition to the work-from-home such as lack of appropriate equipment, limited remote access to essential files/documents/software, family-work conflict, social isolation, and distracting work environments which could well affect the overall productivity of an organization and the well-being of its employees (Galanti et al., 2021). Recently, the COVID-19 pandemic vastly accelerated the adoption of BCS2, with approximately 50% of the Europeans working from home during the pandemic (Ahrendt et al., 2020) as compared with the only 12% prior to the pandemic. Even during non-outbreak periods, many organizations choose to operate with a large percentage of their employees working from home.

Generally, BCS2 is an effective method to increase the productivity of a business following the occurrence of a disaster, especially when the personnel can quickly adapt to the new working conditions. However, it is more suitable for service-based businesses, like those belonging to the Information Technology (IT) industry, since those do not require physical labor or in-person communication with the costumers. By contrast, product-based businesses like manufacturing or agricultural companies can only partially exploit BCS2 by e.g., orienting the accounting department to work from home. In the case of CH areas that attract a lot of visitors, important business sectors such as the “Accommodation” or the “Food and beverage” are less favored by BCS2 and the owners of such firms may choose a different strategy to cope with facility or vendor disruptions.

2.3 Business traffic redistribution (BCS3)

The business traffic redistribution strategy (BCS3) comprises an intra-organization method to mitigate service loss, by orienting business traffic to other branches of the same organization. Thus, BCS3 is better suited for large companies (e.g., banks, consulting companies) operating in a series of interchangeable physical assets. Interchangeability requires a comprehensive business plan to secure data integrity and real-time communication among the individual branches. Moreover, for businesses that require in-person activities, the branches should be densely placed within the community, so that the costumers can be easily redistributed from the disrupted to the non-disrupted branches/premises.

BCS3 can also be applied on smaller firms that employ only few (or even one) physical premises, by following an in-cast procedure. In particular, if one asset experiences facility and lifeline disruptions (e.g., power outage, structural or non-structural damages), the owner of the business might choose to transfer critical departments to the non-disrupted premises, so that serviceability is maintained at satisfactory levels. Even in the case of one-asset firms, BCS3 can be performed by renting additional workplaces to accommodate the critical departments. However, this procedure can be applied reliably only if a comprehensive BCP secures that such additional workplaces will be available during a disaster and that the personnel of the disrupted departments can be oriented to them without major difficulties.

2.4 Insurance (BCS4)

Insurance (BCS4) comprises a pro-active method to reduce both the direct and the indirect losses resulted by CC or non-CC hazards. Two insurance approaches are considered herein, namely the traditional (indemnity) and the parametric (index) insurance (Lin and Kwon, 2020). In the traditional insurance, after the occurrence of an adverse event that leads to losses (e.g., fire, flood, storm, car accident) the insurer reimburses the insured for the total value of the loss, assuming no limits and deductibles are included in the insurance policy. To quantify loss, a representative from the insurance company assesses the damage. As a consequence of this process, settlement of the claims can be delayed (e.g., six months after the event), which also amplifies the indirect losses, since the businesses are forced to shut down and wait for post-event inspections and insurance assessments to be completed prior to the initiation of any rehabilitation works.

On the other hand, parametric (index) insurance refers to an insurance contract under which the insurer becomes responsible for the payment of an ex-ante agreed or scheduled amount once a parameter (index) has reached a contract-defined threshold. The amount of payment, the parameter, and the third party responsible for verifying that the parameter threshold has been exceeded, must all be specified in the signed contract (NAIC). As for an example, a manufacturing company decides to insure its facilities against earthquake hazards using the following parametric insurance policy: If a seismic event occurs with a magnitude of 5.0 or greater, the insurance company instantly pays €100,000 to the manufacturing company. The third party to approve that the parameter was exceeded is typically a government agency, for example the national earthquake information center.

Recently, there has been a rise of innovative parametric insurance solutions covering a wide range of risks and serving from individual to business clients, or even governments. Parametric insurance can be advantageous compared to more traditional insurance schemes since the insurers benefit from an almost immediate release of their capital holdings given that parametric insurance claims are short-tailed by design. Yet, no matter the particularities of the insurance schemes that were discussed above, insurance is always recommended since, when widely adopted, it can effectively mitigate severe economic losses, ultimately assisting local business to survive the occurrence of a catastrophic event and strengthen the resilience of a community.

Managing the so-called basis risk in one of the key factors for the success of BCS4. In the traditional insurance, basis risk is interpreted as the difference between the actual loss and the amount of indemnification from the insurance contract (Lin and Kwon, 2020). Thus, it can be controlled by insurer's capabilities in risk underwriting and claim assessment. On the other hand, in the parametric insurance basis risk is defined as the deviation of the ex-ante agreed claim from the actual loss. It can be positive when the insurer pays claims to insureds that were either not affected by the adverse event or the capital required to restore the induced damages is lower that the ex-ante claim. However, it can also be negative when the insurer is not obliged to pay claims to insureds that experienced financial losses by perils with intensities below the set thresholds or the capital required to restore the damages is higher that the ex-ante claim. Negative risk basis was reported after a drought in Malawi during the 2015-2016 agricultural season. Malawi had purchased parametric agricultural insurance through the African Risk Capacity, but many farmers had since shifted to a crop that is more vulnerable to drought, however this was not considered in the risk model originally assumed. A payout was not originally triggered because the losses were not estimated to be widespread. After an investigation and recalibration of the model, a payout was triggered (NAIC).

3 Assessment of Business Continuity Strategies

3.1 Description of socioeconomic model and CH sites

Each BC strategy requires a certain degree of involvement by the municipal authorities or the individual firms operating within the CH area so as to enhance the redundancy of the local economy to facility and lifeline disruptions. Thus, depending on the local socioeconomic characteristics and the mitigation strategy of the considered urban region, one BC strategy might be more favorable than others. To demonstrate the impact of the BCS on the recovery process of an economy following the occurrence of a hazard event, the socioeconomic model developed in Task 5.5 and consequently reported in D5.5 "HYPERION resilience framework" will be used herein. This framework is founded on the Adaptive Regional Input-Output (ARIO) model that was initially proposed by Hallegatte (2008) for simulating failure propagations due to supply and demand outages. The model is built upon a business taxonomy approach, which involves the aggregation of the individual businesses that operate on a local community to distinct business sectors. The importance of each business sector to the local economy is reflected by its annual GVA, whose distribution over the year is nonuniform for businesses operating in the tourism industry, in which case it experiences a peak during the high season.

Along with the identification of the supply business sectors, the socioeconomic model employs the following five potential customer categories, that are called "Final Demand Nodes (FDNs)": 1. Residents, 2. Tourists, 3. Government, 4. Investments, and 5. Exports. While both "Residents" and "Tourists" comprise the local consumption component of an economic system, they are treated separately due to their substantially different consumption profile and hence impact on the CH region. The "Government" FDN refers to the government consumption expenditure (e.g., equipment, infrastructure, and payroll) and gross investment. The "Investments" FDN is related to the private domestic investments or the capital expenditures (e.g., purchase of equipment and machineries by a manufacturing company). Finally, "Exports" refer to the total intra/international exports of the CH region economy.

To assess the capacity of a business sector to absorb the initial shock (robustness), respond, and adapt in order to maintain its functionality and hasten recovery (rapidity) (Franchin and Cavalieri, 2014), i.e., its resilience, the socioeconomic model employs for each sector an index that is called performance index (*PerfIdx*) (see Figure 1). Herein, *PerfIdx* is defined as the ratio between the reduced GVA of the business sector following the occurrence of a hazard event and its GVA under ordinary operating conditions (assuming a structurally static economic model, i.e., structural changes over long time periods are ignored). For simplicity, *PerfIdx* is bounded between 0.0 (total loss of performance) and 1.0 (full performance), which implies that a business sector cannot "bounce forward" during the recovery phase (i.e., its GVA cannot increase higher than the pre-event one). Evidently, *PerfIdx* is a multi-variant time function that depends not only on the operability of the considered business sector, but also on the socioeconomic impacts of the disaster on the CH site. For instance, a natural disaster that does not result in direct structural damages to the premises of a business sector, may lead to severe loss of performance (i.e., loss of GVA) due to supply outages or reduction of tourist arrivals during the recovery phase.

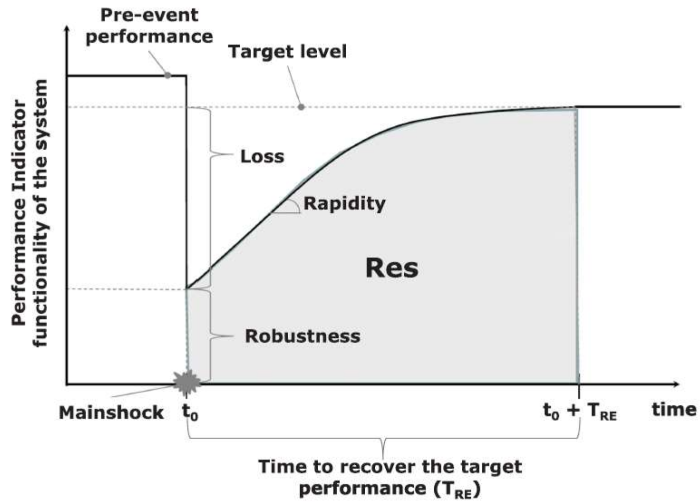


Figure 1: Definition of resilience (Cimellaro et al., 2016).

To depict the individual socioeconomic factors affecting the performance of a business sector, *PerfIdx* is discretized into three distinct components: (a) the infrastructure index (*InfraIdx*) (b) the input index (*InputIdx*), and (c) the output index (*OutputIdx*). The infrastructure index (*InfraIdx*) measures the reduced production capacity of a business sector due to facility and lifeline disruptions, while the input index (*InputIdx*) is used to account for the supply outages. Finally, the output index (*OutputIdx*) is introduced to account for the propagating reduction in the demand during the post-event recovery phase, a condition that is likely to lead into severe economic losses even for businesses that remain fully functional in terms of indices (a) and (b). At each time step, a distinct set of (*InfraIdx*, *InputIdx*, *OutputIdx*) is calculated for each business sector, following a hybrid (macro/microscopic) methodology to account for cascading failures and socioeconomic impacts. Ultimately, the overall performance index *PerfIdx* is calculated as the minimum value of its three key sub-indices:

$$PerfIdx = \min(InfraIdx, InputIdx, OutputIdx) \tag{1}$$

Two CH sites were used as testcases for assessing the impact of the considered BCSs: the city of Rhodes and the city of Tønsberg. Both cities have approximately 50,000 inhabitants based on the latest demographics (“Rhodes (city)”, 2022; “Tønsberg”, 2022). They also constitute two out of the four demo sites that were considered by the HYPERION project, comprising several CH assets with significant natural beauty and historical value. As a result, they attract a lot of domestic/international visitors, who vastly affect the structure of the local economy. The importance of tourism can be demonstrated by examining the GVA of each business sector operating in those CH sites.

Table 1: Business taxonomy for the city of Rhodes (23 business sectors).

#	Full Name	GVA (€ mill.)	GVA (%)
1	Wholesale trade, except of motor vehicles and motorcycles	112.80	13.81%
2	Real estate activities	93.99	11.51%
3	Retail trade, except of motor vehicles and motorcycles	64.10	7.85%
4	Accommodation	60.15	7.37%
5	Food and beverage services	50.31	6.16%
6	Education	44.65	5.47%
7	Human health and social work activities	36.22	4.43%
8	Business, scientific and technical activities	33.77	4.13%
9	Warehousing and support activities for transportation	28.41	3.48%
10	Wholesale and retail trade and repair of motor vehicles and motorcycles	24.27	2.97%
11	Financial services and insurance activities	23.27	2.85%
12	Manufacturing	23.00	2.82%
13	Creative, arts and entertainment activities	20.18	2.47%
14	Agriculture, forestry, fishing	12.44	1.52%
15	Water transport	34.30	4.20%
16	Land transport and transport via pipelines	32.33	3.96%
17	Electricity, gas, steam and air conditioning supply	31.85	3.90%
18	Public administration and defense; compulsory social security	21.52	2.63%
19	Construction	12.13	1.49%
20	Media and communication	10.54	1.29%
21	Air transport	9.48	1.16%
22	Sewerage, waste collection, treatment and disposal activities; materials recovery, remediation activities and other waste management services	7.38	0.90%
23	Other services	29.64	3.63%
SUM		816.71	100%

With respect to the city of Rhodes, we employed a combination of the 1-digit and 2-digits business classification of the NACE rev. 2 taxonomy (Eurostat, 2008) to define a simplified taxonomy that consists of 23 business sectors. The identified business sectors were those with the highest GVAs, while the rest were aggregated for simplicity to a single sector, namely "Other services". The adopted business taxonomy for the city of Rhodes is given in Table 1, along with the annual GVAs for each one of the identified business sectors, using the economic data provided by the Hellenic Statistical Authority (ELSTAT). As the city of Rhodes is a popular tourism destination, the "Accommodation" (hotels, BnBs, etc.) and "Food and beverage" (restaurants, bars, etc.) sectors reflect a large percentage of the city's overall annual GVA. On the other hand, sectors such as "Manufacturing" or "Agriculture" are less important in terms of annual GVA, which indicates that Rhodes relies on external vendors for essential supplies, mainly via marine transportation. Finally, sectors #15 to #22 are related to critical infrastructure, whose impact to the community is considered via the *InfraIdx*.

Table 2: Business taxonomy for the city of Tønsberg (20 business sectors).

#	**Full Name**	**GVA (€ mill.)**	**GVA (%)**
1	Retail trade	181.51	14.76%
2	Technical / scientific	129.11	10.50%
3	Business services	126.20	10.26%
4	Agency and wholesale trade	107.08	8.71%
5	Construction	97.67	7.94%
6	Real estate activities	92.18	7.50%
7	Food Industry	87.15	7.09%
8	Other industry/services	65.01	5.29%
9	Childcare and education	37.19	3.02%
10	Land transport and transport via pipelines	33.21	2.70%
11	Rental of labor (temp agencies)	19.50	1.59%
12	Serving (Restaurant)	16.16	1.31%
13	Activities (Culture)	13.08	1.06%
14	Process Industry	1.71	0.14%
15	Accommodation (Hotel)	1.56	0.13%
16	Public administration and defence; compulsory social security	86.75	7.05%
17	Telecommunications and ICT	67.33	5.48%
18	Healthcare	49.25	4.01%
19	Electricity, gas, steam and air conditioning supply	18.05	1.47%
20	Sewerage,water supply	0.00	0.00%
SUM		1229.69	100%

For the city of Tønsberg, a business taxonomy was realized using economic data from the 2020 regional analysis of Norway's counties (Telemarksforsking). The developed business taxonomy, that is outlined in Table 2, consists of 20 distinct business sectors. As expected, "Retail trade" comprises the most critical business sector (i.e., the one with the highest GVA) for Tønsberg, since Tønsberg is traditionally defined as a trading town and a regional center where thousands of visitors come for shopping. However, given that most visitors only come for day trips and have their own holiday premises nearby, Tønsberg is not considered being a holiday destination such as the city of Rhodes, in which case tourists spend more time and hence should stay in hotels. As a result, there is a limited number of hotels and overnight stays in Tønsberg, a condition that is also reflected in the relatively low annual GVA of the "Accommodation" sector. On the other hand, the "Technical/scientific" and "Business services" sectors occupy a large percentage of the city's annual GVA, since Tønsberg hosts several firms related to Information and Technology (IT) and communication e.g., cloud services, cloud storage, IT consultant, e-commerce services, web design.

3.2 Socioeconomic impact analysis

The main goal of the proposed BC strategies BCS1 to BCS4 is to hasten the intra-sector recovery process, i.e., to mitigate service losses due to facility and lifeline disruptions. In this sense, they affect the *InfraIdx* of a business sector rather than its stocking capabilities (i.e., the *InputIdx*). An efficient BCS may also target to increase the redundancy of a business to supply disruptions by e.g., being able to quickly switch to other vendors or increasing the stock. However, in the scope of the present analysis, such BCSs will not be examined. As a result, the optimal BCS will be identifying on the basis of its capacity to minimize the reduction of the *InfraIdx* right after the occurrence of the disruptive event (robustness) and to rapidly restore its value to 1.0 (rapidity).

In the absence of efficient BC plans, i.e., the do-nothing strategy (BCS0), the owners solely rely on their inherent resilience of their businesses and community to survive the shock. For cases were the company experiences the consequences of critical infrastructure and lifeline disruptions, BCS0 is indeed a rational choice. For example, if several retail stores shut down temporarily due to power outages, the owners (or the decision-makers) may conclude that it is more profitable to wait for the electricity to be restored rather than e.g., activate the business traffic redistribution (BCS3). However, if the disaster causes extensive damages to the facilities of a business, BCS0 more likely will not reflect the optimal choice since the business owners have to rely on their own funds for the restoration of the facilities, and hence their revenues will be harshly reduced.

From a business sector perspective, BCS0 still allows for a limited intra-sector redistribution of traffic, by exploiting the so-called overproduction capacity. Businesses, indeed, are rarely operating in their full production capacity and labor and hence they are often able to increase their production during a crisis (Hallegatte, 2008). For instance, if 50 out of 100 hotels are forced to shut down as a result of infrastructure damages caused by a catastrophic event, the actual *InfraIdx* of the "Accommodation" sector might be greater than 50/100=50%, as the remaining 50 hotels may have available rooms to serve a certain portion of the extra demand that was created due to the loss of functionality of the hotel premises that were damaged. However, if the disaster occurs during high season, the non-disrupted hotels will probably be fully booked and they will not be able to satisfy the increased demand.

In the socioeconomic model, two overproduction approaches are offered:

a) Time-independent overproduction: At each time step, *InfraIdx* is multiplied by a constant overproduction factor. For instance, if right after the shock the "Retail trade" sector has *InfraIdx* = 0.6 and the remaining 60% can overproduce by x1.1, eventually resulting in an *InfraIdx* = 0.66. Figure 2 shows the effect of two overproduction factors, x1.1 and x1.15, to the post-recovery process of a business sector.
b) Time-dependent overproduction: Essentially a time function is given for the overproduction factor to account for the increased demand during high season. In the example applications, this approach was used for the "Accommodation" sector as in case of several hotel shutdowns, it is difficult to create new dwelling/rooming units.

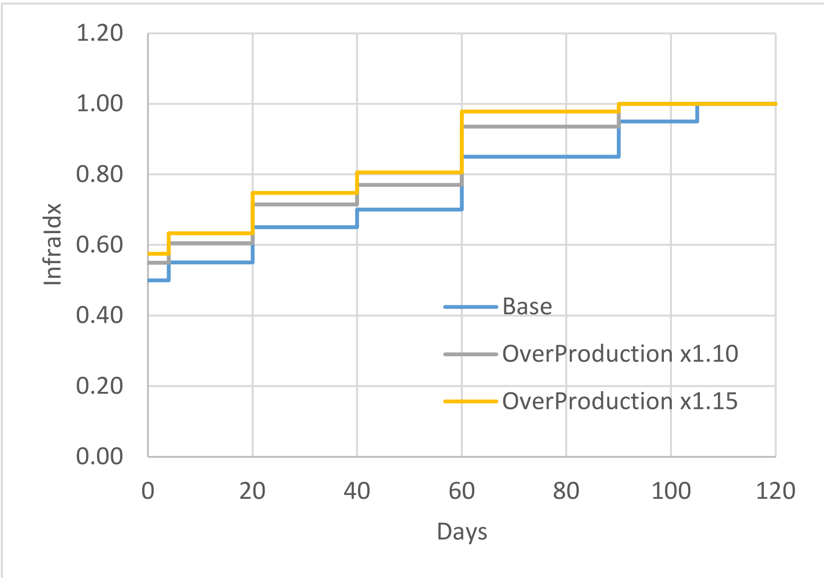


Figure 2: Effect of overproduction to the post-event recovery process of a business sector (two overproduction factors are shown, x1.1 and x1.15).

3.2.1 Assessment of BCS1

The reciprocal agreement strategy (BCS1) is based on pre-approved mutual actions to redistribute business traffic and to ultimately increase *InfraIdx*. BCS1 is advantageous with respect to overproduction, as the redistribution is performed in a systematic manner that protects the impacted businesses. In particular, the resilience load balancing that is offered by reciprocal agreements can enhance business survival, as the owners of the disrupted firms maintain a percentage of their revenue. In case of "intra-community" reciprocal agreements, i.e., mutual actions signed between businesses operating inside the CH community, BCS1 can be modelled similarly to the overproduction. Essentially, the disrupted businesses will transfer the demand to the non-disrupted ones, which will then increase their productivity, to the extent their production capacity and labor allows.

Reciprocal agreements can also be signed with businesses outside the CH area, however inside the municipality limits, so that business traffic can be transferred with limited costumer dissatisfaction. For example, near the city of Rhodes there are small villages such as Faliraki, Lindos, Kremasti, etc., which comprise several accommodation assets that can assist the principal city in case of service disruptions. In the socioeconomic model these "intra-municipality" reciprocal agreements are modelled somewhat differently with respect to the intra-community ones. Specifically, we assume that in the region near the CH community there are always available facilities to satisfy the demand, e.g., in the villages near the city of Rhodes there are always "backup" rooming units to transfer the tourists from the damaged hotel premises. In this sense, instead of multiplying the *InfraIdx* by an overproduction factor, we instead add a constant value to account for the backup capacity of the relevant business sector (e.g., +0.15 or +0.30 back up capacity, see Figure 3).

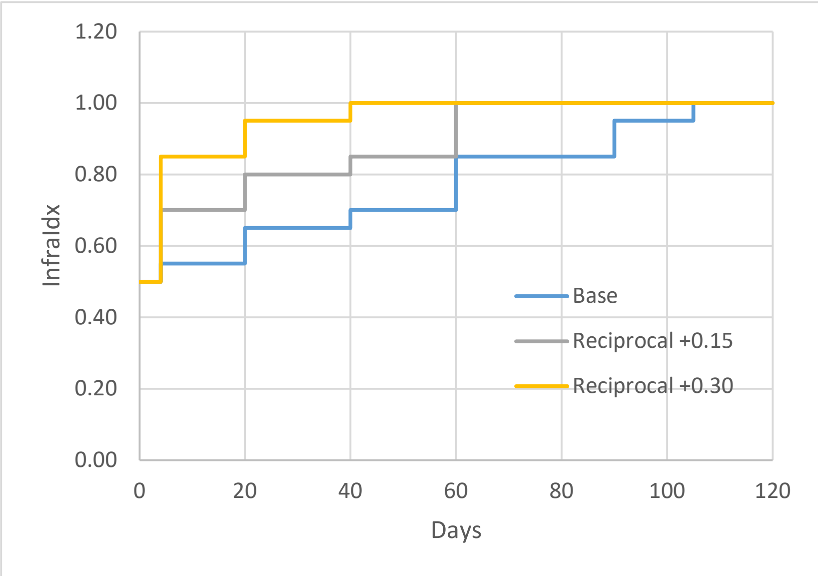


Figure 3: Effect of intra-municipality reciprocal agreements to the post-event recovery process of a business sector (two extra backup capacities are shown, +0.15 and +0.30).

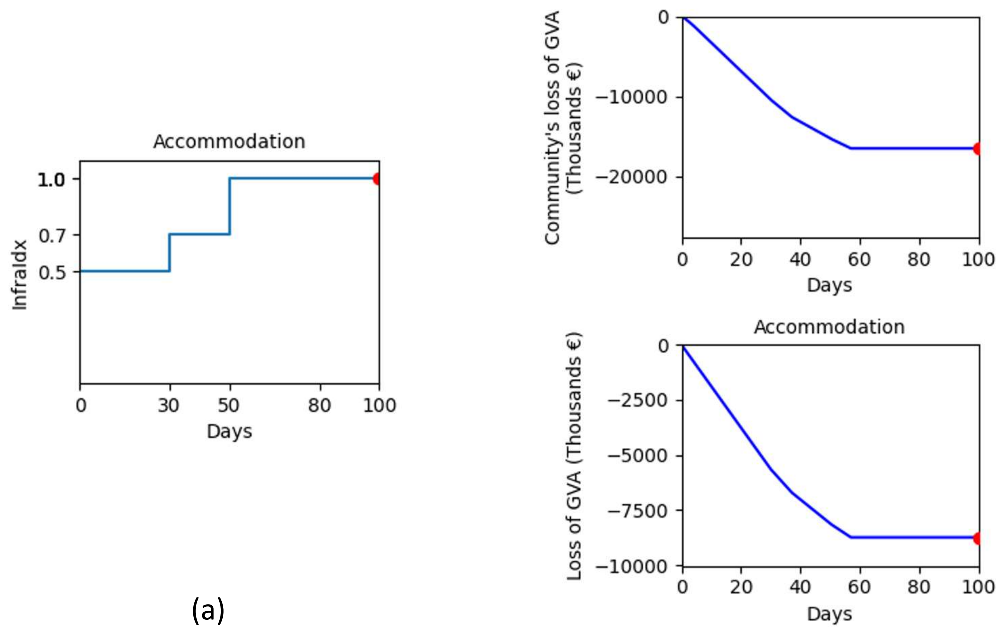
To demonstrate the effect of the two BCS1 approaches, a disaster scenario is considered for the city of Rhodes. The damage scenario assumes that a peril results in damages to the "Accommodation" business sector, forcing the 50% of hotels to shut down, i.e., *InfraIdx* = 0.5. This damage scenario (as well as those that follow) was considered only for illustration purposes, since, apparently, it is highly unlikely the occurrence of a hazard event to directly damage the infrastructure of only one business sector. The disastrous event was assumed to take place during high season, (e.g., 1st of June 2022), a month that is vital for several tourism-based firms that are operating in Rhodes. Three BCS were compared:

a) BCS0 without any overproduction (as a baseline). Essentially, this reflects the case where no rooming units are available to increase the *InfraIdx* of the

"Accommodation" sector following the destructive event, and a total of 50 days is needed for the damaged hotels to fully recover.

b) BCS1 with intra-community reciprocal agreements. As the disruptions occurred during high season, the non-disrupted hotels can accommodate a limited number of tourists, by increasing their production capacities only by x1.1.
c) BCS1 with intra-municipality reciprocal agreements. The backup rooming units in the nearby villages allow for a +0.25 increase of hotels' *InfraIdx*. However, the mutual actions foresee a 50-50 share of the revenue, and thus a percentage of the city's GVA related to the accommodation sector is transferred to the nearby villages.

Figure 4(a)-(c) illustrate the impact analysis results from the socioeconomic model for the three considered BCSs. The left-hand side of each figure shows the downtime diagram of the "Accommodation" sector as this is depicted by the *InfraIdx*. For the BCS1 scenarios (i.e., Figures 4(b)-(c)), the so-called "enhanced" *InfraIdx* is considered, which takes into account the increased productivity of the sector due to the reciprocal agreements. In particular, if at any time instance the demand (i.e., *OutputIdx*) of the "Accommodation" sector is higher than its capacity (*InfraIdx*), the reciprocal agreements are activated and the tourists are transferred to alternative rooming units. For instance, right after the occurrence of a disaster that reduces the accommodation capacity of pertinent sector, the *InfraIdx* of the hotels could be increased from 50% to 55% and 75% for the intra-community and the intra-municipality BCS1 options, respectively.



(a)

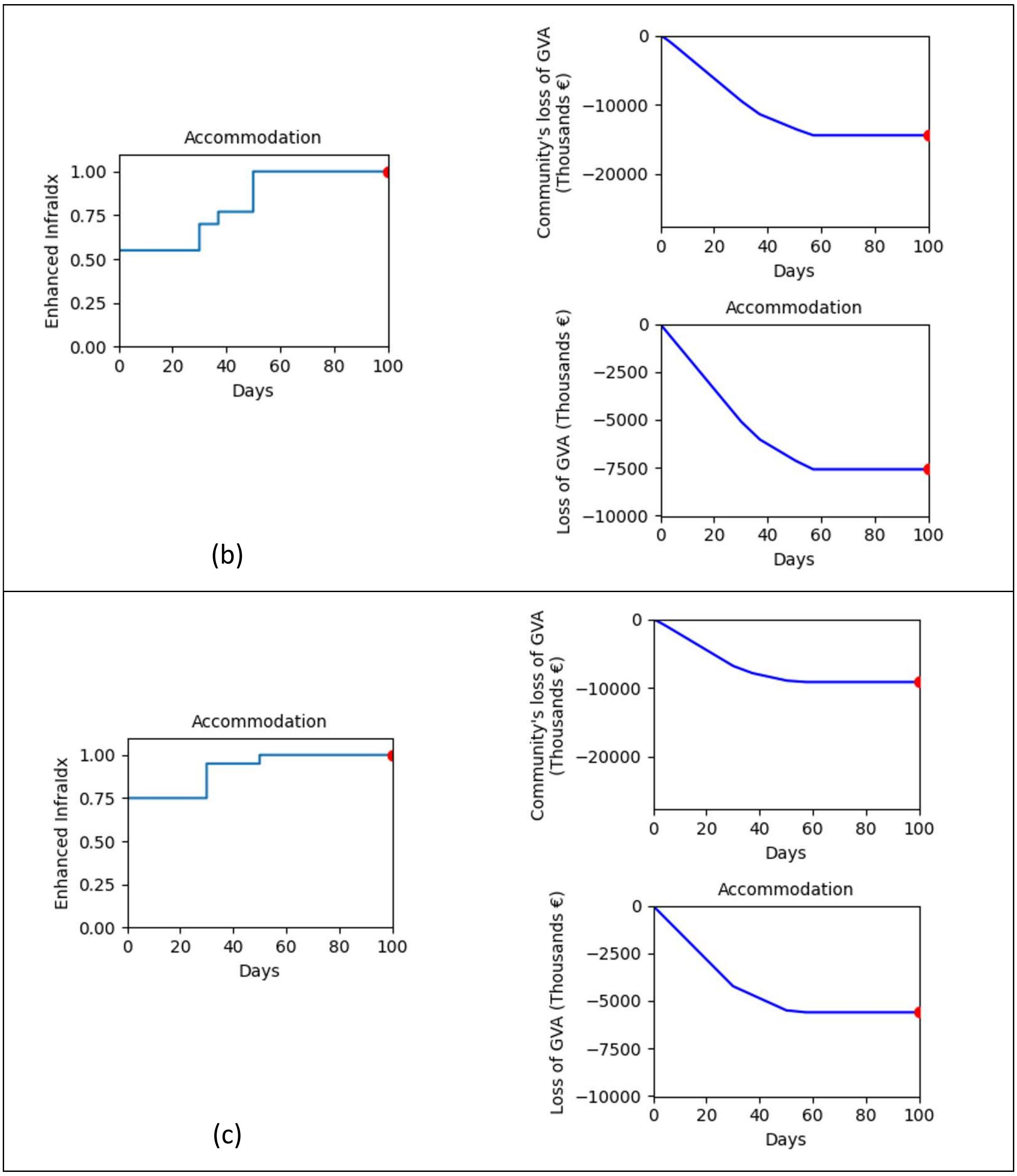


Figure 4: Hypothetical disaster scenario for the city of Rhodes that occurs during high summer season and impacts only the “Accommodation” business sector. Three BC strategies are considered: (a) BCS0 without overproduction, (b) intra-community BCS1, and (c) intra-municipality BCS1.

The estimated indirect economic losses of the “Accommodation” sector as well as the entire CH community are illustrated on the right-hand side of Figure 4(a)-(c). When no BC strategies were considered (i.e., BCS0, Figure 4(a)), a disaster that reduces the capacity of the accommodation sector by 50% results in indirect losses for the sector and the community that amount to 8737.8 and 16525.1 thousand euros, respectively. Evidently, disruptions in the “Accommodation” sector forced many tourists to leave the CH area, cutting also the revenue streams of other business sectors, such as the

"Food and beverage" or the "Retail trade". When intra-community reciprocal agreements were assumed, the estimated sector and community indirect losses were slightly reduced, compared to the "to-nothing" strategy, to 7590.7 and 14404.9 thousand euros, respectively. In this example application, the economic benefits from the intra-community BCS1 were relatively low due to the very limited number of available rooming units within the historical city of Rhodes during high season.

On the other hand, intra-municipality reciprocal agreements result in more notable loss reductions, reducing the sector and community indirect losses to 5604.8 and 9134.6 thousand euros, respectively. This is due to the several backup lodging assets that are available in the intra-municipality area which could accommodate the directed visitors from the damaged hotel properties. In this case, the generated revenue from this transfer of visitors is being equally shared between the city of Rhodes and the nearby villages. Yet, as the *InfraIdx* of the "Accommodation" sector was increased by +0.25, even a 50-50 share is more beneficial profit-wise compared to the other BCSs. Moreover, the traffic of the local tourists was maintained inside the CH area, assisting the survival of the remaining business sectors, whose *OutputIdx* (i.e., the demand) was maintained at a satisfactorily adequate level.

3.2.2 Assessment of BCS2

The work-from-home strategy (BCS2) can effectively restore the production capacity (i.e., *InfraIdx*) of a service-based business sector in cases where the physical presence is restricted, e.g., due to social distancing measures or facility/infrastructure disruptions. In the proposed socioeconomic model, a simple procedure to model BCS2 for a business sector was adopted. In particular, it was assumed that x% of the firms comprising the sector of interest are capable of shifting to remote working if needed. If at a given time instance the sector's *InfraIdx* is reduced to y ($y < 1.0$), BCS2 is activated and *InfraIdx* increases to $y + (1-y)\cdot x\%$. One may also consider a delay time that is required for the BCS2 to be activated. For instance, Figure 5 illustrates the effect of two work-from-home percentages (i.e., x equal to 30% and 50%) on the production capacity, where a total of 4 days was assumed as the time needed for the businesses to switch to remote working.

For illustration purposes, a hypothetical disaster scenario was assumed for the city of Tønsberg, which occurred during winter and resulted in facility damages to the "Business services" sector. For safety reasons, 60% of the companies decided to temporarily prohibit the physical presence in their premises, a decision that resulted in the *InfraIdx* being dropped to 0.4. It was also assumed that a total of 90 days was needed for the post-event inspections and the rehabilitation works to be competed and consequently to restore the *InfraIdx* of the sector to 1.0. The "Business services" sector comprises firms with business-to-business (B2B) activities, such as training, consulting, marketing, software services, etc. As a result, intra-sector redistribution of traffic, e.g., by signing reciprocal agreements, is apparently not an efficient impact mitigation strategy, as businesses are reluctant to change their B2B partnerships. A more efficient BCS is to maintain the production capacity of each firm, by orienting employees to work from their own premises (BCS2). Herein, three BC strategies were tested and consequently compared:

a) BCS0 without any overproduction.
b) BCS2 with 40% of the companies being able to shift to work-from-home.
c) BCS2 with 70% of the companies being able to shift to work-from-home.

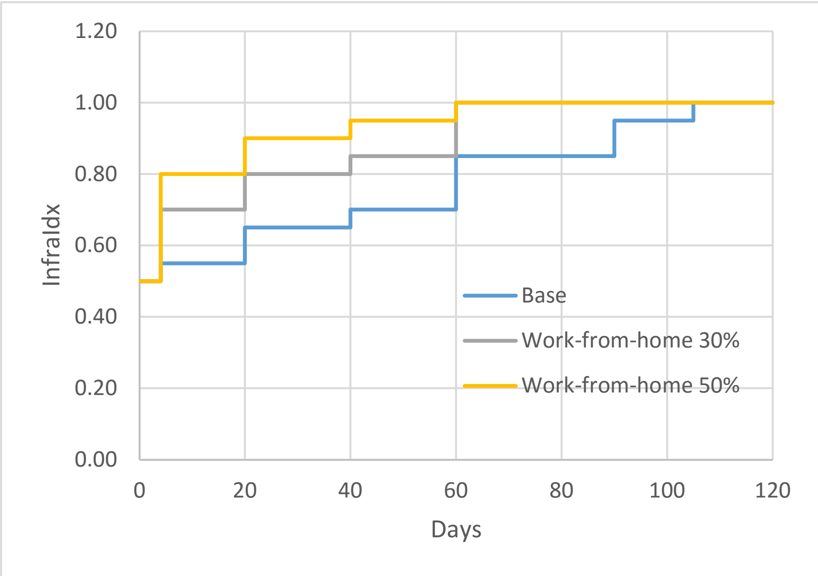
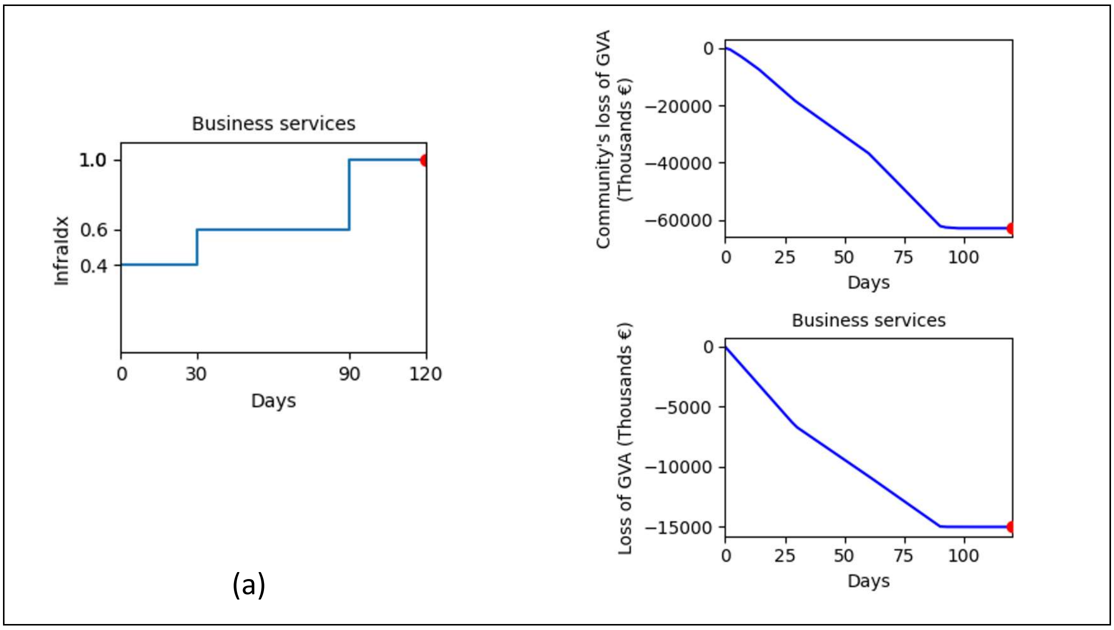


Figure 5: Effect of work-from-home strategy to the post-event recovery process of a business sector.



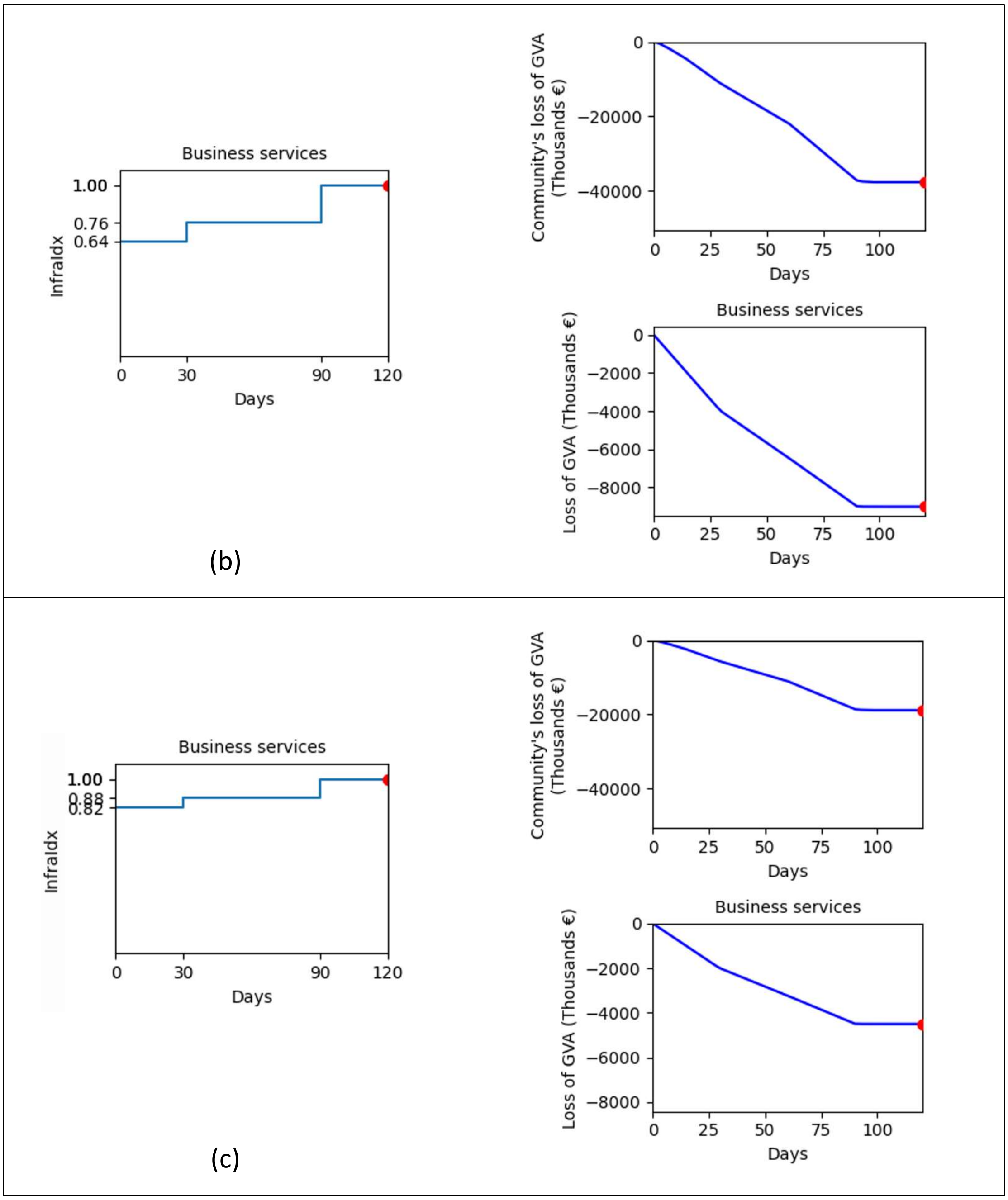


Figure 6: Disaster scenario for the city of Tønsberg that occurs during winter and impacts "Business services". Three BC strategies are considered: (a) BCS0 without overproduction, (b) 40% BCS2, and (c) 70% BCS2.

Figure 6(a)-(c) shows the results of the socioeconomic analysis for the three considered BCSs. In case that no damage mitigation planning is adopted (i.e., BCS0) the hypothetical disaster scenario resulted in sector and community indirect losses that are equal to 15014.5 and 62901.1 thousand euros, respectively (see Figure 6(a)). Evidently, the functionality of several business sectors such as "Telecommunication and ICT", "Process Industry", or "Technical / Scientific" was affected by the disruptions in the "Business services" sector, and this was reflected to the reduction of their

InputIdx. Since B2B partnerships are crucial for the proper function of several firms, the indirect losses of the community that are predicted by the socioeconomic model are high yet might somewhat overestimated. This overestimation is a consequence of the Tønsberg being examined as a closed economic system, while in reality, a company can easily develop intercommunity B2B relations. In other words, the analyses undertaken herein did not consider for the effect of imports when calculating *InputIdx*. Nevertheless, in the considered example application that was formulated herein for illustration purposes such effects were not modelled. Nevertheless, this is an expansion of the socioeconomic model that will be considered in its future versions.

On the other hand, when 40% of the companies were able to switch to remote working, the estimated sector and community indirect losses were evaluated to be 9008.7 and 37740.7 thousand euros, respectively (see Figure 6(b)). Clearly, BCS2 can effectively mitigate severe economic impacts by increasing the *InfraIdx* of important service-based firms, assuming that pro-active measurements have been taken to secure data integrity and rapid personnel adaptation. When 70% of the businesses adopted BCS2, the sector and community indirect losses were estimated being equal to 4632.4 and 19223.4 thousand euros, respectively (see Figure 6(c)).

3.2.3 Assessment of BCS3

In the business traffic redistribution strategy (BCS3), demand is oriented to other branches of the same organization. This strategy essentially comprises an intra-organization method to increase *InfraIdx*, by relying on the overproduction capacities of a company's own non-disrupted branches. In the proposed socioeconomic model, BCS3 is accounted for by means of a multiplication factor (e.g., x1.1 or x.1.0) that is applied to sector's *InfraIdx*. This factor is activated only when the demand becomes greater than the production capacity. For example, a hypothetical hazard event is assumed for the city of Tønsberg that occurs during winter and damages the facilities of the "Food industry" sector. Tønsberg accommodates one of the largest meat companies in Norway, which is reflected by the high revenue produced by the food sector (7.09% of city's total GVA, see Table 2). For the aforementioned disaster scenario two BCSs were tested:

a) BCS0 without any overproduction (to serve as our baseline).
b) BCS3 with x1.25 redistribution capacity. The company transfers its manufacturing machinery and equipment from the disrupted assets to the non-disrupted ones (e.g., by rearranging old facilities used for stocking purposes).

The hypothetical disaster scenario on which the efficiency of the different BCSs will be tested, assumes the occurrence of a catastrophic event that results in a 40% reduction of the industry's production capacity (*InfraIdx* = 0.6) and a total of 4 months as the repair time needed for the damages to be fully restored. The results of the socioeconomic analysis are presented in Figure 7(a)-(b) for the two BCSs. In the do-nothing approach (BCS0) the estimated indirect losses of the "Food Industry" and the entire city of Tønsberg were found to be equal to 10219.2 and 28766.2 thousand euros, respectively (see Figure 7a). It should be pointed out that, apart from the direct impact of the damage scenario on the food industry, sectors such as the "Wholesale trade" are also experiencing minor supply bottlenecks, since the meat product wholesalers will reduce their exports. On the other hand, when the business traffic redistribution strategy was activated (BCS3), the food industry was able to increase its *InfraIdx* from 0.6 to 0.75, and the estimated sector and community loses were reduced to 5518.3 and 14813.8 thousand euros, respectively (see Figure 7(b)).

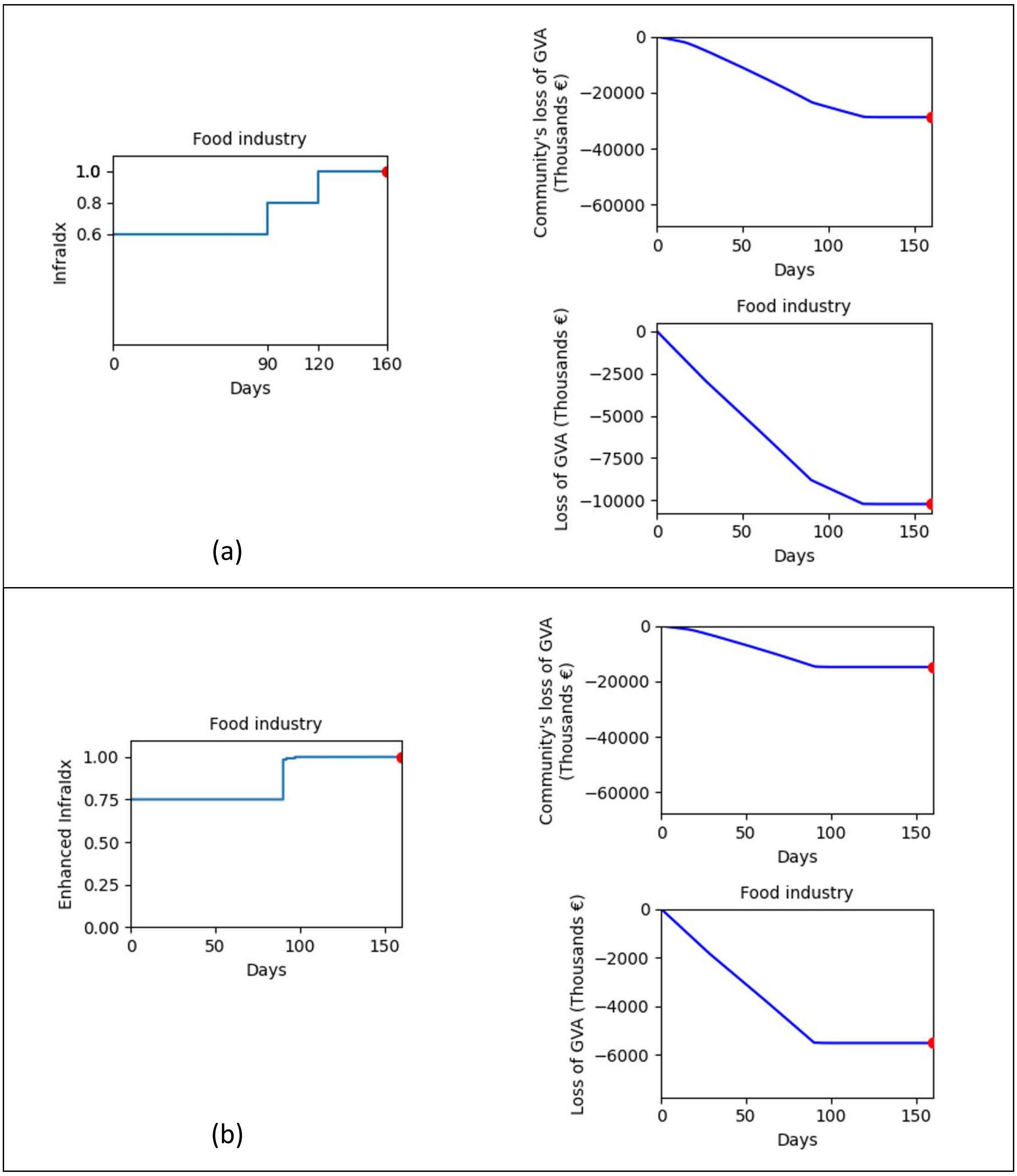


Figure 7: Disaster scenario for the city of Tønsberg that occurs during winter and impacts "Food industry". Two BC strategies are considered: (a) BCS0 without overproduction, (b) BCS2 with 25% overproduction capabilities.

3.2.4 Assessment of BCS4

The insurance strategy (BCS4), when widely adopted, can effectively mitigate both the direct and the indirect losses of a business sector. In the proposed socioeconomic model, BCS4 can be modelled by increasing the rate at which *InfraIdx* is restored, as it is shown in Figure 8. As can be inferred from this figure, when no insurance is adopted (base case), business owners rely on their own funds to repair the damaged assets in case of a catastrophic event and as a consequence, the restoration processes are likely to be delayed (i.e., *InfraIdx* increases slowly) or even aborted (i.e., *InfraIdx* < 1.0 at $t = \infty$). On the other hand, traditional insurance can enhance the sector's recovery capacity by providing claim payments to the impacted companies. The payments are distributed after the insurance companies conclude with the damage assessment, a process that however could take several months (e.g., 3 months in the example presented in Figure 8). By contrast, parametric insurance can offer a faster increase of the *InfraIdx*, thanks to the immediate pay-outs when the intensity parameter exceeds the set threshold value.

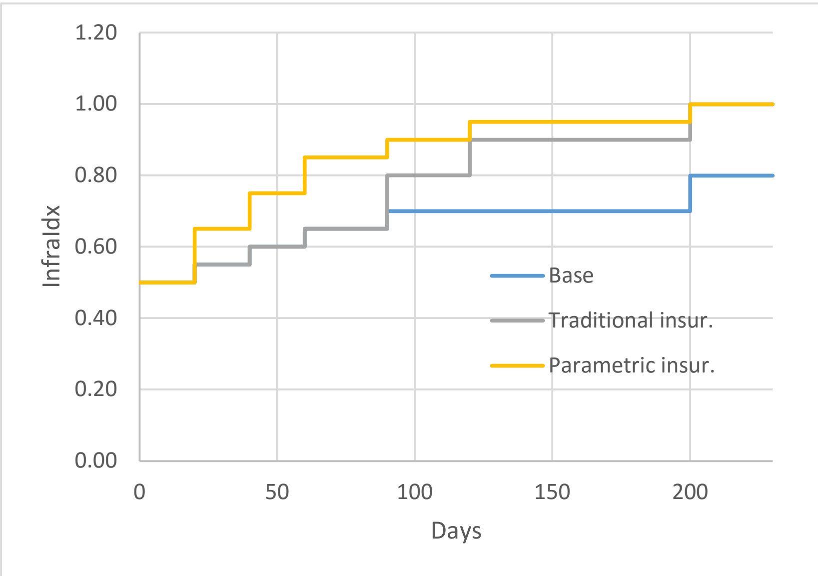


Figure 8: Effect of insurance to the post-event recovery process of a business sector.

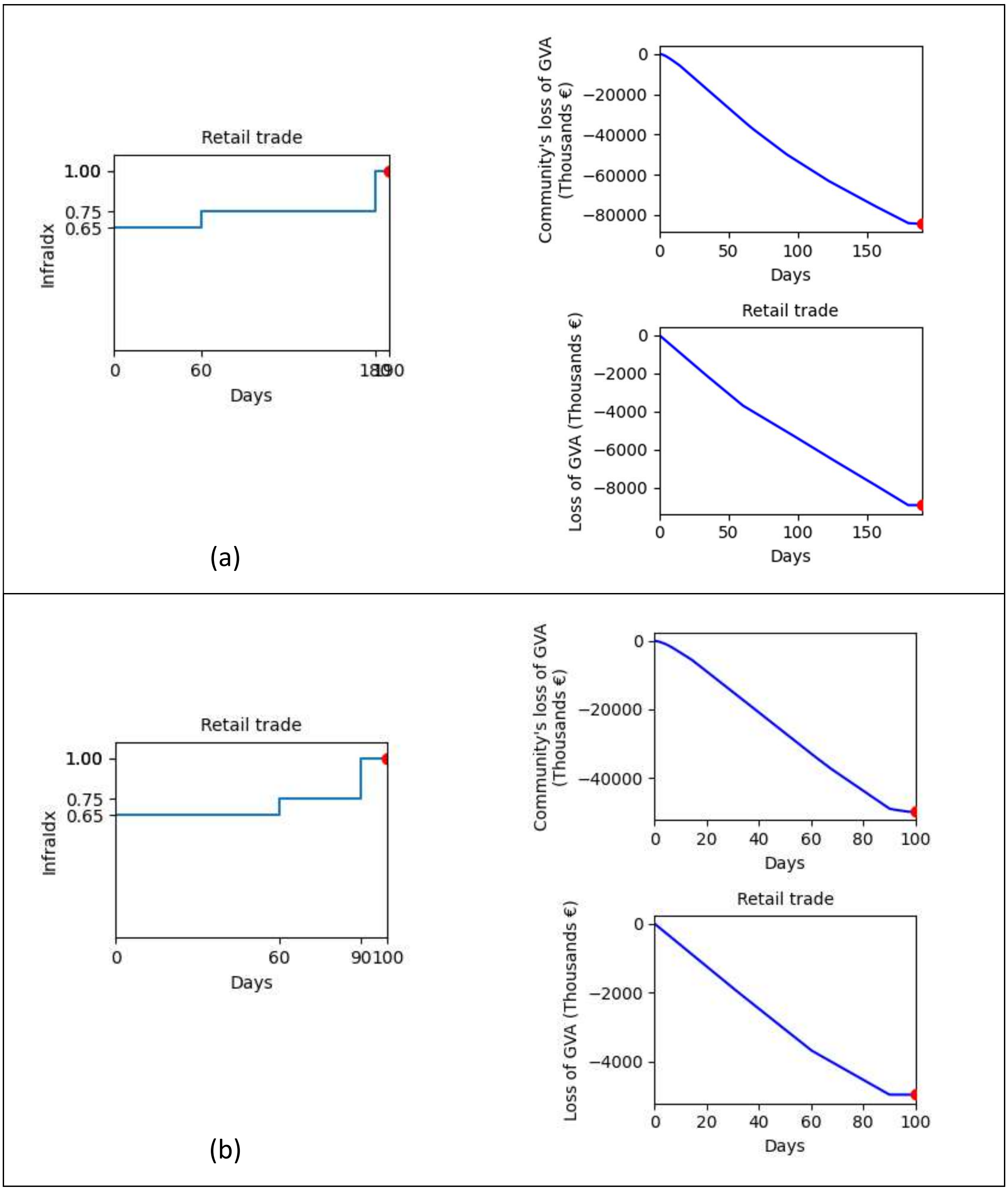
To demonstrate the effect of the two BCS4 approaches, a hypothetical disaster scenario is considered for the city of Rhodes. The damage event was assumed to occurr during summer and to result in facility damages in the "Retail trade" sector. As a consequence of these disruptions, 35% of the retail stores were forced to stop their normal operations (i.e., *InfraIdx* = 0.65).

Three BCSs were tested under the aforementioned disaster scenario:

a) BCS0 without any overproduction. From the 35% disrupted retail stores, the 10% was able to repair the damages after 2 months. On the other hand, the remaining 25% had to seek for external funds to repair their facilities, a procedure that extended the restoration time to 6 months.

b) BCS4 with traditional insurance policy. A total of 3 months was required for the damage assessment and rehabilitation procedures to restore sector's productivity to 100%.

c) BCS4 with parametric insurance policy. Assuming that no negative basis risk was reported, payout started immediately after the event and repair works were initiated after 20 days. A total of 2 months was required for the "Retail trade" sector to restore sector's productivity to 100%.



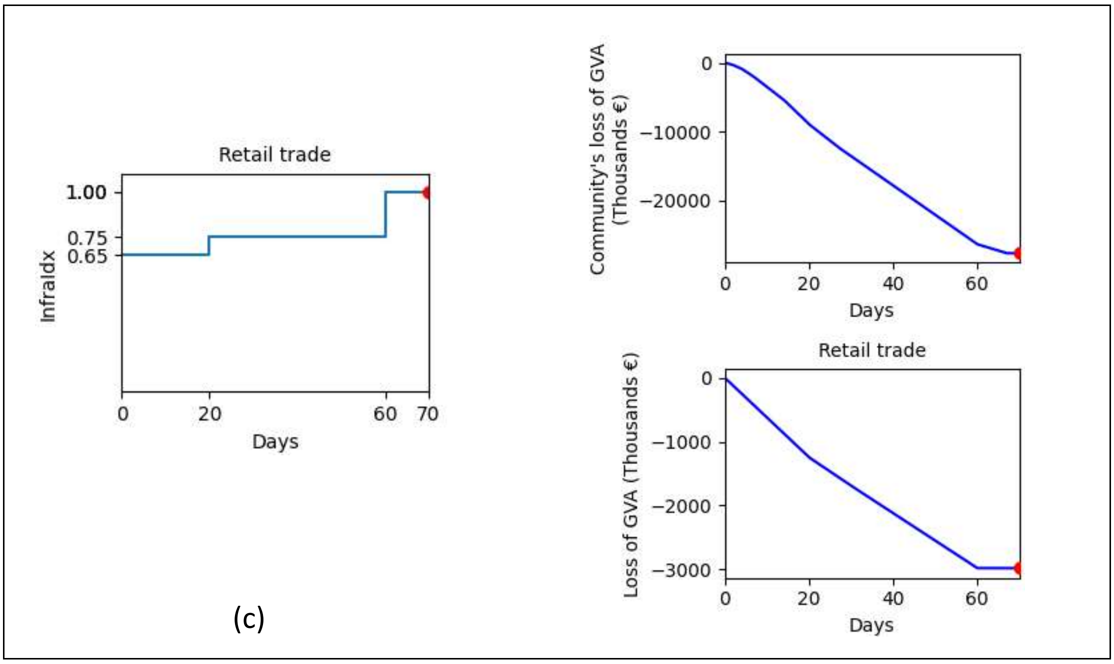


Figure 9: Disaster scenario for the city of Rhodes that occurs during summer and impacts “Retail trade”. Three BC strategies are considered: (a) BCS0 without overproduction, (b) traditional BCS4, and (c) parametric BCS4.

The output of the analyses undertaken for testing the aforementioned BCSs utilizing the proposed socioeconomic model are presented in Figure 9(a)-(c). When no insurance was adopted, the sector and the community indirect losses under the assumed damage scenario were estimated to be 8930.8 and 84427.2 thousand euros, respectively (see Figure 9(a)). On the other hand, the traditional insurance policy (traditional BCS4) reduced the financial losses to 4971.0 and 49801.5 thousand euros, respectively (see Figure 9(b)). Finally, the parametric insurance policy (parametric BCS4) reduced the indirect losses even more, specifically to 2984.0 and 27731.3 thousand euros, respectively (see Figure 9(c)).

4 Conclusions

Five Business Continuity Strategies (BCSs) for maximizing BC and consequently minimizing service disruptions were examined within Task 7.2 and were summarized in Deliverable 7.3, namely “BC Models and Adaptation Strategies assessment report”. The considered BCSs are the: (a) do-nothing, (b) reciprocal agreement, (c) work-from-home, (d) business traffic redistribution, and (e) insurance strategies. A detailed description of each BCS was offered in this deliverable, discussing their advantages as well as their limitations when applied to specific business sectors with distinct characteristics. Thereafter, a number of methods were proposed for simulating the aforementioned BCSs in a manner that complies with the socioeconomic tool developed in Task 5.5. In particular, the effect of each BCS was considered by increasing the production capacity of the considered damaged sector and its efficiency was investigated by means of the developed socioeconomic model via considering several hypothetical disaster scenarios for two HYPERION pilot sites. It was showcased that by adopting intra-municipality reciprocal agreements (BCS1), the revenue streams of the “Accommodation” sector can be protected effectively, even if a percentage of the revenue is transferred to regions nearby the CH area. Moreover, the work-from-home BCS was found to be a reliable approach that could assist the operation of the critical service-based sector. For large companies that comprise several interchangeable assets, business traffic redistribution was also found to effectively increase intra-organization productivity by orienting business traffic to the non-distributed branches of the organization. Finally, the enhanced effectiveness of the parametric insurance over the traditional one as a BC approach was demonstrated, on the condition that negative basis risk is prevented at all times.

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