CCRAAAFFFTING
Creating Collaborative Resilience Awareness, Analysis and Action for the Finance, Food and Fuel System in INteractive Games

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Abstract

The "why, what, how, who and what's in it for society" of the proposed project in a few words

Why (aim): The resilience of the Swedish society in case of a disruption of the payment system does not solely depend on the preventive and mitigating actions of public and private actors directly responsible for the payment system (i.e. the actors represented in SOES and FSPOS). Resilience depends also on how other stakeholders in the food and fuel system, citizens and voluntary organizations react. More importantly, resilience on a societal level depends on how all these stakeholders succeed to develop collective action (instead of when one stakeholder becomes the weakest link and counteracts the initiatives of others). In this project a large variety of stakeholders are enabled to explore what collective action strategies are most effective to create resilience for payment system disruptions in the food system, the fuel system, the finance system and society at large.

What (goals): The main deliverable of the project is the identification and evaluation of a set of collective action strategies to increase resilience for and to mitigate minor and major disruptions of the payment system. Intermediate goals to arrive at this final goal are: a simple and rough computer simulation of the payment system, food system and fuel system; a role playing game where a large variety of societal actors collaboratively interacts with the computer simulation; and measurement techniques to evaluate the 30 game sessions from two quantitative and one qualitative perspective.

How (method): Literature research is performed on two themes: "important decision variables in the payment, food and fuel system and their interactions" and "means to obtain collective action in large societal public-private policy networks". Action research involves the development of the computer simulation and role playing simulation and their combined use in 30 game sessions. The first 10 sessions are used to better understand the consequences for each stakeholder, their action alternatives, and the overall system dynamics. Hereafter, the game is refined. In the next 20 game sessions, the game facilitators will actively try to persuade the stakeholders to behave collaboratively and to develop collective action. The game results will be evaluated with qualitative and quantitative methods. Qualitative methods will aim at mapping "how" the different actors reason, "how" they actually collaborate and "how" they overcome difficulties. Quantitative methods will evaluate the "quality of the actual decisions" in the computer simulation and measure "the degree of collaboration".

Who (project participants): University of Skövde (HIS), Combitech (CT), Linköping University (LIU) and Mid Sweden University (MIUN) will develop a role playing game and computer simulation, facilitate 30 gaming sessions, analyze results and summarize identified collective action strategies and their impacts (in scientific publications and in practical lessons learned for the various stakeholders).

Who (target groups): Representatives for citizens, voluntary organizations, and public and private actors in the payment-, the food- and the fuel-system will participate actively in the 30 game sessions.

Benefit (what's in it for society): The research project will create insight in how interruptions in the payment system affect the many different stakeholders. Next, these stakeholder groups will become more aware of what different kinds of collective action are available to them, and what the effects of these collective action strategies are for themselves and for Swedish society as a whole. This will in turn increase the resilience of Swedish society with regard to disruptions in the payment system.

The research area: Developing collaborative resilience in complex dynamic systems

Resilience is defined by Weick and Sutcliffe (2007) as the ability to absorb strain and preserve functioning despite the presence of adversity and an ability to recover or bounce back from unexpected events (e.g. to absorb a surprise and stretch rather than collapse). Resilience, as interpreted in the context of safe systems, is strongly connected to earlier work in the domain of High Reliability Organizations (HRO) as both domains focus on the human ability to remain in control when facing unexpected or imperfect conditions (Bergström, van Winsen & Henriqson, 2015). While early HRO work did not use the label "resilience", they largely addressed the same problem areas and factors contributing to successful outcomes even in adverse situations (Benn, Healy & Hollnagel, 2008).

Lundberg and Johansson (2015) discuss that the definition of resilience is vague, and runs the risk of becoming meaningless when it has too many meanings. Both Lundberg & Johansson (2015) and Bergström, van Winsen & Henriqson (2015) list that resilience amongst others can refer to: bouncing back to a previous state, or bouncing forward to a new state, or both; absorbing variety and preserve functioning, or recovering from damage, or both; and being proactive and anticipating, or being reactive (when recovering during and after events), or both. Given the variety of interpretations of resilience, resilience is hard to operationalize into a measurable indicators (Lundberg and Johansson, 2015). Lundberg and Johansson (2015) have therefore proposed the Systemic Resilience (SyRes) model as a step towards better metrics and a more comprehensive understanding for determining the resilience of a system. Lundberg and Johansson (2015) argue that measuring resilience is complicated and that methods building upon their SyRes model need to be practically tested and theoretically developed to increase our ability to scientifically and in practice monitor system resilience. Lundberg and Johansson (2015) also address the complexity of determining and improving resilience with regards to systems of systems (e.g. as most open systems are part of other systems, the potential levels of analysis are countless).

This brings us to the next challenge in resilience engineering: collective resilience. Weick and Sutcliffe (2007) summarize resilient behavior as follows: Anticipate through 1) Pre-occupation with failure, 2) Reluctance to simplify and 3) Sensitivity to operations. Contain the unexpected when it occurs through 4) Acting in order to think more clearly and 5) Shifting leadership to the most experienced. Weick and Sutcliffe (2007) argue that loosely coupled systems are more resilient and rely on sensemaking, whereas tightly coupled systems are extremely vulnerable for disruptions as they assume that the system can be controlled in the sense that all possible system states can be foreseen and that appropriate measures can be prepared in advance. This resembles the distinction between Safety I and Safety II in resilience engineering (Hollnagel, 2013) where Safety I is signified by the idea that safety can be designed into a system and Safety II is signified by the idea that human adaptability is the most important contributor to success despite inadequate design or insufficient predictive capacity. Weick and Sutcliffe (2007) argue that a dilemma exists in sensemaking: you can optimise for analysis or action, but not both. This dilemma seems contradictory to the requirements of resilience, because Weick and Sutcliffe argue for sensitivity to operations and reluctance to simplify (i.e. an interest in details and scrutinize the situation at hand) and simultaneous blunt and immediate action without thorough analysis. The way out is that the deep knowledge about the system should have been acquired earlier (long before the disruption) so that in case of disruptions quick and blunt action is possible based on deep understanding of the system's dynamics. As more actors may simultaneously initiate a quick and blunt response, a risk is that these responses counteract each other. In an earlier publication, Weick and Roberts (1993) discuss how attentiveness (heedful interrelating) is key in a resilient group response, i.e. while acting quick and blunt, various actors should pay close attention to how other actors respond and to what kind of system behavior their collective response leads. Heedful interrelating has been demonstrated in small groups, but becomes challenging when systems become larger, more interrelated and involve more and more decision makers that do not really know each other and do not understand the impact of their decisions on nearby systems, as research on large interdependent infrastructure systems has been arguing (Ansell et al, 2010). Then these groups of stakeholders may lack swift trust (Weick and Roberts, 1993) and may lack a shared understanding of the situation and a shared vision, which may lead to inferior performance (Berggren et al, 2014). Now, how should actors learn about the interaction between their many potential collective responses and the total system's behavior?

Simulation is nicely defined in Sauvé et al. (2007) as "a simplified, dynamic and precise representation of reality represented as a system". Gaming simulation (Daalen et al, 2014; Laere et al, 2006) aims at representing reality and enabling an individual actor or a group of actors to experience the dynamics of the simulated system. A gaming simulation mimics the behavior of a real-world system using (computerized) simulation models, in which the roles of some human decision makers are enacted by real human participants and others can be simulated by computer model. Having a goal, each participant tries out different scenarios to identify the ones that best achieve their goals or the shared goals of a group of decision makers. The participating decision makers can compare intended consequences with unintended and unexpected consequences and create a deeper understanding of the system as a whole and the behavior of other game participants.

Atkinson et al. (2015) emphasize that systems science methods, such as system dynamics and agent-based simulation modelling, offer promise in being able to better operationalize research evidence to support decision making for complex problems and offer a foundation for strengthening relationships between policy makers, stakeholders, and researchers. The potential utility of these systems science methods lie in their ability to systematically and quantitatively analyze a range of interventions and identify leverage points (places to intervene) in the system where small inputs might result in large impacts. In line with this, Stefano et al. (2014) inferred that the systems thinking and system dynamics approach may prove a useful dynamic tool for next generation policy making, as it was revealed by the results obtained in two subsequent EU FP7 projects. The CROSSROAD project and the CROSSOVER project addressed the challenges facing the model-based collaborative governance and the policy modelling issues in practice. This approach can be applied in conjunction with other modelling techniques to produce hybrid models for public policy analyses (Stefano et al. 2014). Other researchers like Termeer et al (1995), Bots and Daalen (2007) and Caluwe et al (2012) discuss successful applications of simulation-games that have been applied to explore the complex interactions between multiple stakeholders with partly conflicting goals facing complex policy making or organizational change situations.

With respect to resilience of the payment system, a few simulation based approaches has been reported in the literature focusing on the banking sector, and thus not incorporating interaction with the fuel and food sectors. For instance Bedford et al. (2004) exploits a simulation framework for assessing the worst-case impact of operational incidents in large-value payment systems where a typical incident is the inability of one part to send and receive payments. In their approach the liquidity of the banks are simulated through transaction delay factors which increase in the case of liquidity drops, making the approach similar to causal map modelling. Another related approach is presented in Galbiati and Soramäki (2011), modelling banks as agents in a multi-agent system and simulating how these banks, as artificial decision makers, minimize their own costs due to delays and liquidity acquisition resulting in game-theoretic equilibriums. However attempts on relating the payment system to the fuel and food systems in a simulation environment is lacking.

When role playing simulation games and computer simulations are combined a powerful simulation environment is created. Actors, as game participants, can collaborate or compete with each other in different rounds, enter their decisions in the computer simulation and receive the output of the computer simulation as input in their next playing round. As such, participants can experience social interaction (role playing) and large scale system dynamics (impacts of their decisions over time, or on a large scale). Although there is a long history of combining role playing simulation-games and computer simulations, there are still many unanswered questions in how to design and develop games (Daalen et al, 2014). One major issue is to gain insight in the consequences of varying the many design criteria (degree of realism, degree of computer interaction, degree of facilitator interaction), another issue is the complexity of measuring the actual learning impact of simulation games.

The paradigm of system dynamics, or causal mapping, can simulate how changes in one or more decision variables cause changes on other variables in a system of variables with causal relationships. In the approach of Ibrahim and Larsson (2016), for an actor, the triggering of change in one of the variables controlled by a decision maker imposes the expenditure of funds and resources. Studying how human players act in these games in then the main interest for the field of behavioral game theory. Worth mentioning is that there is also a prescriptive decision theory in a game context, aiming to provide decision guidance on how decision makers should act in games with competitors and risks, labelled as adversarial risk analysis (Insua et al. 2009). Another simulation paradigm that might be suitable for the purpose of this project in the case when simulating decision makers directly interact with each other is the agent-based modelling paradigm (ABM). ABM focus on simulation of decision making agents on a micro level, how decision makers respond to stimuli or actions of other decision makers or from environmental changes. It needs decision rules and definitions of context awareness, see, e.g., (Gilbert and Terna, 2000). ABM typically focuses on micro level simulation and to a less extent on simulating macro level effects of, for instance, policy interventions. ABM has been rather extensively employed in the literature for simulating agent’s actions in the case of an emergency calling for evacuations, see (Chen et al. 2006; Christensen and Sasaki 2008) among others. One early task of the project proposed herein is therefore to decide upon which simulation paradigm that should be used in the role playing simulation games.

In summary there are several open research challenges in this research area which could be addressed in the proposed project: 1) defining and measuring collective resilience; 2) facilitating collective resilience in large interdependent systems and 3) design simulation games that combine gaming (role playing) and computer simulation, 4) developing a simulation environment that includes interactions across the payment, food, fuel and finance system.

Research needs: Including more stakeholders and develop collaborative understanding

Studies of the Swedish payment system and interventions (like developing alternative payment routines and collaborative exercising) have thus far mainly focused of the roles and responsibilities of the main actors in the payment system, represented in the networks SOES (forum for Economic Security) and FSPOS (Forum for Private-Public collaboration in the Financial sector). Despite this impressive work of identifying, analyzing and developing risks and routines for preventing and mitigating serious disruptions in the payment system in Sweden, there is still lacking insight in how the proposed action plans exactly need to be executed and how numerous other actors in society (e.g. citizens, food stores, petrol stations, voluntary organizations, and so on) will act in case of a temporary or complete breakdown of the payment system. For instance, several key actors in the payment system have in earlier studies expressed that they will take a larger responsibility than their formal responsibility (MSB-2009-3309, 2010), but it is not clear what this exactly implies and whether these organizations actually will do that when crisis hits. Next, in MSB (2007) it is argued that the fuel and food system will be mainly affected in case of payment system disruptions. Insight is lacking what measures stakeholders in these sectors, citizens and voluntary organizations will take when problems escalate across the food, fuel and the payment/finance system. As the current refugee crisis shows, it is hard to foresee and manage the interactions between decision making on all system levels (from local actors to the EU level) and especially hard to collaboratively develop resilience. In conclusion, there is a need to more extensively investigate how the many involved stakeholders can develop collaborative responses to disruptions and thereby form a resilient system.

Future research development: Collective intelligence across societal sectors

As argued in Ansell et al (2010), our infrastructures become more and more entangled, and resilience of these systems depends more and more on collaborative responses from people with diverse backgrounds that may not be familiar with side impacts in totally different areas. At the same time, there are opportunities so support communication in social networks, to build more advanced and engaging Serious Games to learn about large interrelated systems, and to use Business Intelligence to present indicators of system status and resilience levels. This research project is a first concrete step in actually building an environment where many actors collaboratively can learn. Simulation-game environments can be used for different purposes (Caluwe et al, 2012; Daalen et al, 2014; Stefano et al, 2014). The developed arena can be used to explore viable intervention strategies (this project), but also later on to train and educate stakeholders about the complexity of the sociotechnical system they are part of. From the experience gathered in this project, similar simulation environments could be developed for other sectors (e.g. electricity, health care, transport).

Project aim and goals: creating collective awareness and action through interactive gaming

The societal aims of the project are:

- understanding how disruptions of the payment system impact the food-, fuel- and finance system
- identifying and developing collective actions to increase overall system resilience

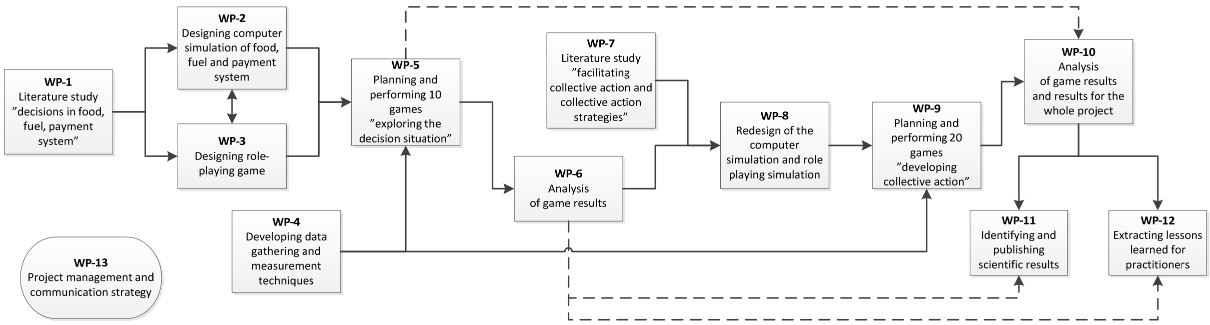
The research aims are:

- understanding and defining the notion of collective resilience
- creating an integrated role playing and computer simulation that gives insights in interactions between the payment system, the food, fuel and finance system
- measuring the quality of the decisions, collective action and the learning in the game from a quantitative and qualitative perspective

With these aims, the project combines grounded research (defining resilience, measuring collective action) and applied research (building a simulation game, developing measurement instruments). More detailed deliverables for each work package are listed in the table at the next page.

Research design: literature study, action research and qualitative & quantitative analysis

The overall research approach is an action research study (changing society & creating research insights through gaming-simulation) as earlier demonstrated in Laere et al (2006) and Laere (2013). The figure below shows how the thirteen identified work packages relate to each other over time. The first 10 games are played to further improve the simulation environment, the next 20 games are played to evoke and explore different types of collaborative responses.



Although the games may remind of crisis management exercises, it is important to understand that the purpose in this project is not to train participants, but to explore the future and to learn how the simulated system might behave. In training, desired action is known on beforehand. Here, potential feasible collective actions need to be identified. Many games with many different stakeholders need to be played to explore many possible futures. Finally, the observed collective action patterns are not a "*ready to implement recipe*", but rather a "*smörgåsbord*" of available action alternatives. Stakeholders with a larger action repertoire are more resilient, as they have more potential means available to meet system disturbances.

Work package	Start	End	Lead	Deliverables
WP-1-Lit-FFF	07-2016	01-2017	CT	Important decision variables identified
WP-2-Comp	09-2016	05-2017	MIUN	A functioning computer simulation
WP-3-Game	01-2017	08-2017	HIS	An executable game design
WP-4-Meas	01-2017	08-2017	LIU	Complementing measurement techniques developed
WP-5-Play10	01-2017	05-2018	CT	10 games executed
WP-6-Anal-1	11-2017	09-2018	MIUN	A rich analysis produced that informs next WPs
WP-7- Lit-ColAc	01-2018	09-2018	LIU	Collective action examples identified
WP-8-Desi-2	06-2018	01-2019	HIS	An improved game and computer simulation
WP-9-Play20	09-2018	12-2019	CT	20 games executed
WP-10-Anal-2	03-2019	05-2020	MIUN	A rich analysis produced that informs WP11 and 12
WP-11- Science	01-2018	12-2020	LIU	5 journal articles, 6 conference papers
WP-12- Practic	01-2018	12-2020	CT	Usable guidelines for practitioners how to behave
WP-13-Mgtcom	07-2016	12-2020	HIS	Project stakeholder satisfied, WP deadlines met, A blog running from 2017-01-01

A clear theory on how actors need to organise collective action in the payment, food, fuel and finance system is lacking. As such, there is a need for theory building rather than theory testing, which leads us to an inductive research strategy (Eisenhardt and Graebner, 2007). As depicted in the figure and the work packages above different data gathering and data analysis methods will be used to achieve triangulation. For example: In the early phases (WP-1 to WP-8) the overall aim is to develop an integrated game- and computer simulation that is a good representation of the actual complexity of the payment, food, fuel and finance system to be studied. Here, we combine experience from Combitech consultants (that have worked with continuity planning of these systems), literature study (scientific studies and reports that describe and evaluate the Swedish societal system), interviews with representatives from the different stakeholders, analysis of the first 10 games to be performed in WP-4 to arrive at a validated model of the most important decisions, consequences and interactions incorporated in a simulation game that is playable.

Similarly, in WP-4, WP-6 and WP-10 when designing and applying our measurement and analysis techniques, we will combine qualitative and quantitative data gathering and data analysis methods that will both evaluate the resilience process (how things are achieved) and the outputs (the quality of the collective actions and decisions). The project partners have complementary skills with respect to qualitative evaluation of gaming sessions (HIS and CT; Laere, 2013), quantitative evaluation of decision output (MIUN; Hansson et al, 2011; Larsson and Ibrahim, 2015) and quantitative evaluation of collaboration and collective action (Berggren et al, 2014).

Given these methodological grounds, theoretical contributions will be produced in several areas. As argued earlier, a simulation environment that covers the payment, food, fuel and finance system is not existing as far as we are aware of. Note that we will ***not*** develop a simulation environment that in detail represents all these systems. Rather, an environment is created where the ***main*** ***interactions*** between these systems are highlighted. The design of this environment (WP-1-2-3-8) and the application and analysis of this environment (WP5-6-9-10) will create a deeper insight in the functioning of these interconnected infrastructures.

Also, when stakeholders in these systems need to develop and demonstrate resilient measures through collective action, a second main research contribution will be to be specific on how we understand resilience and design collective action, building upon the work of LIU (Lundberg and Johansson (2015). Here, WP-7-8-9-10-12 will be the main road to develop our understanding of resilience from a scientific and practical perspective.

Finally, in WP-2-3-5-6-8-9-10 knowledge and experience will be created considering “how to simulate” and “how to integrate computer simulation and gaming-simulation”. Although previous research has shown the value of this approach, there are still numerous design questions to be discussed and scientifically developed (Caluwe et al, 2012; Daalen et al, 2014; Stefano et al, 2014). Our research can contribute to the identification of better simulation development methods from complex infrastructural societal problems.

The project organization will consist of a team of 10 researchers (5 senior researchers, 3 senior consultants and 2 doctoral students). The table below gives an overview of the identified competencies that are needed to perform the project successfully, and how the 4 participating organizations contribute to them.

Prior experience relevant for the project	HIS	CT	LIU	MIUN
Experience with the payment system, food, fuel and finance system		x		
Experience with building system dynamic computer simulations	x		x	x
Experience with design and facilitation of role playing games	x	x		
Experience with resilience and collective action	x		x	
Experience with qualitative evaluation of gaming sessions	x	x		
Experience with quantitative evaluation of decision alternatives				x
Experience with quantitative evaluation of collaboration			x	
Experience with studying national actors		x	x	
Experience with studying regional and municipal actors	x		x	x
Experience with studying citizens and voluntary organizations		x		x

As project members are or may be working in several cities short bi-weekly project meetings will be organized by phone/video conference. The project members will meet at least 4 times a year face to face for a 2 day or 3 day project seminar. In some phases of the project these meetings can be co-located with the gaming sessions that will be performed in the period 2017-2019. The project will also include a communication manager (5%), who is responsible for developing a communication strategy, for assisting in creating news flashes at specific moments in the project and for maintaining a project blog in close collaboration with involved researchers and societal stakeholders. A steering group will be appointed, with one international gaming-simulation researcher, one resilience/systems-theory researcher, three representatives from the involved sectors (finance, fuel and food) and one representative from MSB. The steering group will continuously evaluate the rigor and relevance of the project results, will monitor whether all project activities serve the long term aims of the project and will coach in finding and realizing future spin-off project opportunities. The steering group will also assist in identifying ways to communicate the project results to different stakeholder groups.

Budget

The total budget is 14 000 000 SEK. With this budget it will be able to obtain the scientific results in three areas (understanding resilience, developing simulations and measuring collective action) and to deliver insight in what feasible collective actions of different stakeholders contribute to resilience of the food, fuel and finance system. When MSB would prefer to grant multiple projects in this call, our budget can be decreased to 9 or 10 million SEK. In that case we will still perform the whole cycle as depicted in the figure on the previous page and we will still perform 30 games. The amount of games played does namely not impact the costs to a large extent; the major costs appear in development of the computer simulation and the analysis of the game sessions results.

As such, while the current project design includes the development of 3 scenarios to be played, a first consequence of a diminished budget will be that we will limit ourselves to 1 scenario. As variation is very beneficial to learning a consequence of this limitation will be that less collective action repertoires might be discovered (the "*smörgåsbord*" will include less dishes at the end).

Secondly, while now aiming to contribute to three research areas (understanding resilience, developing simulations and measuring collective action), a result of a smaller budget will be that we (in consultation with MSB) will drop one of these research areas and focus our efforts on two of them. Also, the number of scientific publications produced will drop from 11 (5 journal- and 6 conference publications) to 7 (3 journal- and 4 conference publications). A lowering of the budget will be distributed equally over the different partners, i.e. for example lowering the research personnel for each partner from 3 million SEK (current level) to 2 million SEK.

Target groups: Citizens, voluntary organizations, public and private actors

Representatives for citizens, voluntary organizations, and public and private actors in the payment-, the food- and the fuel-system will participate actively in the 30 game sessions. Next, the main results of the project will be communicated to the general public and the main stakeholders in these sectors.

Project Communication Strategy

A dedicated communication officer (5%) will be appointed to develop a communication strategy for the project and monitor its execution in close collaboration with the involved researchers. The project will maintain a blog throughout the whole project period and continuously share its results. The simulation game will be demonstrated at national science days and practitioner conferences.

Benefits for society

Stakeholder groups involved in this research project will become more aware of what different kinds of collective action are available to them, and what the effects of these collective action strategies are for themselves and for Swedish society as a whole. Lessons learned can be spread to the sectors and other groups in society they represent. This will in turn increase the resilience of Swedish society with regard to disruptions in the payment system. The developed method (increasing resilience awareness and collaboratively developing collective action strategies in interactive games) is also applicable on other scenarios and sectors in society. A second major deliverable is therefore that a method becomes available for increasing collective intelligence and developing collective resilience in Swedish society.

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