Enhancing the resilience of social infrastructures:
issues on agents, artefacts and processes. Proceedings of the 2016 Modena Workshop

Francesco Pagliacci*, Simone Righi**, Margherita Russo*** (eds)
in collaboration with M. Casoni, M. Farinosi, L. Fortunati,, C. Garzillo, M. Guggenheim,
P. Lauriola, B. Oppi, S. Pedrazzi, K. Petersen, M. Villani

November 2016

* University of Modena and Reggio Emilia
CAPP (Center for the Analysis of Public Policies)
Address: Viale Berengario 51, 41121 Modena, Italy
email: francesco.pagliacci@unimore.it

** University of Bologna
CAPP (Center for the Analysis of Public Policies)
email: s.righi@unibo.it

*** University of Modena and Reggio Emilia
CAPP (Center for the Analysis of Public Policies)
Address: Viale Berengario 51, 41121 Modena, Italy
email: margherita.russo@unimore.it

Enhancing the resilience of social infrastructures:
issues on agents, artefacts and processes. Proceedings of the 2016 Modena Workshop

Francesco Pagliacci*, Simone Righi◆ and Margherita Russo♣° (editors)
in collaboration with
Maurizio Casoni, Manuela Farinosi, Leopoldina Fortunati, Cristina Garzillo,
Michael Guggenheim, Paolo Lauriola, Biagio Oppi, Stefano Pedrazzi,
Katrina Petersen, Marco Villani

* Department of Economics, University of Modena and Reggio Emilia (Italy) and CAPP, francesco.pagliacci@uni-more.it

◆ Department of Agricultural and Food Sciences, University of Bologna (Italy) and CAPP, s.righi@unibo.it

♣ Department of Economics, University of Modena and Reggio Emilia (Italy) and CAPP, margherita.russo@unimore.it

° corresponding author

Abstract

In the social sciences domain, the term 'resilience' is usually associated to a wide set of changes that affect people and their communities. In particular, both the Hyogo Framework for Action 2005–2015 and the Sendai Framework explicitly focus on the way in which communities face both natural and man-made hazards. To this respect, both material and non-material infrastructures play a critical role, hence deserving a specific focus when assessing local communities' level of resilience. Among them, this paper focuses on: health services, social services, government (according to a multi-level perspective, from the national to the local level), communication infrastructure (i.e. specific tools to interconnect all aforementioned networks). Firstly, this paper discusses some of the most important issues and theoretical frameworks that should be addressed in the analysis of the processes of enhancing the resilience of social infrastructures. Secondly, the discussion that took place in a workshop promoted in May 2016 as the outcome of a one-year dialogue across a group of EU researchers is returned. The debate moves from some theoretical perspectives on resilience and it eventually returns some case studies and real experiences, such as the actions of local governments and the role of risk communication.

JEL: O35, R58, Q54

Keywords: social infrastructures, Sendai Framework, risk reduction, resilience

1. Introduction

Being defined in physics as a property of materials, in the social sciences, the term 'resilience' has been associated to a wide variety of changes affecting people, communities, organizations. In policy measures and recommendations, there is an increasing attention on strengthening the resilience of communities facing "both natural and man-made hazards and related environmental, technological and biological hazards and risks" as in the Sendai Framework (UNISDR, 2015), thus associating policies to a variety of domains of actions, to be specified case by case (UNISDR 2009, 2011, 2015; OECD 2013[1]; COE 2011; EU Commission 2015[2]). Furthermore, a series of recent Horizon 2020 calls specifically addresses resilience with a focus on indicators, asking for "new methods and solutions of assessing resilience based upon comprehensive threat, criticality, and vulnerability assessments. […] In order to anticipate current and emerging threats and security challenges […] a scale approach of 'resilience' level should be proposed across critical infrastructures (energy grids, transportation, government, nuclear research infrastructures, water, etc.) [and] validated indicators, including economic indicators, could be applied to critical infrastructures in order to assess its level of "resilience" (2015 H2020 Call DRS-14-2015).

In June 2015, moving from the abovementioned H2020 Call (whose deadline was in August 2015), a group of researchers, involved in the socio-economic analysis of the 2012 earthquake in Emilia (Energie Sisma Emilia project), opened a dialogue with other research teams in Italy[3], UK[4] and Germany[5] who were working on social infrastructures. Four domains were considered as the most critical ones: health services, social services, government (namely multi-level government, from the national to the local level), communication infrastructure (i.e. specific tools to interconnect all aforementioned networks). A complementary topic that was addressed by this team of researchers is the "resilience of organizations", crosscutting all those domains. Although these infrastructures were not explicitly mentioned in that call, they are of the utmost relevance in the Sendai Framework and were a core issue emerging from the analyses undertaken in the research project Energie Sisma Emilia (Russo & Silvestri, eds., 2016). In particular, the researchers' focus was on the role of social infrastructures' resilience in coping with natural disasters.

After the Hyogo Framework for Action 2005–2015, in 2015 the United Nations Office for Disaster Risk Reduction approved the Sendai Framework for the next fifteen years[6], stating the many dimensions of analysis, stakeholders and actions that must be taken into considerations to significantly reshape our future on this planet.

---

[1] "Discussions between experts from OECD regions hit by natural disasters led to the elaboration of eight policy recommendations for rebuilding after a natural disaster. The recommendations found in the report can guide regions in all countries to more resilient growth and help them monitor good practices and improve the well-being of local communities after natural disasters: 1. Make sure that short-term decisions do not constrain long-term options. 2. Identify the economic base and the social and economic drivers specific to the region to increase its resilience. 3. Develop an integrated strategy to redevelopment after a natural disaster by strengthening the dialogue among stakeholders to raise the profile of needed reforms and quality of decisions. 4. Strategic choices have to be locally led. 5. Use the occasion of a crisis to introduce reforms or standards for the country. 6. Foster public participation to help decision making. 7. Make public deliberation a regular component of the regional development strategy. 8. Build trust, increase accountability of policy-making and improve capacity of administrations." http://www.oecd.org/regional/regional-policy/buildingresilientregionsafteranaturaldisaster.htm

[2] See Albrito et al. (2015).

[3] Manuela Farinosi and Leopoldina Fortunati (University of Udine), Laura Sartori (University of Bologna), Stefano Pedrazzi (OT Consulting, Italy)

[4] Paolo Cardullo and Michael Guggenheim (Goldsmiths University), Monica Büscher and Katrina Petersen (University of Lancaster).

[5] Cristina Garzillo (ICLEI, Germany).

[6] http://www.preventionweb.net/files/43291_sendaiframeworkfordrren.pdf

This document goes in the direction of the Sendai Framework, focusing on issues and theoretical frameworks to be addressed when analysing the processes of enhancing the resilience of social infrastructures. A first result of the year-long dialogue across the European research groups was a meeting in Modena, Italy, in May 2016 to participate at the workshop promoted by the Center for Analysis of Public Policies (CAPP, www.capp.unimore.it) of the University of Modena and Reggio Emilia[7].

The structure of the paper is the following. Section 2 outlines the issue of resilience of social infrastructures. Section 3 presents some theoretical perspectives on resilience with regard to the broad definition in social sciences (by Michael Guggenheim), to its specific meaning in the context of making, maintaining and repairing social infrastructures (by Katrina Petersen) and to computational modelling (by Marco Villani). Section 4 presents the perspective of analysis on social infrastructures resilience discussed in the workshop. First of all, the actions of local governments and health agencies are described with regard to: the role of local governments (by Cristina Garzillo), the multilevel coordination in the post-earthquake emergency phase (by Francesco Pagliacci and Margherita Russo); the environmental health emergency (by Paolo Lauriola). Then, risk communication is presented with regard to three perspectives: the management of the 'last mile' in risk communication (by Leopoldina Fortunati and Manuela Farinosi); the critical aspects of the 'second' last mile in risk communication, with specific reference to the UK case (by Michael Guggenheim); a case of systematic use of storytelling in the communication strategy of the history of crisis/opportunities in a big company post-earthquake recovery (by Biagio Oppi). Eventually, two contributions address the design and implementation of ICT platforms to strengthen infrastructures' resilience, respectively through organizations' optimization, by capturing and reproducing best practices, (by Stefano Pedrazzi) and through software-defined network orchestration (by Maurizio Casoni). Section 5 summarizes a series of comments and suggestions from the workshop's participants for further research.

2. Resilience of social infrastructures: an overview

When it comes to discussions of infrastructural impact of a natural disaster, the focus is typically on material infrastructures (such as roads, buildings, water systems, etc.) and livelihoods. Such infrastructures are indeed subject to clear disruptions during and after natural disasters and/or human threats and their recovery is an issue for ensuring the regular socio-economic activities. Nevertheless, other types of infrastructures affect socio-economic activities and the quality of life of individuals as well: socio-cultural infrastructures, assuring the regular provision of a large set of services, e.g., social services, health services, education. Disruption of the material components of such infrastructures (buildings, devices and machineries) is typically addressed by emergency and recovery interventions.

Beyond those material components, also the disruption of the socio-cultural components of the social infrastructures and their implementations, in terms of information structures and software, can worsen the impact of natural disasters on the daily life of individuals slowing down the path of recovery after a natural disaster. Furthermore, natural disasters also have other long-term effects, such as gentrification and neo-liberal urbanism. On the opposite, a specific focus just on environmental resilience might hide the long-term catastrophe of urban displacement, also as a consequence of natural disasters (e.g. the hurricane Katrina and the race issue in New Orleans: that was a natural disaster that became a social disaster).

Resilience is the ability of a system to cope with external unpredictable perturbations and to better withstand and recover from disasters. Weak resilience within the immaterial components

---

[7] The program of the Workshop can be browsed at http://www.capp.unimore.it/site/home/archivio-eventi/documento720044005.html

of those infrastructures can impose further socio-economic costs on societies and local communities. Weak resilience within social infrastructures can depend both upon limits in their conception and implementation and upon their non-integration with other areas of public policies. Due to existing interconnections, cascades of effects starting from one sector may results in devastating impact on the functioning of other sectors as well as of the overall society.

Thus, besides physical infrastructures, also immaterial ones can be impacted by natural disasters and form an integral part of community resilience. This causes interconnected mis-services in other sectors. Among different typologies of social infrastructures, the most relevant for coping with the effects of natural disasters are the following:

- Health services: they represent typical public services, which are deeply rooted in the EU social model. The provision of these services (through hospitals, pharmacies…) can be organised at different territorial level, but mostly at regional level. In this sector, are frequent the interactions between public and private actors which are to be taken into account if one wants to design resilient services. A local health system is impacted by a natural disaster, both in physical structures (e.g., hospitals) and in immaterial relationships among service providers. Furthermore, these impacts also apply to partner services and supply chains, which will be damaged by the health sector's inability to deliver care[8].

- Social services: their provision couples with the provision of health services. They target elderly people and early-children (the former being a particularly large age class in Western and other developed countries) as well as families in need (e.g., through social and psychological counselling, …). During natural disasters these services could be ineffective as staff members may be themselves injured or because the regular organization of those services has not an emergency plan. In such cases among others keeping effective contact with the assisted population becomes impossible.

- Civil protection: it plays a key role in the very emergency phase. Well-structured organisations may reduce costs and time of damage recovery process. They can also organise the provision of emergency services in the most efficient (and effective) way. Furthermore, a critical issue is also represented by the way civil protection retrieve information from and provide information to public administration at both national and local level.

- Local/regional government structures represent the institutional framework, whose activities are crucial in order to implement local policies on many domains impacting also on immaterial dimensions of social infrastructures. Our focus in this project is on their internal organization, on the intra-level and inter-level coordination, and on the consequence that organization and coordination have on their effectiveness in dealing with natural disasters. A specific focus is also aimed at assessing importance of multilevel governance, under different national regulations.

- Institutional communication services: promoting communication is a key issue for institutional bodies and organizations; this being the easiest way to inform citizens about their activities and receiving feedbacks from them, about the perceived quality of the service. During emergencies, specific communication services take place (e.g. the provision of emergency information through civil protection). In particular, an efficient and reciprocal interchange of information among sectors of the Public Administration and between them and citizens can go a long way in reducing the impact of natural disasters on population, well beyond the emergency phase: it is a crucial component also in the recovery phase aiming at enhancing resilience and then strategically asking for citizens' engagements.

---

[8] See also "Adaptation Report for the Healthcare system 2015", www.sduhealth.org.uk/ARP

According to their specific features, all these typologies of infrastructures may suffer disruptions after a natural disaster, their ability to support community resilience being impacted in a very different way. EU Countries organize social, health and education services, but they may differ with regard to relative resources committed, governance, degrees of autonomy in the different levels of organization, coordination intra service and inter-services, involvement of private initiatives. From a theoretical perspective, the assessment of the major drivers and determinants of those differences is a preliminary step to enhance social infrastructure resilience. With regard to the organization of social infrastructures, optimal organizational levels represent a key issue. Optimal functional areas could actually replace administrative boundaries in providing social services. Besides the definition of optimal organization level, natural disasters also lead to impressive changes in bureaucratic structures, which typically occur in very short time spans and according to highly unpredictable paths. Learning from these experiences helps increasing the level of resilience of the social infrastructures designed.

Among possible innovations, ICT currently represents the most important one in reshaping and enhancing inter-municipal and inter-service cooperation in order to improve delivery of services even in normal times. This is true especially for small municipalities and for wide rural areas. The role and the impact of ICTs in fostering the resilience of social infrastructures is put to test during natural disasters. Furthermore, a better use of ICTs would increase resilience of aforementioned social infrastructures.

An analysis of the aforementioned typologies of social infrastructures should highlight the major interactions among them, during a range of typologies of natural disaster. Moreover, resilience of different typologies of social infrastructures must be analysed referring to different natural events/disasters. Particular attention should be devoted to the design of ad hoc ICT platforms able to face the exogenous shocks provoked by natural disasters.

So far, other research projects have been confronted with similar and related topics, such as the Bridge project, the Evidence Aid Project, the Secincore Project, the Smart Mature Resilience Project. Appendix 2 summarises their main goals and results. In what follows contributions from the participants at the Modena Workshop will refer to them, also as members of those projects.

3. Theoretical Perspectives

Defining Resilience, *the contribution of Michael Guggenheim*

In his contribution to the Modena workshop, Michael Guggenheim introduced himself as a 'stranger' in the field. Indeed, in his own research, he does not really use the term 'resilience'. He actually prefers the word 'preparedness', as he mostly deals with infrastructures[9]. So, why do some people refer to the former term (i.e. resilience), while other refer to the latter one (i.e. preparedness)?

In part, this is a disciplinary problem. The term resilience has originated in ecology: it is the capacity of ecosystems to absorb external perturbations. Although system theories focus on it, this term is absent in sociological theory of systems[10]. With regard to social infrastructures as systems, concepts are slightly different: resilience is not a 'property of those systems'. If we consider the contamination between ecological concepts and system theoretical framework, the key question is 'how far we want to carry on that system theoretical framework?'.

Actually, resilience became so important in policy, as in 2005 the Hyogo framework for action came about. This is an important policy history (even for policy makers). An interesting

---

[9]   In Section 4 he refers to some examples of research.
[10] Being trained as sociologist in Germany, Guggenheim reminds us that in the works of the German sociologist Niklas Luhmann this concept is mostly absent.

consequence is that in ecology resilience is just a property of the system. In the Hyogo framework (and in the social sciences) resilience is implemented by actors within the social systems. In particular, people and places matter: this means communities as well.

Time dimension is crucial as well. Within the Hyogo framework, resilience is part of preparedness. It brings in specific time dynamics: it is expected to have an influence on preparation for future events. Organisations and communities can think about themselves in terms of resilience, which influences their action in the now in an anticipatory way. They do something now that will improve resilience for future events (i.e., preparedness). But, resilience itself can just be assessed after the natural event has happened, and not before it. We can only look up at what happens after a disaster, how certain communities cope with it. Thus, there is a sort of tension in this logic of resilience. To some respects, this idea is similar to Katrina Petersen's concept of 'repair' (see below).

In more general terms, resilience also invokes bouncing back to a previous standard. Again, this idea can be highly problematic, according to some policy-relevant researches in the UK: the pre-event stage itself may be part of the problem (e.g., flooding in Northern England: there, urban settlements just represent part of the problem, and restoring the pre-event standard would imply great damages in the future as well; the point is that infrastructures were not good enough to deal with a disaster and this is the problem). This is also a problem of time dimension (post hoc problem): we can only know it after the disaster. This is also a complex policy problem. It is about insurances: they are expected to pay more money to repair damaged buildings.

Vale *et al.* (2005) refer to axioms of resilience (in their work 'the resilient cities'). They suggest that each phase (measured in weeks) expands in a logarithmic scale (i.e. they multiply tenfold). After the event, the emergency phase occurs first: it is very short. Then, restoration is ten times longer than emergency. Then, reconstruction (as rebuilding or replacement) is ten times longer than restoration. Then there is reconstruction 2, which also includes commemoration (you remember what happened).

Besides time dimension, another important dimension is materiality. If we look at the sociology of disasters, historically, sociologists had to make themselves autonomous from the engineers. The discipline of disaster studies was (and probably still is) dominated by engineers. So, sociologists moved away from the materiality of the damage itself and from damages to material infrastructure. In fact, they focused on the social dimension of disasters. This mostly happened between 1960s and 1980s. Their main focus was on: i) community building; ii) commemoration. Sociologists created their own niche. In this field, social means non-material, i.e. connection between people, education, values...

For a newer sociologist, it is important to turn back to the materiality of disasters. It is impossible to understand what happened if we don't focus on how specific materiality is involved. Previously, for a sociologist this was a non-issue.

Organization dimension matters as well. Let's make an example from a health case study (from a work by Aranda and Hart, 2015). Where is resilience located? There are different forms of it:

▪ Resilience 'found': resilience resides somewhere (e.g. in a body), it is a property of an object;
▪ Resilience 'made': resilience is produced. It is an ongoing process, it is not a property. It can be transmitted to the others;
▪ Resilience 'unfinished': one can learn it, so there is a connection to time, but we can never know whether one is resilient enough. This is the central problem/topic of a project dealing with resilience of social infrastructures: connecting object properties with time. We never know what happens with these transmissions, until after the fact.

Now, let's turn to critiques of the concept of resilience. They all come from the UK. There is a specific political situation there, so it is not a coincidence. These critiques come from a similar theoretical background (Foucault, 2009)[11]:

1. Resilience is a form of governance. It is not neutral. It emphasizes individual responsibility (the main reference here is the article on "resilience embedded neo-liberism" from Joseph 2013).
2. There is nothing 'natural' about resilience. Joseph (2013) claims that in the UK it is tied to the duty of care. Thus, it is in the responsibility of the State (in addition to single individuals' responsibility).
3. Rigidity trap in resilience: issues related to defining benchmarks and standards. It is not possible to define standards. Resilience is an object of organizational experimentation. We may create more resilient organizations, but because of standardisation organisations risk to lose contact with some communities.

In the UK, resilience became a prominent issue at the point in time when the Conservative government reduced (or actually it did not improve) support for local communities. That led to a huge fight for allocation of funding. Thus, insurances for endangered properties became a key problem.

For all these authors, the term resilience is becoming an 'ironic' issue when confronted with bottom-up organisation (more on this below)

Reactions to Micheal's contribution
Leopoldina Fortunati refers to co-operation among people after the 1976 earthquake in Friuli. It is the 40th anniversary of that earthquake: in Friuli, the resilience that community expressed was mostly grounded on solidarity. People should help themselves even today, but this seems working properly no longer. She also considers relevant the relationship between resilience and preparedness.
Margherita Russo points out the importance of opening a dialogue with engineers on the social dimension of the issues introduced by Michael in his talk.
Katrina Petersen notes that both resilience and preparedness refer to prevention. It is also important to look at the role of time-line of disasters. We have to deal with the unknown, although different technologies obviously matter. Where to look?

Infrastructuring and repair*, the contribution of Katrina Petersen*

Katrina Petersen's contribution focuses on resilience repair and on information infrastructures (as a part of social infrastructures). She works with Monika Büscher, a sociologist[12]. Katrina's background is in risk communication, visual studies and technology studies.

Her research team[13] moves from the concepts of risks, and the use of ICT resources, which may enhance resilience. Accordingly, they are trying to map what happens during an emergency

---

[11] With the lessons on 'Security, territory, population' at the Collège de France 1977-78, Foucault opened the reflexion on 'governmentality' (problem of government) – that is, 'how to govern oneself, how to be governed, by whom should we accept to be governed, how to be the best possible governor?' (see Sokhi-Bulley, 2014)

[12] Monika is not attending the workshop because is at the Public Safety Communication Meeting, in Brussels (mobility data and disaster data).

[13] They have been involved in two main projects: Bridge and SecInCore. BRIDGE Project (www.bridge-project.eu) ended two years ago (it was a 3-years long project). Designing systems of systems: its idea is combining together pieces of information among different actors. Please, remember the concept of interoperability: resilience is different at different scales. Focus on the emergency phase: verbal and non-verbal communication. How do physical actions and repeated gestures matter? The role of information is crucial: under an emergency phase, it is important to be aware to be all on the same page, but who has the right to access information? Indeed, ICT may help, but it always introduces new layers of complexity. SecInCore Project is a cross-border pan-EU disaster inventory to share data, supporting a

8

phase: different drivers can either enhance or undermine resilience. All these issues are related to the surveillance purpose. ICT actually allows the development of some tools, which enable resilience[14]. ICT helps in identifying needs, managing vulnerabilities, better distributing resources, monitoring changes. Please, note that ICT may also undermine resilience: indeed, freedom of expression, autonomy, surveillance, privacy violations are major issues that are tied to the implementation of ICT tools. Moreover, information overload can occur as well. It is important to look beyond the social-ethical dichotomies associated with ICT. Tool sets may overcome such an assumed trade-off (security/freedom). In particular, science and technical studios lead to tools implementation: security and freedom (participatory design, co-design, labs, and experimental sociology). They use a range of methodologies, from technologies studies to mobility studies, to be on the same page with engineers.

Some of the questions they are addressing are:

- Resilience is about communities. How can information exchange create new communities of action?
- What about the most appropriate tools? Information is data, it is knowledge and it is representation. How does it follow information?
- Which kind of shared sense can be made? And how, by examining intersections of information, communities and sense-making during disasters, can we gain better insight into resilience?

In the research perspective of her team, infrastructure is a network, relationship is a pathway: this is their idea of resilience. Then, resilience is not a property, it is not a status. It is a practice, defined by content and action. Sometimes, it is successful, sometimes it is not.

Practice on resilience is a very complex task. This is a form of community building. In such a process, physical actions are important as well. Even with similar people, it is difficult to be on the same page. Understanding (and agreeing) follow.

Community infrastructures are flexible and fleeting. ICT can extend it. Infrastructure need to be made, remade and repaired. Boundaries may be either spatial and physical or social and cultural conventions. The content of the information that are shared turns out to be less important than expected. Rather, the focal point is on connecting all those elements that produce risk. Connections through infrastructure means sharing information. The role of information stewards (legitimation and trust issues) is to be addressed. In what follows, some related issue to be considered in discussing resilience are now briefly outlined with regard to risk governance, improvisation and repair, information and sharing, scale and dynamic element of resilience.

Risk governance (but here the sense of governance is different from Michael's one). Social relationship and contradictions in disaster management is often top-down managerial model. Other models (activists) are very bottom-up processes and they cannot talk to each other. Governance tries to get back to the idea of democracy: individuals fed themselves on their own ideas, then there are experts. And eventually there is a negotiation between the public and the experts. Negotiations among people, practitioners and experts are quite difficult. Solutions are neither global nor local. Infrastructure creates a venue where diversity meets and acknowledges itself. Resilience lies somewhere in the middle to them. It is more about democracy.

The ideas of Improvisation and Repair. How to model them? Established systems usually fail to repair disasters' damages. This just represents a temporary repair. A way of improvising

---

common across-borders action. Sometimes, resilience may occur at a very local level, but it occurs at different (larger) scales as well.

[14] ICT makes important things possible, e.g.. the use of the "cloud" after the March 11, 2011 earthquake in Japan. Some examples are provided in the slides (e.g. map vulnerability, criticalities...).

through may help in accommodating the existing situation. We are talking about very simple forms of improvisation (e.g. the case of zip files). Social networks play a key role to this extent.

Information and sharing: assumptions may differ. Rather than rules, also guidelines and models matter (about ethical and legal issues as well as social ones). Under some circumstances, rules do not work, as they are too structured. We have to find what could work: adaptability should be considered, as well as working with engineers and practitioners, and producing guidelines (ethical, legal, social issues guidelines) that could help in creating resilience.

Biggest and most dynamic elements of resilience. Different scales of action and justice matter, but, defining social elements of resilience is a difficult question. How to make data compatible? Social technical and material systems are really important. Furthermore, infrastructure is not only global or only local.

Infrastructure and repair meet. How are communities sliced and rearranged as we make the necessary decisions about infrastructures that solidify specific approaches to ethical, legal, and social implications boundaries they must negotiate? Rules and responsibility are reflexively performed. Who makes the decision? Who monitors the infrastructures?

Reactions to Katrina's contribution
Cristina Garzillo suggests to expand the discussion on "improvisation". Is it a positive aspect? Katrina Petersen answers that it is actually a necessary aspect. The ability of improvisation means that there is flexibility in the system (you can grow and change, you can move on).
Cristina Garzillo adds that in the field of analysis on adaption to global changing, there is the concept of "maladaption" (i.e. a form of spontaneous ways of fixing). Katrina Petersen: please note that, in this context, improvisation differs from fixing.

Resilience and the structure of complex systems, *the contribution of Marco Villani*
Marco Villani, a physicist interested in mathematics applied to social systems, points out the importance of computational models in framing the analysis of resilience.

Resilience is ability of a system to cope with changes, preserving its own characteristics. Computational models can make predictions and help in understanding the phenomena under investigation. The latter are simpler than predictive models. Nevertheless, they can provide insights, when they focus on not trivial behaviours (and variables) characterizing the agents in the system.

In economic and physics models, abstraction plays an important role. Those models capture essential features, without dealing with too many details. Details are usually local whereas behaviours can be considered as global. Marco's research group is mostly interested in the rules driving the behaviours of real systems (global behaviours, not deeply influenced by non-essential details). With regard to complex organisations, a related topic involves the identification of groups of non-linearly interacting agents, through the observation of their behaviours. Sometimes, these groups could form complex organisations, able to give birth to or to modify other groups (e.g., structures such as vortices in the sea). So these studies concern a huge amount of heterogeneous data. Often these groups of agents emerge between two pre-existing levels (the so called "sandwiched" emergence): for example, in biology organs emerge when the lower level (the cells) and the upper level (the multicellular being) already exist. If an agent's behaviour is coherent with the behaviour of other agents, they all compose an organism (from single cells). Intermediate organisations in biology can be easily detected. Accordingly, social systems could be mapped as well, although it is more difficult to recognise intermediate organisations (e.g. groups in a political party). More in general, the class of models his research team develops, refers to some measures of entropy.

Are agents coordinated? If their integration is high, they represent a dynamically relevant set. One can observe hierarchical groups as well, even in social systems, and dynamical hierarchies. Under an emergence, organisations act: which are the groups of agents acting together? Here the concepts of organisms and organisations overlap. Theory could provide hints to model

both global and local behaviours. The latter refer to subsystems (both internal and external). Furthermore, systems can change over time.

Let us consider now the issue of disordered vs. ordered behaviour. When dealing with avalanches of changes, you can estimate (or control) their distribution starting from the dynamical regime of the system. So, systems may differ in the extent of their resilience because of their dynamical regime.

Resilience is the way an organism may adapt to external shocks while preserving its own proper characteristics. Which are the changes that can disrupt the system? We can act on parameters (namely, change self-organising properties of the system). Social infrastructure's resilience may be affected by their conception / implementation and upon their non-integration.

Reactions to Marco's contribution
Margherita Russo suggests that the definition of what a "detail" is matters in any specific context we are analysing and modelling. What will be the relevant details to be included in building computational models should be a research issue not an a priori exclusion.
Leopoldina Fortunati underlines the issue related to theorizing societies as systems (i.e. processes).
Katrina Petersen focuses on modelling resilience. How do you model changes? Marco answers that randomness occurs if changes are not directed. Random changes mean noise: the level of noise can affect the behaviour of components and the outcome of the system (a disruption). Models may be used to outline scenarios.
Matteo Di Cristofaro asks how to define the relevant characteristics in the most appropriate way. Marco answers that precise questions may require precise systems. He recalls the concept of exaptation (rather than adaptation): it refers to a major change in the use of something, which dramatically changes the outcome (there is no bouncing back to the previous step).
Paola Bertolini opens the discussion on the "regularity issue" that could apply to social sciences as well (e.g. size of population)?

Issues in addressing the analysis of social infrastructures resilience

Local governments and health agencies

Resilient local governments, *the contribution of Cristina Garzillo*

Cristina Garzillo introduces ICLEI, an association of cities, a movement and a resource centre as well, offering information, tools, networking, training and consulting services. It comprises 170 local governments across 38 countries. Its main aim is to support ambitious local governments to find sustainable solutions and ensure their views are heard at the European and International level. ICLEI researches focus on the following key topics: from adaptation to climate change to urban resilience and a broader range of sustainability activities. A selection of projects carried on by ICLEI introduces how the issue of resilient cities is currently addressed.

The Ramses Project (FP7) aims at developing methods, tools and case studies to design strategies, quantify costs and evaluate the impacts of adaptation to climate change in urban areas. It focuses on the impact of climate change in cities (e.g. Antwerp, Bilbao and London) and receives large support from external stakeholders.

The Resin Project aims at developing standardized approaches to increase the resilience of European cities and urban areas to extreme weather and climate change. The main issue here is on standardization of processes. Tier 1 Cities: Manchester, Bilbao, Bratislava and Paris; Tier 2 Cities: Ongoing selection based on fixed criteria.

The ICLEI–SMR Project (Smart Mature Resilience) is a multi-disciplinary research project, working for more resilient cities in Europe. Researchers and cities come together to enhance cities' capacity to resist, absorb and recover from the hazardous effects of climate change. A guideline and a set of practical tools are piloted in a core group of cities (Glasgow, Kristiansand and

Donostia / San Sebastián) and shared with a wider group of cities, strengthening the nexus of Europe's resilient cities. Indeed, it is good for the cities to learn from each other (one specific focus is on climate change and adaptation). Selecting cities in different stages of resilience maturity is a unique advantage for the feasibility to conduct, test, demonstrate and validate pilot implementations of the Resilience Management Guideline across the range of maturity levels: starting, moderate, advanced, robust and vertebrate. Peer-reviewing is particularly helpful in revising categorization.

Certain shocks and situations can create opportunities for communities to increase resilience capacity. The challenge will be for trade-offs between resources, and resilience across scales, to be well understood: "so, where to start in an emergency situation?" In each city, the events and the issues addressed are quite different, ranging from natural disasters to unexpected events. For instance, in Rome the death of John Paul II was taken into account. Eventually, security sector matters in different ways according to different events.

Cristina Garzillo also shares with the workshop participants an additional presentation, by Professor John Dagevos, from Tilburg University. His research team is currently working on monitoring social resilience within the Dutch province of Brabant. In the Dutch experience building urban resilience is about managing different coexisting strategies and policy fields, having reliable and comparable information at regional, local and neighbourhood level to make informed decisions. The main research question refers to investigating why has erosion of social components occurred in their regions. Some tools to monitor social resilience have been provided. Important is to note that government is just one of the partners; responsibilities are shared among various actors.

Social resilience refers to different assets/capacities at community level, including: resistivity, recovery, adaptability, change capacity (not bouncing back, but becoming stronger).

Moreover, the focus is on the interplay between social capital (e.g. participation in society), personal capital (e.g. trust) and external resources (e.g. multi-deprivation): "where are the gaps? What is really needed?"

Multilevel coordination: emergence phase & reconstruction phase in the 2012 Earthquake in Emilia (Italy), *the contribution of Francesco Pagliacci*

Francesco Pagliacci provides a short description of the Energie Sisma Emilia project (www.energie.unimore.it), addressing the analysis of the socio-economic effects - on both the material and the non-material components of the system - of the 2012 earthquake in Emilia.

Setting the scene: two big earthquakes hit the Northern part of the Emilia-Romagna region on May 20th 2012 and May 29th 2012. Largest cities were not directly hit by the earthquake: medium-sized cities, but with a large presence of industrial districts. There are several difficulties in properly defining the affected areas (institutional definitions: 53 affected municipalities). Nevertheless, it is one of the most productive areas in the country: e.g. bio-medical districts, textile district, agro-food districts. A lot of industrial activities were involved. The peculiar model of governance which characterises Emilia (i.e. a special balance between public and private action) is a key aspect to be considered in the analysis. Furthermore, cooperative firms represent one of the key components of the system.

With regard to the material damages produced by the earthquake, according to first estimates they amount to 13 bln € (mostly involving industrial buildings and residential ones). Historical and cultural heritage was damaged as well. Nevertheless, material damages just represent part of the story. The focus here is on non-material damages, and in particular on local communities and (public) service providers, with regard to the disruptions in social and organisational infrastructures.

To disentangle the emergency phase and the reconstruction one, within the Energie Sisma Emilia project some focus groups have been carried out. All of them have singled out the importance of non-material damages. During the emergency phase, there was a general lack of preparedness: no specific earthquake protocols; big damages to public buildings and other public structures, which made the situation even worse; collapse in material infrastructure (e.g. internet); databases about patients are usually no longer available; lack of information; managerial criticalities. During the reconstruction phase: major delays in the reconstruction process, although the Emilia model still represents a reconstruction best practice, at least in Italy (lack of any GIS systems; public archives were mostly unavailable; other bottlenecks in the overall process, because of a lack of practitioners); re-organisation of social services and their infrastructures (new methodologies to retrieve information); major changes in the public administrations (take advantage to change routines).

Environmental health emergencies: the role of epidemiology*, the contribution of Paolo Lauriola*

Paolo Lauriola suggests to disentangle natural disasters from man-made disasters. Each of them has different direct and indirect effects on health, both in the short and in the long term. Consequences can be both primary and secondary.

Risk is made of different elements. Hazard (it is mostly natural) x vulnerability (man and built environment) = Risk (risk actually causes the consequences). Even capacity can be considered as a separate element and is included among main drivers of vulnerability.

Focusing on disasters impact, it is possible to refer to the EM-DAT (the international disaster database, www.emdat.be). It includes both natural and made disaster impact. In years 1960-2015, 1637 natural disasters have hit Europe (54 countries). Furthermore, 957 technological disasters have occurred. The overall effects were on more than 44 million people in Europe, of which more than 3 million people in Italy.

Environment and disaster management is a key tool to improve safety and sustainability. According to the Intergovernmental Panel on Climate Change (IPCC), extreme events will become more and more frequent, and more and more extreme. Vulnerability matters: adaptation can increase resilience.

Resilience can be defined as the ability of a system, community or society exposed to hazards to resist, absorb, accommodate and recover from the effects of a hazard in a timely and efficient manner, including through the preservation and restoration of its essential basic structures. Thus it can be either proactive or reactive. A paradigm shift is necessary to reduce risk and enhancing security: analysis and interventions on disasters (conflicts, natural disasters, migrations...), development, and environment must be addressed by taking account of cyclical inter-linkages (vicious cycles) A complexity perspective should be adopted in analysis.

In this framework, the role of epidemiology in emergency is relevant. Epidemiology is the quantitative study of the distribution and determinants of health-related events in human population. Surveillance can be considered both a way to drive your organisation and ad hoc procedures require systematic surveillance.

Reactions to Paolo's contribution:
Routines may create constrains, flexibility may help. Trust and social integration couple with cultural identity: in this perspective we should consider the role for active citizenship. The perception that citizens have of vulnerability may differ from their perception of risk. Vulnerability may lock-in the development path of a community.
Human causes are of utmost relevance in determining "socio-natural" disasters. EU is obsessed by the triple topic "awareness of risk, terrorisms, man-made disasters".

Information losses can be relevant, e.g. the database of the University of L'Aquila went lost after the earthquake.

Risk communication

The management of the 'last mile' in risk communication, *the contribution of Leopoldina Fortunati and Manuela Farinosi*

The most vital sign of a society is its capacity to metabolize environmental and socio-economic changes. In particular, the dynamics of socio-economic changes assumes a wave rhythm (Sarrica et al., forthcoming). Pareto (1916; 1988) describes it as "oscillating". When the socio-economic change intersects with a disaster, however, the change becomes composite and shows a precipitate of natural, artificial, social and economic transformations simultaneously. Coping with such change in extra-ordinary contexts becomes much more difficult (Farinosi, 2012; Quarantelli, 1988).

Indeed, "disasters provide a realistic laboratory for testing the integration, stamina, and recuperative powers of large scale social systems." (Fritz 1968: 202). Disasters are thus specific contexts for examining several factors how affected citizens conceptualize and co-construct the emergency they live through whether and how people use social media to reconnect the social links destroyed by the disasters and virtually rebuild the public space by empowering themselves (Farinosi & Treré, 2010); how people conceive and practice the reconstruction of the affected areas and how their economic fabric copes with the event.

Natural disasters such as earthquakes, flooding and landslides, which are the oldest and recurring phenomena in human history, only recently have attracted increasing attention, not only from scholars, but also from media and public administrators. The fragility of the land and the need for prevention programmes are perceived as increasingly needed to mitigate the economic and social effects of natural disasters. According to the report written by AGIRE (Italian Agency Emergency Response) for the last ten years more than 1 million people have lost their lives due to natural disasters. Only in 2010, there were more than 370 natural disasters in the world that have affected over 200 million people and caused an estimated $ 110 billion of damages with enormous, economic and socio-environmental consequences.

The specific contribution by Leopoldina Fortunati and Manuela Farinosi at the workshop focuses on the management of the 'last mile' in risk communication. The main approach refers to the field of sociology of communication. Communicating with citizens requires to define a standard procedure in the communication chain: how to use social media platforms to communicate and to enhance resilience.

It can be singled out a disaster management cycle:
▪ Preparedness (activities prior to a disaster that aim to plan how to respond);
▪ Response (activities taken as the event takes place. It involves efforts to minimize the hazards created by a disaster);
▪ Recovery (activities following a disaster which aim to return community to normal. Ideally, the affected area should be put in a condition equal or better that it was before the disaster took place);
▪ Mitigation (measures and activities that reduce the effects of disasters);

The relationship between ordinary and extra-ordinary events is important as well. The focus is on the 'ordinariness' to prevent and prepare for a disaster (what about its connections with routines?). The relationship between society and environment is fundamental not only to understand the ability of systems and complex organizations to govern the uncertain, but also to investigate

the size of the vulnerabilities in the management of natural risks and the mechanisms of perception and social acceptability of the risk itself.

EMAs (Emergency Management Agencies) are essential to improve awareness (even in forecasting activities). The impact and consequences of disasters on population can be reduced if people become aware of the dangers of the phenomena that may take place on their territories and if EMAs prepare the public for any emergency scenario that may occur. Also the scientific community has an important role in prevention and risk communication.

Communication plan does not only refer to internal communication, but also on external one. Nevertheless, pre-planned and coordinated management are underestimated from public bodies, which care more to coordinate the internal communication and overlook the external one. The 'last mile' communication just refers to the connection to citizens.

The surge of ICT tools has been tied with new communication strategies. Indeed, a large growth in the use of social media to communicate in real time with the public has flourished. A typical example is represented by Facebook safety check.

Furthermore, while traditional media made possible just a one-way communication, new social media make possible a two-way communication. In fact, citizens are considered as sensors. They are non-specialised creators of geo-referenced information. They increase crisis situation awareness. They can spread and get real time information.

More research is needed in this respect and it us urgent to update (and expand) theoretical knowledge about emergency & social media, with a perspective on both local and global level. It would be relevant to support three major initiatives: to collect and share guidelines and good practices in 'last mile' communication; to define standard procedures describing the 'last mile' activating direct channels of online communication.

The 'second' last mile: flood preparedness in the UK, *the contribution of Michael Guggenheim*
Michael Guggenheim introduces the case of flood preparedness in the UK as the 'second' last mile. Flood action groups have emerged in the past two years: people from local communities. State help is not good enough. Local authority does not organise anything similar. No one else is organising. Flood groups became intermediary organisations between the State and the citizens (namely, the local population). Volunteers play a key role, self-supporting themselves.

A flood forum was created: actually, elderly people do not communicate digitally. Those groups looked at the needs from a bottom-up approach: they focused on documentation of what happens (by taking photos and/or notes). For instance, they checked the water level (when receiving a weather alert). So they meant to face very basic problems to population.

Elderly people suffer from changing conditions: resilience is under stress. Health circumstances and habits play a key role: indeed, any register of people living in the area is difficult to be implemented, maintained, and used. Furthermore, non-official caregivers cannot have access to such a register (because of the presence of sensible information). The concept of vulnerability is dynamic over time.

Intermediate levels between this group and the State play an important role in setting permissions and assuming responsibilities. The absence of technology (and of digital communication) is a key issue here.

2012 Earthquake: a case history of crisis, opportunities & storytelling, *the contribution of Biagio Oppi*
Biagio Oppi is member of FERPI (Federazione Relazioni Pubbliche Italiana) and at the time of the 2012 earthquake he worked for Gambro, a firm of the bio-medical cluster, as communication manager. In his talk, he focuses on two main topics:

i) the role of communication (as a top-down process) and public relationship (much more balanced, i.e. a two-way relationship) with the public under a natural disaster.

ii) the importance of a tool of communication that is a storytelling, both in the acute phase and in the recovery.

Firstly, it is important to keep the public sector, business, NGOs... all together; they can solve the problems that arise from a disaster. Furthermore, it is important to have an infrastructure of relations (see: "rebuilding a company after a natural disaster").

History of Gambro: the 2012 earthquake happened when the company was celebrating its 50° anniversary. A perfect storm! The shock provoked a specific crisis related to the patients (almost 50 per cent of the Italian dialysis patients uses disposable produced by Gambro and any interruption could interrupt the health service). To find a solution was an imperative.

Baxter's crisis management is very high, but a natural disaster differs from a normal crisis, as it affects the entire environment and all the stakeholders.

Improvisation adopted during this crisis: temporary manufacturing plants were at work, in order to produce dialysis machines. Improvisation means the use of R&D competences to change and test the new products.

Round table among stakeholder (a phone call per day) was a crucial component in supporting the solutions to be adopted.

Story telling was important as well. At Gambro, they started collecting a database of "stories" of people, restarting their own lives. A video was produced to tell the story of the reconstruction ("*new hope for the future*"). Attention from the media was obtained immediately, in a few days, as Gambro itself was expected to represent its own local community[15].

In Gambro, stakeholders refer to both the patients and the employees. Aligned communication, internal vs. external communication, had to be considered. Newspapers (i.e. an external channel of communication) are important in order to deliver internal communication, as well, but internal communication had to be changed over time. In 2012, SMS and visual communication on video (plasma screen) were the most effective forms of communication: newsletters were perceived as less clear and less trustful. In 2013, SMS were no longer favourite (they were adopted just in case of an emergency); conversely, plasma screens were still important.

It is important to have just one voice, talking outside the organisation! Different kinds of people need different kind of communication. And different leaders, as well.

Although storytelling is fundamental to engage with people, and also for internal communication, a final key concept is "augmented corporate responsibility": you have to become the champion of your own community.

ICT platform design and implementation

Optimization of organization - Capturing and reproducing best practices*, the contribution of Stefano Pedrazzi*

Moving from the concept of resilience as a process, in his talk Stefano Pedrazzi (CEO at OT Consulting) addresses a critical issue in enhancing organizations' resilience: the absence of any knowledge and reflexivity on the internal procedures adopted as current practices at many organizational levels. Stefano presents a series of case studies in which routines are developed locally and contingently within organizations with no perspective on the negative effects (inefficiencies) they can imply at a systemic level. A basic question is how to describe and analyse those practice

---

[15] Different styles of communication affected mayors as well. Let's take two examples: Medolla and Mirandola. Medolla's mayor was involved in providing greater reassurance to his own people; Mirandola's mayor was used to adopt social media in a very different way.

using a machine learning procedure of processes, as they emerge from actual practices and confront them with the abstract model of efficient practice, or to a benchmark defined case by case according the specific goals of each process. In fact, a typical problem in addressing the efforts of enhancing local or systemic improvements within organizations is that even the acquiring of knowledge on what the practices are is a very hard task. To address those issues, OT Consulting has developed 'myInvenio' a software application to support process management activities and process analysis of data related to events and specific times (people, things, space, places ...)[16].

Data show a large set of problems: volume, velocity, variety, veracity (namely, you are not always certain about them). How to manage all these problems? Data science supports business process intelligence and process mining. How to do automatically all operations about data? It is important to logging any event. Software systems may actually track all kinds of activities: Play in; Play out; Data for simulation; 'Replay' with data. In process mining cognitive technology also applies (to deal with structured data vs. automatic process flow; predictive analysis vs. automatic compliance and checking).

Major benefits of such an approach: (i) real life to reference model comparison is visual and more effective; (ii) immediate identification of critical paths, bottlenecks and variations; (iii) process analysis and governance costs are drastically reduced.

An example: Credito Emiliano. Before, they were using three different softwares. By using myInvenio, they move from a dossier identification (dates and activities) and check a reference model.

Taxonomies can be compared within and across companies. Implications are the optimization of the processes implemented by the organization, by capturing and reproducing best practices. All these aspects, generally overlooked by business companies and by public administrations as, may offer an important support to study them as well as to support the process of strengthening their resilience.

Security: building the resilience in communication through software-defined network orchestration, *the contribution of Maurizio Casoni*

The work of Maurizio Casoni focuses on building the resilience in communication through software-defined network orchestration. He has been involved into several EU projects, such as Esponder and PPDR-TC, where Thales (a major France company) is a partner. In each case, a holistic approach has been proposed.

The idea is to provide support to the first supporters (E-sponder). Three different levels of intervention (service delivery platform): Police; Fire brigades; Ambulances. Esponder's tool was tested at the Schipol Airport in Amsterdam (satellite communicators) and at the Marseille airport. PPDR-TC (it is mostly a standard in this field): roadmap to future PPDR to develop EU Agencies and stakeholders.

The goal is to obtain secure communication and safety. In case of a disaster, only the people being there know what is happening. You have to communicate information even to the central station. Learning from remote should support video communication, then broad band is needed.

Furthermore, it is important to distinguish planned vs. unplanned events: the former may refer to a concert in a stadium, the latter may refer to an earthquake. Key questions: how to improve resilience of those systems? Resilience is at network level. Please, note that resilience (e.g., it may refer to tolerance to human mistakes) also yields to the persistence of the service: actually, it is possible to talk about survivable network design (redundancy).

---

[16] myInvenio is a BPM tool capable of automatically designing business processes by reading the information already present in the log information systems such as ERP, CRM and SFA..

Here, the underlying idea is the concentration of resources and strong connections with existing infrastructure (e.g. LTE). But, if all networks collapsed, you need something else: interoperability of agencies usually lacks in most cases. Indeed, each agency has its own command chain and they do not talk to each other. This means that there is a political issue related to interoperability. According to this issue, both NFV (Network Function Virtualization) and SDN (Software-Defined Networking) can be relevant. In case of planned events, you can allocate dynamic resources, on demand. This means to have some functions which are virtualised. Many mobile phone companies are working that direction. Possible idea: to pool resources, so you can increase throughput. If a path goes down, you use another path. In this context, a software-defined network orchestration software has a major role.

Reactions to Maurizio's contribution
Matteo Di Cristofaro asks to know more on package replication. Maurizio answers that resources are managed by controllers: users ask for info. Replicating may assure resilience. It's resource pooling.
Katrina Petersen highlights the need to consider the connections between disruptions and congestions, and between congestions and resilience. Maurizio answers that in the software-defined network orchestration resources are assigned on demand, otherwise there is congestion. Resilience is mandatory.

DISCUSSION

This section summarizes some of the main questions and issues proposed by the discussion with the workshops' participants.

Matteo Di Cristofaro. He points out that the analysis of social infrastructures resilience should consider implications of the centralised vs decentralised systems. To be more resilient, organisations should be decentralised (people may recognise immediately what is going on): (1) to rule routines/planned activities; (2) to behave an emergency organisation, according to a very different logic (redundancy etc.). This hypothesis has to be properly tested. In a questionnaire we should ask: "how to design the parallel organisation? And how to maintain it 7/24?" Education and training may play a role in enhancing resilience. People redundancy matters as well. Who are the actors? Furthermore, in network firms: how to organise relations among different firms?

Margherita Russo. She proposes to focus on understanding which are the fields in which organisations have changed most. Moreover, the typology of natural risk matters in properly assessing the resilience of social infrastructures.

Katrina Petersen. She points out that 'normal accident perspective' should be set in the socio-technical system. You have to disentangle Close vs. Loose ties among activities; moreover, interdependencies must be analysed.

Biagio Oppi. He reminds that redundancy needs a non-proportional scale at local and global level: more at local than at global level. Moreover: immaterial infrastructures matter in enhancing resilience; in making communication more effective it is important to keep people aligned by adopting very specific/precise messages.

Christian Quintili. He asks what is the role of democracy when discussing of resilience. When talking about de-centralisation, are we talking about democracy? Citizens engagement implies democracy. How could we explain to mayors and other people these topics? These are crucial questions when addressing resilience of social infrastructures. Why do communities shift their mode of operation in a disaster? How do they operate in case of a disaster? A lot of these organisations are completely new, other already existed. Sometimes, organisational procedures keep democracy outside of these processes. This happens just because of the need for speed. In many cases, under the umbrella of speed, much more things happen. To some extent, we should scale back the process. How much speed do we need?

Editors: We should add another issue in the discussion: facing risks is a matter of costs. Costs are just a matter of the competitive market. Here, social responsibility of companies (from both an institutional and a legal setting) enters in the discussion: in their ordinary activities, companies use resources that they do not actually pay.

Barbara Luppi. She recalls the link between law and economics, which is relevant when we consider architecture and risk management law. It includes risk reduction as well. Nevertheless, laws are mostly country specific. Let's just compare Italy and New Zealand. In the former country, a regulatory approach prevails and it is very prescriptive. In the latter one, the approach is non-regulatory and it implies larger discussions among the actors involved. Laws actually shape incentives. Education is important as well vs. dissemination culture. Human and social capital also matter. Moreover: with regard to regulatory environment at sub-national level, which are implications for changes of social infrastructures?

Michael Guggenheim. He is sceptical about educated people: when they know more, they tend to adopt non-expected patterns.

Katrina Petersen. She suggests the need to develop a more balanced perspective taking into account both education and participation/dissemination.

Francesca Pancotto. She reminds her research on these aspects through field experiments.

Marco Villani. He highlights a focus on sharing common values (common rank of values).

Paola Bertolini. She stresses the importance of discussing the differences between urban and rural contexts with regard to resilience infrastructures. Furthermore, even the demographic structure and the cultural heritage matter.

References

Albala-Bertrand, J.M. (1993). Political Economy of Large Natural Disasters: With Special Reference to Developing Countries. Oxford. Oxford University Press.

Albrito, P., Sørensen, C., Manyena, B., Wilkinson, E., De Groeve, T., Lindahl-Olsson, M., (2015). Towards a Post-Hyogo Framework for Action: Strengthening Disaster Resilience for Sustainable Development, Proceedings of the European Parliament, Directorate-General for Internal Policies of the Union Meeting, Workshop. Luxembourg: Publications Office. http://bookshop. europa.eu/uri?target=EUB:NOTICE: QA0415154:EN:HTML.

Anderies, J.M., Janssen, M.A. and Ostrom, E. (2004), A framework to analyze the robustness of socialecological systems from an institutional perspective. Ecology and Society 9(1): 18.

Aranda, K., e A. Hart. 2015. «Developing Resilience to Tackle Health and Social Inequalities». Primary Health Care 25 (10): 18–25. doi:10.7748/phc.25.10.18.s27.

Boschma R. (2014). Towards an Evolutionary Perspective on Regional Resilience, Regional Studies 49 (5): 733–751.

Bruns A. & Burgess, J. (2013). Crisis Communication in Natural Disasters: The Queensland Floods and Christchurch Earthquakes, in Weller K. Bruns A., Burgess J., Merja M. and Puschmann, Cornelius P. (eds), Twitter and Society. Peter Lang, New York, pp. 373-384.

Christopherson, S., Michie, J., & Tyler, P. (2010). Regional resilience: theoretical and empirical perspectives. Cambridge Journal of Regions, Economy and Society, 3(1), 3-10.

Council of Europe (COE), European Commission (EC), United Nations Office for Disaster Risk Reduction - Regional Office for Europe (UNISDR EUR), European Forum for Disaster Risk Reduction (EFDRR), (2011). Implementing the Hyogo Framework for Action in Europe Regional Synthesis Report 2011-2013, (2011) www.unisdr.org/we/inform/publications/33 275 (accessed 11.10.16).

Cuaresma, J.C. (2009). Natural Disasters and Human Capital Accumulation. Policy research working paper 4862. Working Paper. Washington, D.C.: World Bank.

DuPont, W. e Noy, I. (2013). What Happened To Kobe? A Reassessment of the Impact of the 1995 Earthquake.

Energie Sisma Emilia, www.energie.unimore.it

Farinosi M. (2012). Il contributo della ricerca sociale nel post-terremoto aquilano. In R. Salvatore & E. Minardi (eds) O.R.eS.Te Osservare, comprendere, progettare per ricostruire a partire dal terremoto aquilano, pp. 27-51. Faenza: Homeless Book.

Foucault, M. (2009). Security, Territory, Population: Lectures at the Collège de France 1977-78. Lectures at the Collège de France. Basingstoke: Palgrave Macmillan.

Folke, C. (2006). «Resilience: The Emergence of a Perspective for Social–ecological Systems Analyses». Global Environmental Change 16 (3): 253–67. doi:10.1016/j.gloenvcha.2006.04.002.

Fritz, C.E. (1968). «Disaster». In: International Encyclopedia of the Social Sciences. London: MacMillan.

Geipel et al. (1990). Opportunità, problemi e conseguenze della ricostruzione dopo una catastrofe. Aviani Editore.

Guggenheim, M. (2014). «Introduction: Disasters as Politics - Politics as Disasters: Introduction: Disasters as Politics - Politics as Disasters». The Sociological Review 62: 1–16. doi:10.1111/1467-954X.12121.

Guggenheim, M., Deville, J. and Hrdličková, Z. (eds.) (2016). Practising Comparison: Logics, Relations, Collaborations. UK: Mattering Press. https://www.matteringpress.org/news/first-books-practising-comparison.

Janssen, M.A. and Ostrom, E. (2006), Resilience, vulnerability, and adaptation: a cross-cutting theme of the international human dimensions programme on global environmental change, Global Environmental Change, 16(7): 237–239.

Joseph, J. 2013. «Resilience as Embedded Neoliberalism: A Governmentality Approach». Resilience 1 (1): 38–52. doi:10.1080/21693293.2013.765741.

Latha H.R & Kumari S.K. (2012). An Analysis of Link Strength In Social Networks. International Journal of Engineering Research & Technology (IJERT) Vol. 1 Issue 9, November- 2012

Martin, R. (2012). Regional economic resilience, hysteresis and recessionary shocks. Journal of Economic Geography, 12(1), 1-32.

Merani, M.L., Casoni M. & Cerroni W. (2009). Hands-on networking: from theory to practice. Cambridge, UK ; New York: Cambridge University Press.

Nowak, MA. (2006), Five rules for the evolution of cooperation, Science 314.5805 1560-1563.

OECD (2013). Building resilient regions: Lessons for policy making in post-disaster regions. OECD.

Okuyama, Y. & Chang, S.E. (2004). Modeling Spatial and Economic Impacts of Disasters. Berlin: Springer.

Ostrom, E. (1990), Governing the Commons: The Evolution of Institutions for Collective Action, New York: Cambridge University Press.

Palen L. & Liu S. B. (2007). Citizen communications in crisis: anticipating a future of ICT-supported public participation in «Proceedings of the SIGCHI conference on Human factors in computing systems», (pp. 727-736). ACM.

Pareto, V. (1916). Trattato di sociologia generale (Vol.2). G. Barbèra.

Pareto, V. (1988). Trattato di Sociologia generale, a cura di G. Busino, Torino, Utet: 189.

Qu, Y. et al. (2011). Microblogging after a major disaster in China: a case study of the 2010 Yushu earthquake. In Proceedings of the ACM 2011 conference on Computer supported cooperative work (pp. 25-34). ACM.

Quarantelli E.L. (1988). Disaster crisis management: A summary of research findings. Journal of Management Studies 45(4): pp. 373-385.

Russo, M., Silvestri, P. (Eds.), (2016). Innovation and development after the earthquake in Emilia. DEMB Working Paper Series, 81.

Sarrica, M., Farinosi, M., Comunello, F. Brondi, S., Parisi, L., Fortunati, L. (forthcoming). Shaken and Stirred. Social Representations, Social Media and Community Empowerment in Emergency Contexts. Semiotica.

Sokhi-Bulley, B. (2014). «Governmentality: Notes on the Thought of Michel Foucault». Critical Legal Thinking. dicembre 2. http://criticallegalthinking.com/2014/12/02/governmentality-notes-thought-michel-foucault/.

Strömberg, D. (2007). Natural Disasters, Economic Development, and Humanitarian Aid. Journal of Economic Perspectives, 21(3): 199–222.

Sutton et al. (2011). Changing channels: Communicating tsunami warning information in Hawaii, in «Proceedings of the 3rd International Joint Topical Meeting on Emergency Preparedness and Response, Robotics, and Remote Systems», Knoxville, Tennessee.

UNISDR (2009). Terminology on Disaster Risk Reduction. Geneva: United Nations Office for Disaster Risk Reduction. http://www.unisdr.org/files/7817_UNISDRTerminologyEnglish.pdf.

UNISDR United Nations Office for Disaster Risk Reduction, (2005). Hyogo Framework for Action 2005-2015: Building the resilience of nations and communities to disasters http://www.preventionweb.net/ publications/view/1037 (accessed 11.10.16).

UNISDR United Nations Office for Disaster Risk Reduction, 2015. Sendai Framework for Disaster Risk Reduction 2015 - 2030 http://www.preventionweb.net/files/43291_sendaiframeworkfordrren.pdf (accessed 11.6.16).

Vale, L. J., e T.J. Campanella, (eds.) 2005. The resilient city: how modern cities recover from disaster. New York: Oxford University Press.

Wein, A., and Rose. A. (2011). «Economic Resilience Lessons from the ShakeOut Earthquake Scenario». Earthquake Spectra 27 (2): 559–73. doi:10.1193/1.3582849.

Vieweg et al. (2010). Microblogging During Two Natural Hazards Events: What Twitter May Contribute to Situational Awareness, in «CHI'10 Proceedings of the SIGCHI Conference on Human Factors in Computing Systems», pp. 1079-1088.

Appendix 1 Summary of related EU projects

BRIDGE project *(http://www.bridgeproject.eu)*
BRIDGE has built a computer infrastructure to support emergent interoperability – both technical and social – in large-scale emergency management. The infrastructure serves as a bridge between multiple First Responder organisations in Europe, contributing to an effective and efficient response to natural catastrophes, technological disasters, and large-scale terrorist attacks.

EVIDENCE AID Project *(http://www.evidenceaid .org/)*
The Evidence Aid project was established following the tsunami in the Indian Ocean in December 2004. It uses knowledge from Cochrane Reviews and other systematic reviews to provide reliable, up-to-date evidence on interventions that might be considered in the context of natural disasters and other major healthcare emergencies. Evidence Aid seeks to highlight which interventions work, which do not work, which need more research, and which, no matter how well meaning, might be harmful; and to provide this information to agencies and people planning for, or responding to, disasters.

SECINCORE Project *(http://www.secincore.eu/):*
The overall objective of SecInCoRe (Secure Dynamic Cloud for Information, Communication and Resource Interoperability based on Pan-European Disaster Inventory) is to identify data sets, processes, information systems and business models used by first responders and Police authorities leading to a dynamic and secure cloud based 'common information space'. SecInCoRe is currently building the infrastructure for a pan-European inventory of disaster information, and cloud-based common information spaces.

Liveable Cities *(http://liveablecities.org.uk)*
Livable Cities aims to create an holistic, integrated, truly multi-disciplinary city analysis methodology, which uniquely integrates wellbeing indicators, is founded on an evidence base of trials of radical interventions in cities, and delivers the realistic and radical engineering solutions necessary to achieve our vision. Our vision is to transform the engineering of cities to deliver global and societal wellbeing within the context of low carbon living and resource security through developing realistic and radical engineering that demonstrates the concept of an alternative future.

Low Carbon Innovation *(http://steps-centre.org/ project/low-carbon-china/)*
Low Carbon Innovation is an international collaboration between researchers in the UK and at leading institutions in China to investigate different models of innovation and their role in low carbon transitions. Running from late 2013 to 2016, the project will compare government-led, high-tech 'indigenous innovation' approaches with emergent, lower-tech approaches in the areas of agriculture, energy and mobility.

Catalyst *(http://www.catalystproject.org.uk)*
Catalyst is an interdisciplinary research project which brings together academics and communities to jointly imagine and build the next generation of digital tools for social change, and to explore innovative, bottom-up technology-mediated solutions to major problems in society.

SMART MATURE RESILIENCE Project
Smart Mature Resilience (SMR) will develop and validate Resilience Management Guidelines, using three pilot projects covering different CI security sectors, as well as climate change and social dynamics. The Resilience Management Guidelines will provide a robust shield against man-made and natural hazards, enabling society to resist, absorb, accommodate to and recover from the effects of a hazard in a timely and efficient manner, including through the preservation and restoration of essential structures and functions. A set of tools operationalize crucial interdependent supporting structures of the Resilience Management Guidelines: 1) a Resilience Maturity Model defining the trajectory of an entity through measurable resilience levels; 2) a Systemic Risk Assessment Questionnaire that, beyond assessing the entity's risk, determines its resilience maturity level; 3) a portfolio of Resilience Building Policies that enable the entity's progression towards higher maturity levels; 4) a System Dynamics Model allowing to diagnose, monitor and explore the entity's resilience trajectory as determined by resilience building policies, and, 5) a Resilience Engagement and Communication Tool to integrate the wider public in community resilience, including public-private cooperation. Beyond delivering the validated Resilience Management Guidelines and the five supporting tools, the SMR project establishes a European Resilience Backbone consisting of vertebrae (adopters, from fully committed through direct project participation to alerted potential adopters). The SMR project's powerful impact maximizing measures will assist the implementation of the Resilience Management Guidelines by consolidating the resilience vertebrae as mutually supporting functional units of the European Resilience Backbone. The five tools operationalizing the five crucial interdependent supporting structures of the Resilience Management Guidelines will be commercialized, targeting users in Europe and beyond.

Appendix 2 Biographical notes on the authors

Maurizio **Casoni** - UniMORE (Ita)

Maurizio Casoni is Associate Professor at the Department of Engineering "Enzo Ferrari" of the University of Modena and Reggio Emilia, Italy, in the field of Telecommunications. He received the M.S. with honors and the Ph.D. degree in Electrical Engineering from the University of Bologna, Italy, in 1991 and 1995, respectively. In 1995 he was with the Computer Science Department at Washington University in St.Louis (MO, U.S.A.) as a research fellow. He was the responsible of the University of Modena and Reggio Emilia for the European Technology Platform ISI, the Integral Satcom Initiative, for the EU FP7 Large Scale Integrated Project ESPONDER "A Holistic approach towards the Development of the First Responder of the future", and for the EU FP7 SEC-2012-1 project PPDR-TC "Public Protection Disaster Relief – Transformation Centre". He has been the Chairman of two editions of the IEEE Workshop EN4PPDR "Emergency Networks for Public Protection and Disaser Relief", held within the IEEE International Conference on Wireless and Mobile Computing, Networking and Communications, in 2014 in Larnaca (Cyprus) and in 2015 in Abu Dhabi (U.A.E.). He will also chair the third edition to be held in New York City next October 17. Also, he has been Co-Chair of the Workshop "Next Generation Public Safety and Critical Infrastructure" held within the European Conference on Networks and Communications (EuCNC 2015), sponsored by the European Commission, held in June 2015 in Paris (F). He has been invited as Speaker to the Panel "Network Disaster Management and Recovery" at 12th IEEE International Conference on Design of Reliable Communication Networks in Paris on March 16, 2016.

Manuela **Farinosi** - University of Udine (Ita)

Manuela Farinosi is post-doctoral researcher in the Department of Humanities and cultural heritage at the University of Udine, Italy. She received the Master degree cum laude in Communication Studies from the University of L'Aquila (Italy) and the Ph.D. in Multimedia Communication from the University of Udine. Her academic interests include social and cultural aspects of digital technologies, social network sites, participatory media and DIY culture. In particular, since 2010, she studies the grassroots adoption of digital media in the aftermath of the L'Aquila earthquake and, more in general, the role played by social media in extra-ordinary contexts. She teaches courses in Sociology of communication, Theories and techniques of digital media and Economic sociology at the University of Udine. She has been a visiting scholar at the University of Alberta in Edmonton (Canada) and Université de Namur (Belgium). She is member of the COST Action FP1104 'New possibilities for print media and packaging - combining print with digital'. Her work has been published in peer-reviewed journals, as well as in several edited books.

Leopoldina **Fortunati** - University of Udine (Ita)

Leopoldina Fortunati is the director of the research laboratory NuMe (New Media) at the University of Udine where she teaches Sociology of Communication and Culture and Social Robotics. She has conducted several studies in the field of gender studies, cultural processes and communication and information technologies. She is also active at cross-European level, and especially in COST networks. She has represented Italy for almost 20 years in the COST Technical Committee for Social Sciences and then in the COST Domain Committee 'Individuals, Societies, Cultures and Health', which were the organization bodies that decided what new actions and research programmes on social sciences are to be approved at the European level. She is the author, editor or co-editor of 18 books. She has published more than 50 articles in peer-reviewed international journals such as British Journal of Sociology, Social Science Research, Journal of Computer-mediated Communication, Information, Communication & Society; The Information Society, International Journal of Social Robotics, Cognitive Computation, Journalism, European Journal of Communication, Asian Journal of Social-Psychology, Personal and Ubiquitous computing, etc. Her works have been published in eleven languages: Bulgarian, Chinese, English, French, German, Italian, Japanese, Korean, Russian, Slovenian, and Spanish.

Cristina **Garzillo** - ICLEI (DE)

Cristina Garzillo is an architect and Urban Planner, PhD, Master of Conservation of the Urban Environment. She is co-ordinator, Governance and Social Innovation (Senior Expert), ICLEI European Secretariat GmbH. She has been employed with ICLEI since 2005. Having almost 20 years of experience working in and for local governments, Cristina is recognised for her work as expert in local sustainability processes, integrated management and governance as well as author of numerous publications in the field of local sustainability, knowledge brokerage and transition. Cristina can also draw on a wealth of academic experience gained from previous role as contract professor at the University of Parma.

Michael **Guggenheim** - Goldsmiths University (UK)

He studied in Zürich and Berlin, and obtained a PhD in Sociology in 2005 from the University of Zürich. Prior to coming to the UK, he worked and researched in Budapest, Vienna, Montreal, and Berlin. He has taught both artists at art schools and natural scientists at technical universities, which was important for his understanding of how to teach sociology and how it can be used to intervene in the world. It also worked and experimented with different media and produced both theoretical texts and visual and sensory works. His work has been defined by different yet connected themes relating to the relationship between experts and lay people, the role of objects for this relationship and on methodical and theoretical innovation derived from the combination of science studies with sociological theory. He is currently directing an ERC-funded project "Organising Disaster: Civil Protection and the Population", which looks at how disaster experts conceive of the population. Previously, he has worked on change of use of buildings and how materiality and use interrelate. For his PhD, he studied environmental experts and how they produce the environment at the intersection of science, politics and the economy. Research interests: Science and Technology Studies; Architecture, Buildings and Urbanism, Visual and Sensory Sociology (and other methodological explorations); Sociology of Disasters; Sociology of Experts; Sociology of Organisations.

Paolo **Lauriola** - Arpae Emilia-Romagna (Ita)

Head of Regional Reference Centre "Environment & Health" of ARPA Emilia-Romagna. He is a physician, with post-graduate diplomas in Hygiene and Preventive Medicine (Industrial Hygiene and Public health) and in Medical Statistics. He has also got the International Certificate of Human Ecology (WHO). He carried out in the field experiences in teaching and research . He collaborated and run several EU projects in the field of environmental-health prevention. In particular he led 4 Twinning projects the last which dealt with the "Capacity building in the field of environmental health" in Poland. He also leaded a Central Europe in "Development and application of mitigation and adaptation strategies and measures for counteracting the global Urban Heat Islands phenomenon". He is

involved in many initiatives aiming at setting up environmental health surveillance in Italy. In particular he is the Italian reference person of the International Network of Public Health and Environmental Tracking (INPHET) The main aim of this network is to "fill the gap" between gap between science, policy makers and society. He is a member of the of Scientific Committee of the advanced Course in the Territory Environmental health Emergency. This Course will be carried out by the (University of Modena and Reggio-Emilia in collaboration with the Italian Army, the Civil Protection Agency (Regional Civil protection Agency), the Environmental Protection Agencies (ARPAE) and the main responsible of local environmental health issues which is the Municipality (the Commune of Modena). He published over 100 articles on national and international Scientific Journals.

Biagio **Oppi** - Global Alliance and FERPI (Ita)
Biagio Oppi is member of the Board of GA. Since March 2011, Biagio is responsible for communications and public relations, for Italy, of Gambro, multinational medtech, a leading manufacturer of devices for dialysis. Previously, he has worked for years in Hitachi Group in the food & wine, health and motorsport. For some time it is very busy with international public relations. He is member of the research team Energie Sisma Emilia.

Francesco **Pagliacci** - UniMORE (Ita)
Francesco Pagliacci currently holds a post-doc position at the University of Modena and Reggio Emilia, Department of Economics. His research activity mostly focuses on the socio-economic effects of the 2012 earthquake in Emilia and the reconstruction process. He obtained a PhD in Agro-food Economics and Statistics in 2013 from the University of Bologna. His dissertation thesis dealt with EU rural areas, aimed at identifying major typologies of rurality by means of multidimensional and continuous indicators, as well as their latest performances according to main EU policies. He has been visiting at Arizona State University (USA), where he has improved a main research interest in spatial econometrics. After having obtained his PhD, he held a post-doc position at the Department of Economics and Social Sciences of the Università Politecnica delle Marche. He was involved in a 7 FP Project named "WWWforEurope: Welfare, Wealth and Work for Europe". His research activity mostly focused on territorial allocation of EU funds supporting agricultural activities and rural areas throughout Europe. In particular, he developed spatial econometric models which take into account endogenous and exogenous geographical spillover effects among neighbouring regions. Other research interests deal with regional economics, evolution of urban-rural divides and urban system structure, agricultural economics.

Katrina **Petersen** - Lancaster University (UK)
Dr. Katrina Petersen is Research Associate at Lancaster University, in the SecInCoRe project. She received her PhD in 2014 from University of California, San Diego in Communication and Science Studies. Her main research has been on disaster maps as communication tools, examining how knowledge of a disaster and risk is connected to what goes into visually representing them. She is especially interested in why some representations encourage understandings shared between groups while others impede collaboration. She also volunteers for the San Diego Red Cross as a disaster mapper, helping them design a new system for collaborating, via maps, during disasters. Before pursuing her PhD, she worked for almost 10 years in science museum education and exhibits. Her BA is in Geology and her MSc is in Science and Technology Studies.

Simone **Righi** – UniBO (Italy)
Simone Righi is currently a Post-doctoral researcher at the University of Bologna. Moreover, he is a Part-time Research Fellow at the Research Center for Educational and Network Studies (Recens) at the Center for Social Sciences of the Hungarian Academy of Sciences, a regular visiting professor at ESCP-Europe Business School - Paris Campus (where he collaborates with Prof. Yuri Biondi), and an affiliate member of the Namur Center for Complex Systems (Naxys). The one in Modena is his second post-doc after obtaining, in June 2012, a Ph.D. in Economics from the University of Namur (Belgium) with a thesis on "Information aggregation and Political Economics". His main research interest is the study of network theory's applications to microeconomics, finance and social sciences. The theoretical models he developed are characterized by the presence of a multiplicity of heterogeneous agents, each endowed with a piece of information (an opinion, a belief or a preference) which can be shared with peers in the first order social neighborhood. In particular, the results that he obtained so far concern the influence of networked interactions on the economic incentives related to running a referral program, on the informational efficiency of a financial market and on decision making in groups. His previous research led to the publication of five papers in international peer-reviewed journals (most notably in the Journal of Economic Behaviour and Organization, Advances in Complex Systems, Physica A and Journal of Economic Interactions and Coordinations) and of several book chapters and conference proceedings.

Margherita **Russo** - UniMORE (Ita)
Margherita Russo is Full Professor of Economic Policy at the University of Modena and Reggio Emilia. After her MA in Economics at University of Cambridge (UK) she began her academic activity at the University of Pescara (Italy) in 1985 and then at the University of Modena (since 1989). Her main research interests include: analysis of processes of innovation and competence networks, effects of innovation on the organization of labor, structure and change in local productive systems, evaluation of innovation policies. In the last decade she has been member of international and EU research projects on innovation, and has directed research projects on the mechanical industry in Italy, on the assessment of policy innovation networks and, recently, on the socio economic effects of the 2012 earthquake in Emilia (Italy). Since 2000, Russo is scientific director of Officina Emilia, a project of the University of Modena and Reggio Emilia aiming at the regeneration of competence networks and the increasing of the quality of the education system. She is a Research fellow of CAPP (Centre for the Analysis of Public Policies, Department of Economics, University of Modena and Reggio Emilia). Research Interest: innovation, local development, evaluation of innovation policies, economics of natural disasters.

Marco **Villani** - UniMORE (Ita)
Marco Villani is interested in information processing in complex dynamical systems, where he is developing various kinds of theoretical models, including topics as genetic regulatory networks, cell differentiation, growing protocells, innovation processes. A new and very interesting issue is that of the identification of relevant subsets of variables in dynamical systems. After than 10 years of research in public (ENEA) and private organizations (Montedison), he is currently associate professor at the Department of Physics, Informatics and Mathematics of the University of Modena and Reggio Emilia.