SIMPACT PROJECT REPORT

Report **#D2.1**

Social Innovation Simulation Model and Scenarios

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social innovation
economic foundation
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SIMPACT
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EXECUTIVE SUMMARY

This report describes the theoretical model of social innovation to aim at getting further insights about its economic underpinnings. The baseline model provides a set of predictions by simulating the analytical solution. The model is chosen in a parsimonious manner in order to ensure a tractable and analytical solution, which summarises the level of social innovation as a function of the model parameters and variables. The various versions of the model with different parameter values can be interpreted as reflecting various national and regional as well as welfare state typologies. The social innovation model presented in this report is initially based on tools from neoclassical economics, but it also extends this framework by incorporating behavioural aspects in the decision-making. Specifically, the report moves the baseline modelling approach forward by including future-based scenario building. These social innovation scenarios bring the baseline simulation model closer to the real-life cases and reflect on the future possible events to guide policymaking.

1 OBJECTIVES OF THE REPORT

This report is the first deliverable (D2.1) of SIMPACT's Work Package 2 (WP2) Social Innovation Behaviour Scenarios corresponding to research activities of the following tasks (see SIMPACT, Description of Work, pp. 25):

- *Task 2.1: Simulation Model and Reference Scenarios of Social Innovation (SI),*
- *Task 2.2: Small-scale Stakeholder Experiments – From Model to Reality,*
- *Task 2.3: Simulation Iterations (three iterations at months 18, 27, 32),*
- *Task 2.4: SI Scenario Building.*

The report describes and develops the theoretical model to economically underpin social innovation. The initial model provides a set of baseline results by simulating the analytical solution of the model. The model is chosen in a parsimonious manner in order to ensure a tractable and analytical solution, which summarises the level of social innovation as a function of the model parameters and variables. The social innovation model presented in this report is initially based on tools from neoclassical economics, but it also extends this framework by incorporating behavioural aspects in the decision-making. Specifically, the report moves the baseline modelling approach forward by including future-based scenario building. Social innovation scenarios are "understood as in terms of the probability of social innovation given certain sets of interactions between individuals in and with their environment to support social innovation stakeholders in coping with uncertainties associated with social innovation" (SIMPACT, Description of Work, pp. 25). These social innovation scenarios bring the baseline simulation model closer to the real-life cases, despite the limitations in the theoretical framework. Overall, the social innovation scenarios reflect on the future possible events to guide policymaking.

The initial model and scenarios have been through three iterations over the project lifespan (2014-2016). In particular, during the SIMPACT project progress meetings, each iteration of the modelling and simulation exercise is regularly reviewed by consortium partners, which fed the model with the empirical evidence collected by SIMPACT and contributed to the fine-tuning of the approach. After the internal review process, the modelling approach, simulation results and various scenarios have been regularly presented to and tested with stakeholders during the small-scale stakeholder experiments, which is part of the WP2 Task 2.2 *Small-scale Stakeholder Experiments – From Model to Reality* and are jointly organised by TUDO and CEPS.

2 BACKGROUND AND MOTIVATION FOR MODELLING SOCIAL INNOVATION

The societies of today have been facing various challenges, such as aging, long-term unemployment, migration, gender discrimination, most of which are addressed by public policies across countries. However, for various reasons, these challenges are not completely overcome yet. To this end, new ideas or solutions, broadly gathered under the roof of *social innovation*, complementing or accompanying public policies and services, come more and more to the forefront to address some of these social challenges. Despite the connotation of the word *innovation*, social innovation is actually quite different from a standard market-oriented innovation, whereby the former is not necessarily profit-driven and is mainly a frugal solution to a social problem in an ecosystem with scarcity of funds and abundance of societal challenges.

Bearing these aspects in mind, there are various ways in which one can define social innovation. In the framework of SIMPACT project, social innovation refers to "novel combinations of ideas and distinct forms of collaboration that transcend established institutional contexts with the effect of empowering and (re)engaging vulnerable groups either in the process of the innovation or as a result of it" (Rehfeld et al., 2015; Terstriep et al., 2015). In a way, the focus is mainly on the social innovations, which target disadvantaged individuals that could be socially excluded or whose useful skills could not have been put in effective use (e.g. labour market mismatch and unemployment) because of market or public service failure.

Despite the recent surge in social innovation around the world, the concept of innovation is not so new. In economic history, the pioneering figure advocating the importance of innovation was the well-known economist Joseph Schumpeter. Basically, he identified innovation as the critical dimension of economic change and argued that the latter revolves around innovation, entrepreneurial activities, and market power. He sought to prove that innovation-originated market power could provide better results than the invisible hand and price competition (Pol and Carroll, 2006). In the Schumpeterian approach, technological innovation often creates temporary monopolies, allowing abnormal profits that would soon be competed away by rivals and imitators. These temporary monopolies were necessary to provide the incentive for firms to develop new products and processes. This whole phenomenon is also known widely as "creative destruction". It is possible to adapt some of these concepts of market-driven innovation to social innovation, bearing in mind its social objectives (not necessarily profit maximizing), the context, and lack of resources.

Evidence suggests that there has been rising popularity and interests over the issue of social innovation. One way to check this trend is to have a snapshot analysis in Google Trends using the search "social innovation". Figure 1 depicts this rising trends in social innovation since the early 2000s. We see that the compound word "social innovation" has been entered in search engines in an increasing manner over time. We also look at the word "innovation" using Google trends, but the resulting outcome is more flat (not reported here).

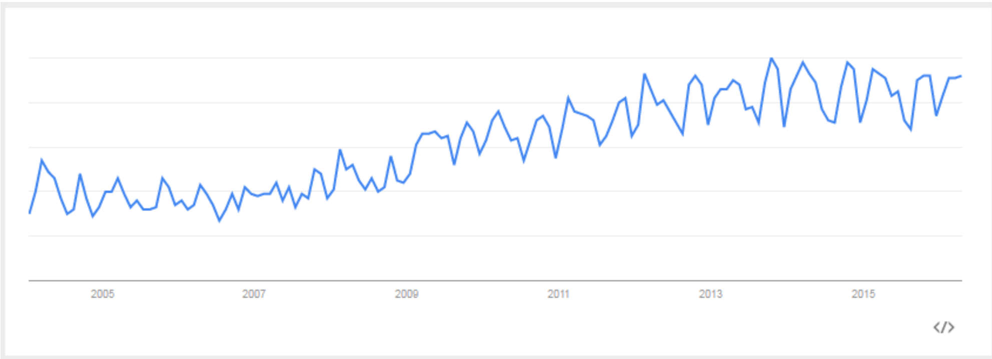

Figure 1. Google Trends of "Social Innovation" (April 2016)

Another way to see the rising interest and popularity of social innovation phenomenon is given by a quick semantic analysis. Mulgan et al. (2007) report that a Google search of the word "innovation" in March 2007 threw up about 121 million web pages, ranging from articles to toolkits, books to consultancies. On the contrary, the search for "social innovation" generated only 840,000 pages. Against these numbers, our recent search analysis in April 2016 involving a Google search of the word "innovation" resulted in 392 million web pages while "social innovation" resulted in 32,900,000. Therefore, there seems to be a big progress and rising interest on the social innovation in the last decade, but the latter still remains far behind the former even today. Nevertheless, this exponential jump in the importance of social innovation in the general interest shows that this type of innovation is going to be on the social agenda for the years to come.

As listed by Mulgan (2006), there are thousands of examples of successful social innovations that have appeared in recent times, including neighbourhood nurseries, Wikipedia, Open University, holistic health care, microcredit and consumer cooperatives, the fair trade movement, community wind farms, online self-help health groups and so on, to name a few. Although the success of and increasing public awareness about such initiatives imply a generally rising interests toward social innovation, there still seems to be a lack of theoretical approach to systematize, streamline, and understand the onset, process, sustainability, and scalability of social innovation. Compared to the vast amount of academic research on technological, for-profit or business-oriented innovations, there is no corresponding supply of academic research on social innovation or at best, it is only at its infancy.

To this aim, there has been a surge among academics toward more social innovation research, such as SIMPACT, among others. Each of these endeavours aim at contributing and advancing the social innovation research from different angles and using various but sometimes overlapping methodologies. SIMPACT's approach is very specific in focusing on the economic underpinnings of social innovations in order to boost their impacts across Europe. The project covers various angles of social innovations ranging from empirical evidence collection with case studies and social innovation biographies, development of tools to understand the "business model" of social innovation and tools to measure and possibly assess the impact of it to more theoretical approaches in conceptualizing, modelling and providing scenario-building based on simulation methods and policy instruments. The current paper is contributing to the SIMPACT project from the theoretical economic model building and scenario simulation perspective.

The objective and structure of this paper is to describe the theoretical model in economics in order to gain further insights as regards to the factors determining social innovation. The model is based on individual preferences and decision making and incorporates elements such as risk preferences, intrinsic utility, bureaucratic barriers, uncertainty (in the form of shocks on the demand side), and costs of undertaking social innovation. Within a comparative static exercise, the analytical solution of the model is then used to simulate various scenarios given different parameter values and suggests pathways, drivers, and barriers to the social innovation process from a theoretical point of view. The purpose of this approach is to contribute to informed decision-making of policymakers, investors and innovators.

3 BRIEF LITERATURE REVIEW

The key industries of the 21st century such as health, education, childcare, eldercare, when added up, are expected to have a larger share in GDP compared to IT in the future. At the same time, these are also the main areas where many social challenges arise such as aging, long-term care, unemployment and so on, which then create vulnerabilities within and across societies. Mulgan et al. (2007) states that a contented and stable world might have little need for innovation and that innovation becomes imperative when things get worse, when systems do not work properly or when institutions reflect past rather than current problems.

Mulgan (2006) states that most of these challenges are being somewhat addressed by public policies and services, but clearly given the recent global downturn coupled with other major socio-ecological societal transitions, these policies and services also depend a lot on co-production, co-creation by the user, patient, learner and so on. What is more, such challenges could be also addressed by innovative solutions endorsed by socially driven, motivated and creative individuals. In this vein, Mulgan (2006) highlights that (social) change, on the one hand, happens usually with brave people who are willing to take risks and who have leadership skills to lead and convince other individuals in the society. On the other hand, it is also very important that the individuals who are to be impacted by the social change could be persuaded to abandon and/or modify existing habits (Mulgan, 2006).

Nevertheless, one should note that to lead a social change that can convince larger groups in the society for a change would likely be the outcome of the actions of many social innovators. In that case, the latter would contribute to mainstreaming and institutionalising new practices that facilitate social change rather than action of individual social innovators. However, SIMPACT focuses on institutional rather than on social change.

As is reflected in SIMPACT's understanding of social innovation, Mulgan (2006) asserts that new social ideas are rarely inherently new per se and that most of the time they combine previous ideas to form creative combinations. In that sense, exchange of ideas can stimulate further creation of ideas through externalities and spillover effects. In the social context that we focus on, such interaction of ideas is even more important.

Pointing to the scarcity of resources and planetary challenges pushing further boundaries of ecological systems, Westley (2013) states that "we need innovative solutions that take into account the complexity of the problems and then foster solutions that permit our systems to learn, adapt, and occasionally transform without collapsing. More important, we need to build the capacity to find such solutions over and over again."

The success of social innovation is influenced by the current state of play of its ecosystem and openness of the system to allow entrance of "new" actors (Terstriep et al., 2015). In particular, social innovations belong to a complex and context-dependent specific ecosystem shaped by already existing legal, economic, and social structures and actors. Therefore, it is not surprising to observe resistance against a socially innovative solution. This is closely related to the notion of incumbent versus newcomer clash as in the business-driven innovation. Accounting for social and cultural complexity, demands of different actors or by actors and their environment, the dilemma approach points to the necessity to balance, for example, economic and social modes of efficiency or between cooperative and competitive modes of interaction (Rehfeld & Terstriep, 2015). It suggests, that there exists no best solution, but social innovations (or underlying processes) always tend to reconcile two extremes of a continuum in a specific way.

As this brief literature review suggests, there is a growing interest over social innovation research from several fields of study. However, to the best of our knowledge, the theoretical model and simulation approach presented in this report is the first exercise of its type in the context of social innovation.

4 THE SIMULATION MODEL

4.1 Our approach

As mentioned in the previous sections, SIMPACT investigates the economic foundations of social innovation in relation to markets, public sector, and institutions with the intention of providing a dynamic framework for action at the level of individuals, organisations, and networks as stated in Terstriep et al. (2015). In line of this objective, we present a theoretical model in order to get further insights as regards the factors determining social innovation.

In the context of this paper , a model is a set of assumptions and equations describing, in general, behaviour of an actor (agent) or a set of actors (agents) under given circumstances. Given the theoretical approach, the analysis of social innovation via such economic model and simulations could be considered as an ex ante approach, i.e. before social innovation takes place.

In the economics profession, researchers build models, which are—to a certain extent—simplified descriptions of reality, in order to enhance their understanding of how things work (Ouliaris, 2012). Obviously, the real world is much more complex than what the model is able to capture; therefore, the economists tend to enrich the model as much as possible with the aim of reflecting the actual pro-cesses, behaviour, and outcomes in real life. However, there is a clear trade-off between model realism—that usually requires complex models while complicating the computation—and parsimony—, which keeps the least number of essential elements in the model simplifying the reality while easing the analytical computations. In other words, while there is the drawback of parsimony leading to models that have certain assumptions and making the model at times far away from reality and complexity of actual problems, there is also a value in the simplification of the reality via modelling, which makes it—at least, analytically—easier for modellers to find solution(s) to a complex phenomenon such as in the case of economic and social challenges.

Considering these aspects, we adopt a parsimonious model approach, which is one of the desirable features in economics and inference analysis (Zellner et al., 2001; Varian, 1997; Varian, 2009). The well-known microeconomist and author of many undergraduate and graduate microeconomics textbooks, Varian (2009) reminds that the whole point of a model is to give a simplified representation of reality. In other words, this suggests that the model has the least number of elements for simplicity, but it is still able to produce testable hypotheses and eventually capture a reasonable amount of pattern and behaviour that are happening in the real world. This is the starting approach of the model presented in the next sub-section. Nevertheless, given the feedback along the SIMPACT project's lifespan, our parsimonious approach has evolved and enriched in order to better reflect the sophistication and multi-faceted nature of social innovations.

4.2 Model ingredients

In this section, we describe all the main elements forming the basis of the model including the agents, their characteristics, preferences and utilities, choices, and conditions.

Actors. For simplicity, we start with three main agents (or actors). The *social innovator or creator*, who creates or comes up with an innovative idea (either by finding new ideas or by creating new combinations using existing ideas); the *users or beneficiaries,* who are people or groups of people that are targeted or impacted in one way or another from the solution or social innovation created by the social innovator. Finally, the model also embeds the *connectors (or facilitators)* as another actor in this framework. The connectors are the actors who help realising an idea such as institutions or (large-scale) entrepreneurs. This starting point is in line with the idea of a micro layer of social innovation as suggested by Howaldt et al. (2015). With regard to our understanding of social innovation, distinct forms of collaboration reflect the interactions between the various actors involving processes of co-creation. Although this framework does not exclude such interactions, the separation of the actors in this way helps distinguish their distinctive role in the social innovation process that we will subsequently simulate.

A social innovator is a person with certain characteristics or skills such as innovative, creative, motivated, benevolent, and resilient etc., but s/he does not need to have all these traits at the same time. We consider her/his job as to come up with an innovative idea or bring together existing ideas in an innovative way in order to address a social problem that potentially affects a number of people.

Without loss of generality, we assume that there are x number of social innovators in a society, which takes a value in the interval [0,1]. If we assume that each social innovator is linked to a distinct social innovation, then x also represents the number of social innovations in an ecosystem. One can interpret this value as the supply of social innovation.

We denote the number of users or people who are the target group of a social innovation by z. Without loss of generality, we also normalize z, the number of users, or alternatively the share of the population who is targeted or meant to be impacted by the social innovation, and assume that it takes a value in the interval [0,1]. One can interpret this value as the size of the demand, depending on the context of social innovation. The model is generic enough to adapt different interpretations.

Intrinsic utility. In economics, the neoclassical approach to modelling individual preferences usually involves only monetary (pecuniary) – also known as extrinsic – utility. However, Benabou and Tirole (2003) and Besley and Ghatak (2005), among others, highlight the non-pecuniary part of a utility function driving individual behaviour via utility maximisation. The intrinsic utility is a way to describe preferences reflecting non-pecuniary aspects, such as social values. Given the context of social innovation, we argue that the intrinsic utility is a relevant and important part of the utility of the social innovator.

Moreover, the intrinsic utility is one of the elements that can take the model beyond the representative agent approach. For example, one way to incorporate heterogeneity among agents using this tool is to rank people by their intrinsic utility as a function of their types. The idea behind the ranking of utilities is that it allows finding thresholds to get the number of social innovators in the equilibrium. Moreover, we augment the intrinsic utility by risk preferences of the social innovators, since evidence shows that risk attitudes are an important element in any innovation activity (Acemoglu, 2009). Overall, we denote the intrinsic utility by $r(x)$ where x reflects the type of an individual and σ reflects risk preferences. This summarizes the intrinsic value of social innovation to the innovator. Here we use the dual interpretation of x as the type of the individual (on top of the interpretation as the number of social innovators) over the continuum [0,1]. We can use this dual interpretation mainly because of the property of the intrinsic utility, which is a decreasing function of x.

To illustrate the dual interpretation of x and assuming that altruism can be associated with being a social innovator, imagine that the continuum of [0,1] represents the spectrum of behaviour of an individual, where 0 represents the most altruistic type and 1 represents the least altruist (or selfish) individuals. Imagine that there are x number of social innovators, where x lies somewhere in the same interval [0,1]. Because the intrinsic utility is ranked and is a decreasing function of x, this implies that any individual who lies to the left of x in the interval has higher intrinsic utility of being a social innovator compared to individuals who lie to the right of x. In other words, if we can associate social innovators as being altruist people, this means that the most altruist individual has the highest intrinsic utility of being a social innovator than an individual who is less altruist. Assuming a linear functional form, $r(x) = 1 - x$, we can see this illustration graphically as in Figure 2.

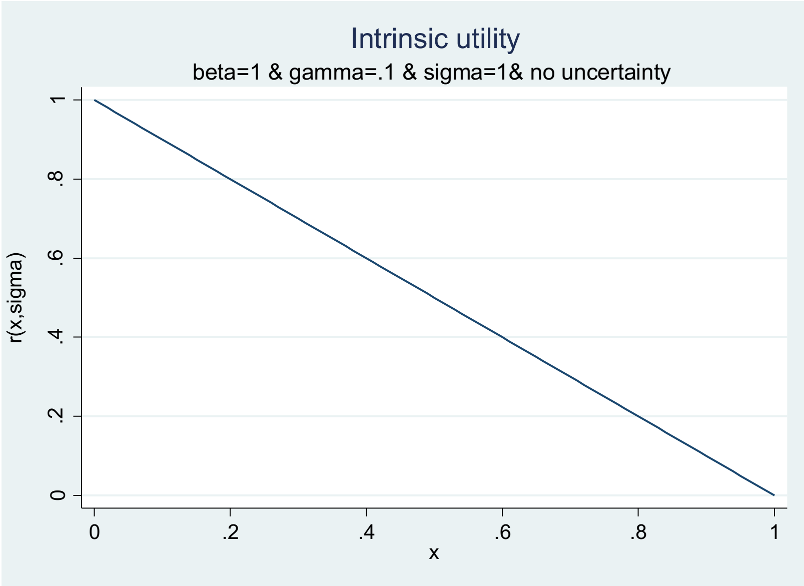

Figure 2. Intrinsic Utility of Social Innovators

Risk preferences. We augment the intrinsic utility such that it takes into account risk attitudes. In particular, we adopt the concept of risk aversion as commonly used in economics and finance based on the behaviour of humans while exposed to uncertainty to attempt to reduce that uncertainty. Intuitively, risk aversion is the reluctance of a person to accept a bargain with an uncertain payoff rather than another bargain with more certain, but possibly lower, expected payoff (Gollier, 2001). There are several measures of risk aversion in the literature. In our context, we include a relative risk aversion parameter denoted by σ, which is defined based on the Arrow-Pratt-De Finetti measure of relative risk aversion (RRA) as follows for a given function $r(x)$:

$$\text{(1)} \qquad \mathrm{RRA} = -x.\frac{r''}{r'},$$

Where r' and r'' denote the first and second derivatives of $r(x)$, respectively, with respect to its argument x. We denote the augmented intrinsic utility function including risk preferences by $r(x, \sigma)$.

Utility from others who benefit from or targeted by the social innovation. As the social innovators are usually individuals who care about the others and hence try to find innovative solutions to address a bottleneck, societal challenge, or a market failure influencing such people, it is relevant to include a component in her/his utility function that includes a parts generated by how many others use the social innovation. We assume that this additional utility component is increasing in the number of people impacted by the social innovation.

However, there could be many reasons influencing how a social innovation can successfully expand or contract its user base. We summarize all such impacts by an efficiency parameter β, which could be interpreted—depending on the context and ecosystem of the social innovation—as social trust, cohesion, ease of adaptation to change, social capital and so on. The idea is that this parameter captures the smoothness for the social innovation to take its desired effects on the target groups.

Taking into account the number of users and the efficiency with which social innovation takes place, we define a smooth function $f(z, \beta)$ with these two elements as the second component—related to the positive impact that the target group gets through the social innovation—of the utility of social innovator.

Network effects. Easley and Kleinberg (2010) describe the network effects within the context of adoption of technologies for which interaction and compatibility with others is important. Accordingly, network effects happen when for some kind of decisions, individuals incur an explicit benefit when they align their behaviour with the behaviour of others. In economics and business, when a network effect is present, the value of a product or service is dependent on the number of others using it.

In the context of social innovation, network effects (and externalities) constitute an important aspect to consider. As we think of social innovators with motivation and desire to help others, we argue that this aspect can be highly relevant. In this sense, we adopt the network effects from the point of view of the social innovator's utility as our micro-level modelling approach revolves around the decision process of the individual social innovator. Specifically, we combine the previous two components of the utility in a multiplicative form to reflect network effects:

$$r(x, \sigma) f(z, \beta) \quad (2)$$

The multiplicative form means that those social innovators who place a greater intrinsic value on social innovation (higher r) get a higher utility from an increase in the number of the people affected by the social innovation (higher f) than those social innovators who place a smaller intrinsic value on social innovation (smaller r), in general. With this network externality effect, the utility of the social innovator is augmented and the whole decision process will be influenced by the interacting factors.

Costs. The last bit of the utility function of the social innovator is the cost. We assume that it takes effort, time, and possibly other material elements or resources to come up, develop and sustain a social innovation. Another way to interpret this in the modelling framework is by considering it as a disutility parameter within the global utility of the social innovator. Following this approach, we incorporate this resource-constraint aspect by adding a cost parameter denoted by γ. For simplicity, we take this parameter as given and constant that is to be deducted from the overall utility of the social innovator. Regarding the cost dimension, one extension of the analysis would be to make the cost variable dependent on the number of users and/or other model parameters. Similarly, the resource parameter could also extended to take into account the issue that some social innovations are more resource-intensive than others to implement, whereby one needs to differentiate cost function per social innovation. We let this varying feature of the cost parameter to be explored as future research.

Global utility of the social innovator. Up to now, we described the main elements of the utility of the social innovator and now we can write the global utility function, u, taking all the variables and parameters into account:

$$\textbf{(3)} \qquad \mathrm{u(x, z, \sigma, \beta, c) = r(x, \sigma)f(z, \beta) - \gamma}$$

4.3 Functional forms and assumptions

In order to find an analytical solution to the utility maximisation problem, we need to define some functional forms for the respective model components.

Reflecting the decreasing nature of the intrinsic utility in x with a risk aversion characteristic[1], we assume the following smooth functional form for r:

$$\textbf{(4)} \qquad r(x, \sigma) = 1 - x^{\frac{1}{\sigma}}.$$

Regarding the second component of the utility function, *f*, reflecting the *utility received* when others are affected by the social innovation in an efficient way, we assume a smooth function that increases in z, the number of users or beneficiaries targeted by the social innovation:

$$\textbf{(5)} \qquad f(z, \beta) = 1 - \exp(-\beta z)$$

Combining the two separate components, the social innovator's global utility function that needs to be maximised in order to determine the level of social innovation, x, becomes as follows:

$$\textbf{(6)} \qquad u(x, z; \sigma, \beta, \gamma) = r(x, \sigma) f(z, \beta) - \gamma$$

$$u(x, z; \sigma, \beta, \gamma) = \left[1 - x^{\frac{1}{\sigma}}\right][1 - \exp(-\beta z)] - \gamma$$

[1] When the exact definition of the relative risk aversion à la Arrow-Pratt-De Finetti is applied to the intrinsic utility function, the risk aversion parameter is not σ, but $(\sigma\text{-}1)/\sigma$. See appendix for the calculation of the risk aversion parameter and how it can still be summarized by σ.

Furthermore, in order to have a workable and analytical solution, the model has several simplifying assumptions as described and discussed in the sequel.

In the language of the research focusing on for-profit innovation, we assume that there is a monopolistic competition when a social innovation takes place, which means that at the onset of the social innovation, the existing services or models are not active. This is a strong assumption, as there might be competing social innovations or other existing networks, organizational structures targeting the vulnerable groups. However, for the sake of finding a stable and analytical solution to the model above, we assume away the incumbency issues. Nevertheless, we acknowledge that in reality, new solutions to a social challenge might need to confront the existing solutions and there can even be a power clash between incumbent actors and newcomers. Our model could embed such frictions through other parameters in the ecosystem through efficiency parameter, β, for example. In this case, resistance to social innovation from the incumbent actors can be represented by higher values of this parameter creating frictions and eventually barriers to social innovation process.

Even though we acknowledge the possibility that rationality is not a necessary characteristic of a social innovator, we assume that the social innovator has some rationality in her/his choice set such as taking a decision when his utility is non-negative. This allows finding an analytical solution as regards the level of social innovation.

Regarding the timing of the model, we do not insist on a specific timing of social innovation process, as there could be many possible combinations of events depending on the context of social innovations. However, it can still be helpful to think of the following chain of actions when conceptualising the theoretical model: first, we assume that there happens to be a social problem and challenge that needs attention and action. In case of a public intervention, the problem is addressed in some way or another or perhaps no action is taken at all. Suppose that some motivated individuals react to this problem and contemplate an innovative solution to tackle it – at least partially. This individual does not have a prior on whether the solution will work or not—in some sense, there is an uncertainty in the "market". Given his/her preferences and resource constraints, this individual (or individuals) offers a solution and eventually implements it to the social problem in question. Based on the model's network effect assumption, the more users benefit from the solution, the higher the satisfaction of the innovator (given the dependence of the utility function on the size of the population targeted) and it is likely that more innovation will follow suite, but not necessarily from the same innovator.

Together with these assumptions, overall, our flexible model allows mimicking all sorts of cases such as when there is a situation with a social problem, but no service is provided to address the challenges. The model is also able to cover situations when there is a solution addressing the problem, but there is a gap in coverage of vulnerable population faced with the challenge, such that some individuals or groups are not addressed sufficiently or the quality of the service provided in meeting the needs of the target group is not very high. In any of these cases, social innovation could be beneficial for vulnerable groups facing a variety of societal challenges.

4.4 Decision making in the model

Imposing a minimum rationality on the social innovator, we write the decision making condition for the social innovator as follows:

$$\textbf{(7)} \qquad \exists \text{ social innovation if } u(x, z; \sigma, \beta, \gamma) \geq 0$$

In other words, the social innovator will take a positive decision to implement the solution if the utility is non-negative. To find the number of individuals who will produce social innovation (or to find the number of social innovations), we equate the global utility function to zero and solve for an analytical expression of x. In other words, the threshold value of x is given by solving $u(x, z; \sigma, \beta, \gamma) = 0$.

The model suggests that, in practice, given the model ingredients and functional forms so far and as individuals are ranked by an intrinsic utility function, each individual (potential social innovator) decides whether to come up with a social innovation by checking the above condition on the utility, $u(x, z; \sigma, \beta, \gamma) = 0$.

To illustrate the mechanism behind the model, imagine that there is a population of 10 individuals in a society. Suppose that the first individual has a utility level u_1 and that it is so that $u_1 \geq 0$, then according to the decision rule, he will innovate. Suppose that the second individual has a utility level u_2 and that it is so that $u_2 \geq 0$, then according to the decision rule, he will decide to innovate, too. Notice that because individuals are ranked (assuming the same number of users and efficiency), we have that $u_1 > u_2$. Suppose now that the third person has $u_3 < 0$, and then according to the decision rule, he will decide to not innovate, given the preferences. Moreover, we can still predict the behaviour of the remaining seven individuals in the population since as we know that individuals are ranked by their type, then we also know that the 4th, 5th, …, 10th people will not innovate either since in this case we have:

$$\textbf{(8)} \qquad u_{i-1} > u_i \text{ and } u_j < 0$$

$$\text{for } i = 2, \ldots, 10 \; ; \; j = 3, \ldots, 10$$

Hence applying our model's decision rule in this hypothetical population, the number of social innovators will be 2 over 10 (the threshold value). Our model will deliver this number of social innovators as a function of the number of users and other model parameters as represented in the global utility function.

4.5 Baseline analytical solution of the model

Regarding the analytical expression of the number of social innovations (or innovators), we replace the specified functional forms in the global utility function and solve for x in terms of the other model variables and parameters as follows:

$$\textbf{(9.1)} \qquad u(x, z, \sigma, \beta, \gamma) = 0$$

$$\textbf{(9.2)} \qquad r(x, \sigma) f(z, \beta) - \gamma = 0$$

$$\textbf{(9.3)} \qquad \left(1 - x^{\frac{1}{\sigma}}\right)(1 - \exp(-\beta z)) - \gamma = 0$$

$$\textbf{(9.4)} \qquad \left(1 - x^{\frac{1}{\sigma}}\right)(1 - \exp(-\beta z)) = \gamma$$

$$\textbf{(9.5)} \qquad \left(1 - x^{\frac{1}{\sigma}}\right) = \frac{\gamma}{(1 - \exp(-\beta z))}$$

$$\textbf{(9.6)} \qquad x^{\frac{1}{\sigma}} = 1 - \frac{\gamma}{(1 - \exp(-\beta z))}$$

$$\textbf{(9.7)} \qquad x = \left[1 - \frac{\gamma}{(1 - \exp(-\beta z))}\right]^{\sigma}.$$

The last expression forms the main equation for the simulation exercise as described in the next section.

5 IMPLEMENTATION OF THE THEORETICAL MODEL: SIMULATION RESULTS

In the previous section, we described the main elements of the theoretical model and found an analytical solution, which offers the possibility to further analyse the model behaviour when some of the model elements are modified. This is part of a more general exercise known as *comparative statics*, which allows running simulations on a range of parameter values *ceteris paribus*. In this context, a simulation is a quantitative result of the model once the model is fed with input data – either artificial or based on empirical data. Using computational techniques, one can compare different simulations of the same model, which can potentially reflect different realities and circumstances. Our simulation exercise is conducted using artificial data points and by changing one parameter at a time in order to observe the behaviour of the model solution, which is the level of social innovation. In this part, we used STATA as the statistical software to program the functional relations for simulation. We note that the goal of this exercise is not to match the actual numbers representing each element in the model (e.g. costs) from reality, but rather assess hypothetical scenarios as to what would have happened—in terms of the direction of change—had a parameter of interest moved up or down. Therefore, the sequel should be read by keeping in mind the purpose of the exercise.

Figure 3 shows the change in the shape of the intrinsic utility when the risk preferences are modified: as the risk aversion parameter σ increases, the intrinsic utility shrinks. In other words, for a given value of x, the intrinsic value of social innovation decreases as the risk aversion increases. Another interpretation is that for a given intrinsic value $r(x, \sigma)$—imagine you draw a horizontal line cutting through the other lines—there are more social innovators (x) when the risk aversion is lower (towards the right and until 1-x line).

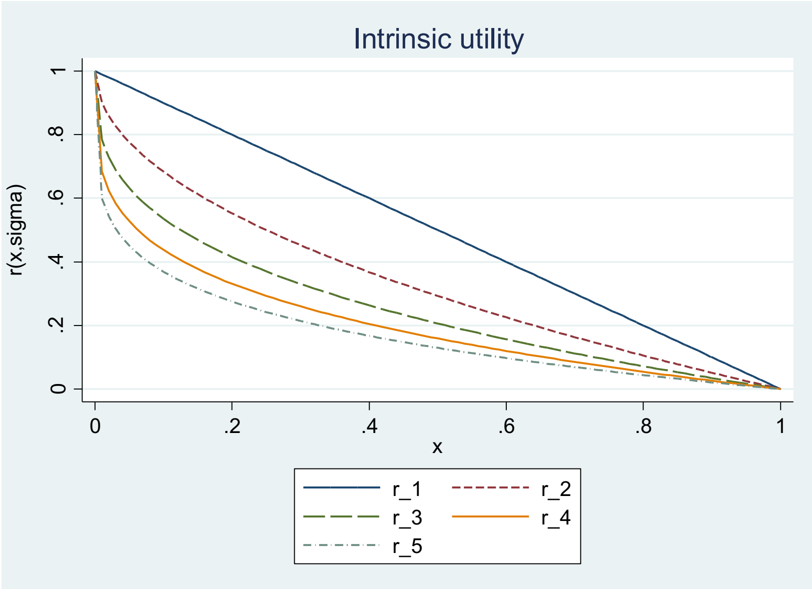

Figure 3. Intrinsic Utility and Risk Aversion

Regarding the utility of the social innovator when the target groups use the social innovation (f(z, β)), Figure 4 shows how that utility is dependent on the efficiency parameter.

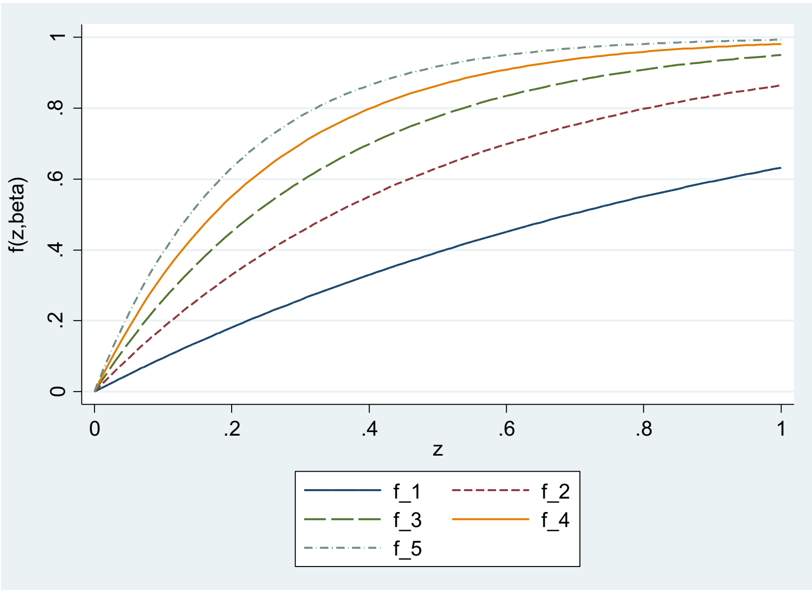

Figure 4. Utility from Others Using SI and Societal Frictions

Figure 5 displays the level of social innovation in this baseline case using the relevant model parameters (for given values, as indicated in the graph title) and a function of the number of users (over a grid) in the deterministic case (no uncertainty).

This figure is mainly a representation of the main equation of interest—that is the analytical solution to the number of social innovation at equilibrium—using artificial values for the parameters and the relevant grid. This particular figure shows that at very low levels of users (z), no social innovation is created. However, after a “tipping point”, the level of social innovation increases in the number of users of it, but the curve starts to flatten for very large numbers of users.

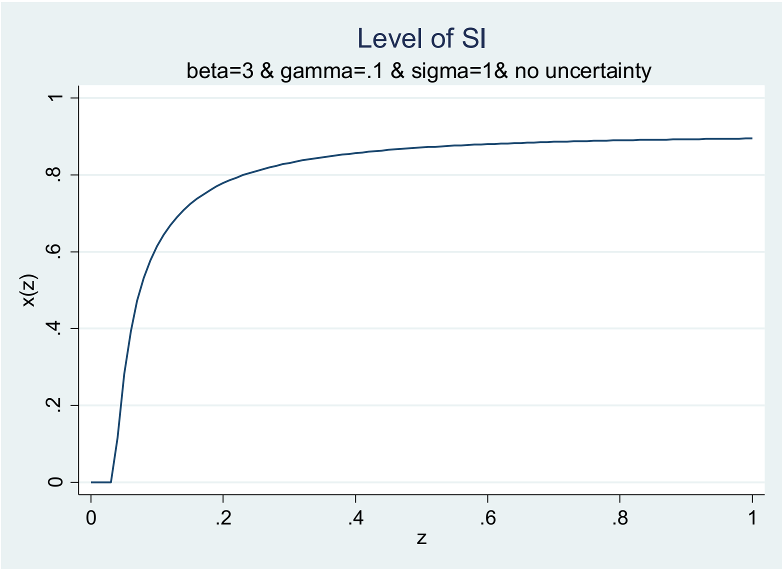

Figure 5. Level of Social Innovation (baseline)

Suppose that for a given number of potential users and costs—ceteris paribus, the risk preferences of the potential innovators have changed so that they are likely to be more risk averse. We can simulate this change by increasing the level of risk aversion parameter in the model and check how the level of social innovation reacts to it. The following figure displays this scenario.

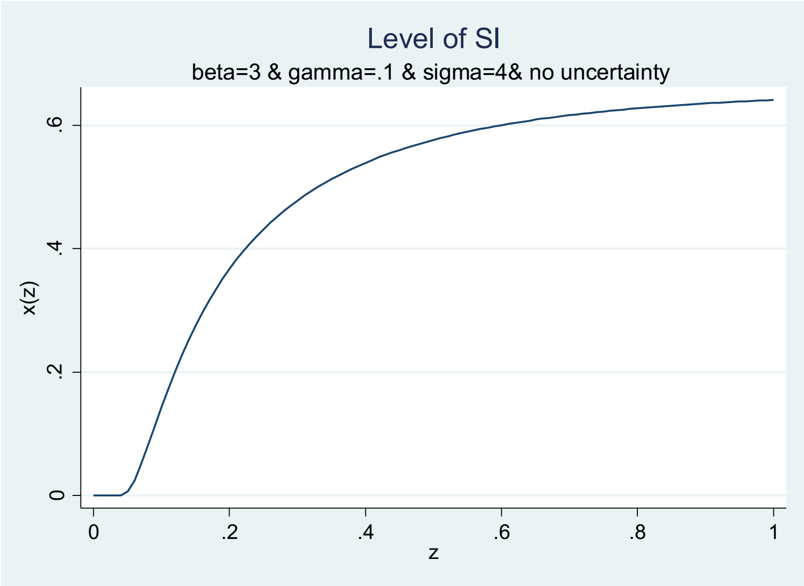

Figure 6. Increase in Risk Aversion

We observe that a higher level of risk aversion induce a lower level of social innovation holding everything else—i.e. number of users, costs, and efficiency—constant. We also see that the maximum of the curve is lower than the initial case as in Figure 5 and this maximum is attained only at very high values of z (users).

Now let us do simulate the level of social innovation under different cost scenarios. Suppose we start with the extreme case that there are no costs associated to creating a social innovation and then we suddenly increase the costs, by keeping everything else the same. Figure 7 and 8 display the consequence in terms of the social innovation level.

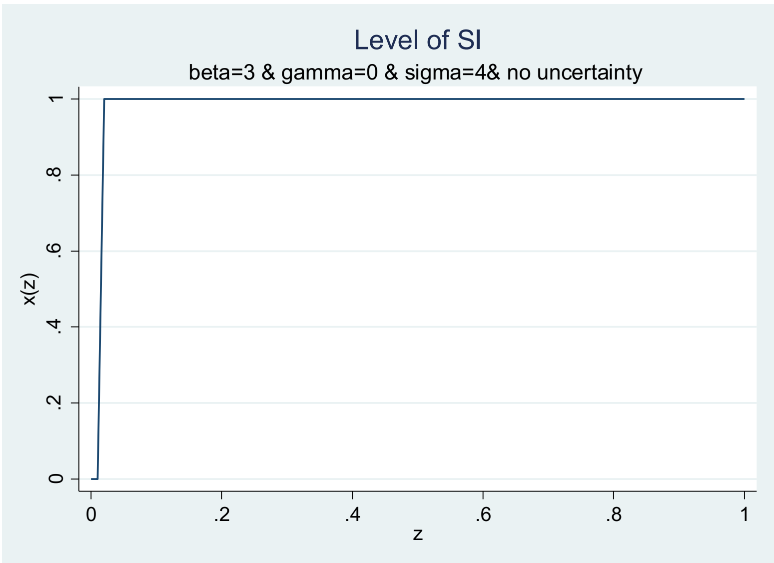

Figure 7. SI Level at Zero Cost Scenario

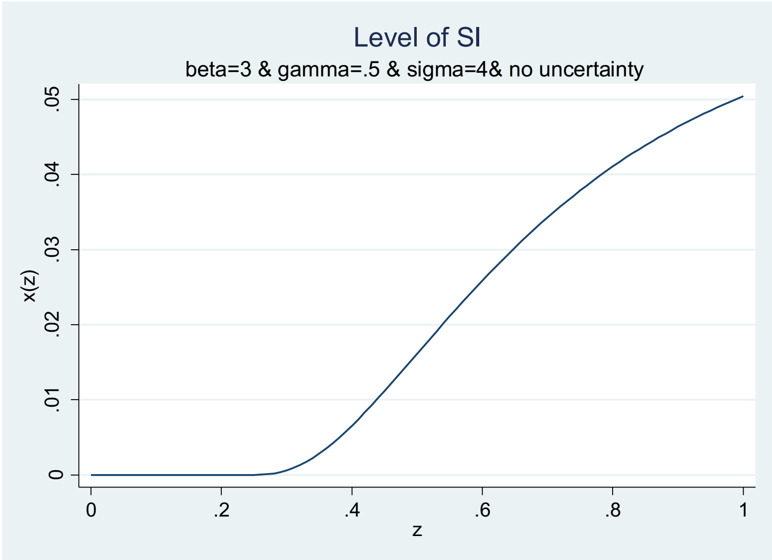

Figure 8. SI Level at High Cost Scenario

The last figures show how the level of social innovation depends on the availability of funds to cover increased costs. In the extreme case with zero costs, together with given parameter values, the social innovation attains the maximum level very quickly. On the contrary, the higher the costs of social innovation, the less will be the level generated for given number of users, efficiency, and individual preferences.

Next, we simulate the changes in the level of efficiency in order to assess the impact on the level of social innovation. Efficiency in this context could be understood as any factor that facilitates and eases the social innovation process to expand among the target group. We start from an extreme case, where the efficiency parameter is at its lowest level and gradually increase it to observe how the social innovation curve reacts. The simulation exercise implies that higher social efficiency—because of social trust, enabling factors in the social innovation ecosystem and so on—the level of social innovation and the target groups reached are larger, while all other model inputs are held constant. The resulting patterns are displayed in Figures 9-11.

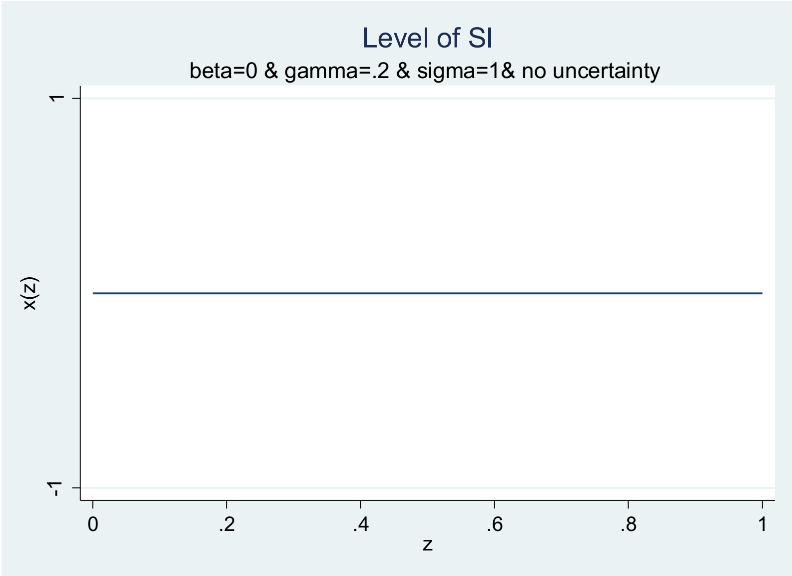

Figure 9. SI Level with Lowest Efficiency

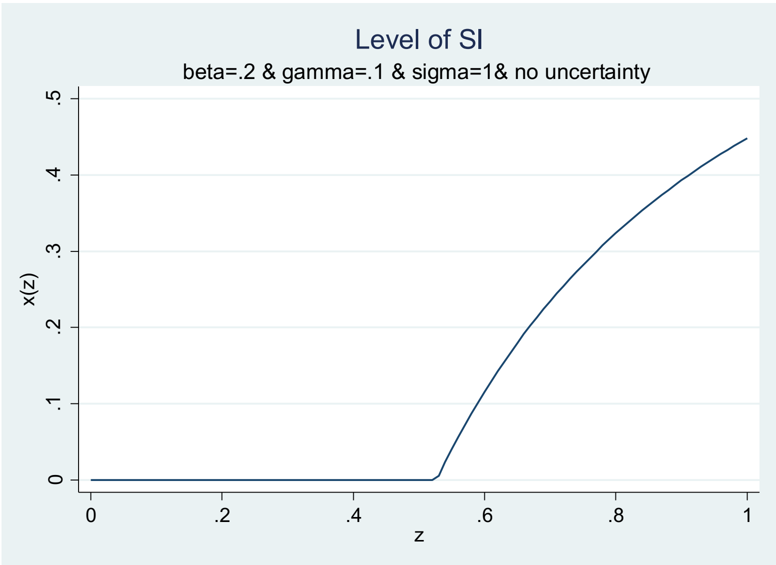

Figure 10. SI Level with Moderate Efficiency

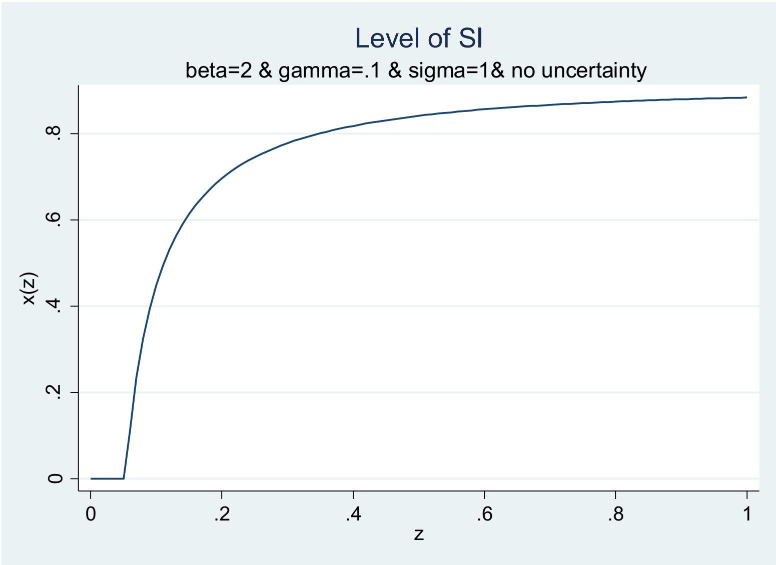

Figure 11. SI Level with High Efficiency

Overall, these simulation exercises allow us to get several interesting conclusions based on the baseline model. More importantly, the simulations based on the comparative statics analysis predicts interesting two-way relations between social innovation level and model elements. Accordingly, our analysis suggests that for a given number of users and taking the impact of a change of an element one at a time, an increase in the risk aversion, costs, and inefficiency is each associated with lower levels of social innovations, or—using the dual interpretation of the model—in the number of social innovators. Results are largely robust to smooth changes in functional forms and flexible with different parameter values.

6 MODEL EXTENSIONS AND SOCIAL INNOVATION SCENARIO BUILDING BASED ON SIMULATION RESULTS

In this section, we present and discuss several extensions to the baseline simulation model as different possible scenarios in an attempt to better reflect the complex economic and social phenomenon of social innovation, its actors, and ecosystems, by augmenting and extending the parsimonious economic model.[2] The social innovation scenarios presented in the sequel should be understood as in terms of the probability of social innovation given certain sets of interactions between individuals in and with their environment to support social innovation stakeholders in coping with uncertainties associated with social innovation. These social innovation scenarios bring the baseline simulation model closer to the reality and reflect on the future possible events to guide policymaking.

6.1 Scenario I: The Role of Enabling Factors for SI

So far the baseline model of the previous section has a broadly defined efficiency parameter, β. One can also interpret this parameter in other ways; for example, it could be any element that can facilitate the social innovation process. In this scenario, we consider the *trust* interpretation. The seminal quote from Georg Simmel suggests that "trust is one of the most important synthetic forces within society" (Wolff, 1950). Empirical evidence also shows that most of the social innovations rely on relationships based on confidence, trust and solidarity between actors (Terstriep et al., 2015). This is especially important in the case of social innovation, where the social innovators are confronted with an evolving target group and a constantly changing environment coupled with scarcity of resources (cf. Terstriep et al., 2015; Rizzo et al, 2015). In such a complex setting, strong trust relations between and surrounding the social innovator and the target groups, or even among the targeted individuals themselves, can influence the success of the social innovation by serving as a smoothing element throughout the social innovation's or life cycle.

[2] We would like to thank all SIMPACT partners and participants at the previous SIMPACT progress meetings and workshops for suggesting valuable ideas and comments. However, given the complexity and difficulty in finding an analytical solution and hence conducting simulations, we were not able to accommodate all of them, but we try to address them in this report and acknowledge some of the limitations of our approach.

At the same time, there could be several types of trust that can differently influence the social innovation process. Two commonly cited trusts notions in this context are social trust and political trust. Social trust is an important notion relating how individuals feel about each other in a society. Prominent political economist Francis Fukuyama asserts that trust and social capital are not mutually exclusive and defines them as follows:

"*Trust is the expectation that arises within a community of regular, honest, and cooperative behaviour, based on commonly shared norms, on the part of other members of that community … Social capital is a capability that arises from the prevalence of trust in a society or in certain parts of it. It can be embodied in the smallest and most basic social group, the family, as well as the largest of all groups, the nation, and in all the other groups in between. Social capital differs from other forms of human capital insofar as it is usually created and transmitted through cultural mechanisms like religion, tradition, or historical habit.*" (Fukuyama, 1996).

Another form of trust that we consider is *political trust*, which is the belief that the political system or some part of it will produce preferred outcomes even if left untended (Shi, 2001). In that sense, political trust is also closely related to state capacity, as the latter can determine the former through (in)effective government administration in economic, social, and public affairs. In the context of social innovation, one can see at least two different ways of interactions between political trust and social innovation depending on the context. On the one hand, if the state or the political actors are failing to address a social challenge faced by vulnerable groups (e.g. long term unemployment), this can trigger a decrease in the political trust and, in turn, the social innovators can be more willing to intervene via their proposed solution to help address the challenge. This would imply a negative association between the political trust and social innovation. On the other hand, if the political system or state is rather pro-active and supportive in the context of social innovation—on top of the already provided public services—in a way to improve social challenges, the political trust would be likely be high, but so will be the level of social innovation as such initiatives would get state support. In this case, we would rather observe a positive association between the political trust and social innovation.

Given these two types of trusts described briefly in this extension, we would rather adapt the broader concept of social trust as a facilitator in the social innovation process. This extension does not necessarily imply an analytical modification in terms of our model and equation[3], but the interpretation of the model results would be enriched if we

[3] In an extended version of the model, we incorporated two different trust variables (social and political) into the model equations and simulated the level of social innovation. Using the assumed functional forms and inversely relating the two trust variables in the relevant utility component, we find that higher level of social (political) trust is associated with higher (lower) level of social innovation. However, given the two-

incorporate the trust, or eventually social capital, as an important element in the social innovation process. All in all, these notions such as efficiency, social trust, and social capital end up as being part of *enabling factors* in the ecosystem of social innovations.

In several of the stakeholder experiment workshops (organised within WP2), the scenario with enabling factors in the form of social trust was discussed and tested. In particular, highlighting its importance, the stakeholders mutually agreed that social trust among individuals is a catalyst for social innovation and is a prerequisite for enhanced solidarity in societies (Pelka and Wascher, 2015).

6.2 Scenario II: Consequences of Uncertainty in the Process of SI

The model that is used to generate the simulations has been based on the deterministic case, whereby we assumed away any kind of uncertainty or shock in the model. However, this might not exactly reflect the reality of an innovation and perhaps even less the social innovation.

To illustrate this scenario in the model, suppose that there is uncertainty related to the social innovation onset or process. One can also think of this as uncertainty on the success chance of the social innovation. In reality, there could be many factors influencing the chance of success of a social innovation. For example, there could be shocks ranging from *force majeure*, disaster, extreme scarcity of resources, exponential increase in costs of social innovation to issues like a severe lack of interest, non-compliance or take-up of the socially innovative solution by the targeted group along the process so that the social innovation does not reach the desired outcome or even it can even stop existing at some point due to such shocks. Such failures can happen despite the initial intentions of the social innovators.

In terms of the economic modelling approach adopted in this paper and as regards to the range of possibilities listed above, imagine that once the innovator comes up with a socially innovative idea, this idea does not generate a high demand on the target group—in other words, it does not necessarily match with a corresponding demand for a reason or another—and hence the social innovation risks to fail. This might imply that only a few (or none) people are impacted by the social innovation, and thus influences the part of the social innovator's utility that is related to the size of the benefits accrued to the vulnerable target groups.

One way to incorporate this risk dimension in the preferences of the social innovator is to augment the utility function by a random component. The utility of the social

directional relation between political trust and social innovation, we do not pursue the latter extension, but mainly adopt the social trust in the extension. The additional results using two trust variables are not reported in the paper, but are available upon request from the authors.

innovator includes the element $f(z, \beta)$, which depends on the size of the "demand" by the target groups, since our model assumes that the social innovator enjoys the impact to the others. In order to incorporate this random component in the model, we include a random variable, ε, as a multiplicative factor next to the f function. The resulting calculations of the equilibrium level of social innovation after this addition gives the following equilibrium level of social innovation:

$$\textbf{(10)} \quad x = \left[1 - \frac{\gamma}{(1-\exp(-\beta z)).\varepsilon}\right]^{\sigma}.$$

Introduction of the random element in the utility function of the social innovator, as a way to incorporate risks and shocks in the "market", allows comparing the level of social innovation between deterministic and uncertain scenarios. Moreover, this extension can also be useful in capturing uncertainties in the social innovation success across different sectors. For example, the uncertainty or success/failure chance of the social innovation in the context of educational services might be very different from that of uncertainty of risks in the social innovations cases in the context of health sector.

Methodologically, the simulation of a function with a random component could be done via Monte Carlo simulations. Monte Carlo simulation method is part of a broad class of computational algorithms relying on iteratively evaluating a deterministic model and repeated random sampling to obtain numerical results. To this end, we assume that the random variable ε has the following normal distribution with mean θ and standard deviation δ:

$$\textbf{(11)} \quad \varepsilon \sim N(\theta, \delta^2).$$

We conduct the Monte Carlo simulations by randomly drawing values for ε from its distribution and then simulate the level of social innovation for each random ε over the grid of z. For simplicity, we assume that $\theta = 1, \delta = 0.8$. From this distribution of ε, we run 500 replications of the model, giving us 500 different values of social innovation level. This means that with the addition of the random component in the utility function, we get a distribution of the level of social innovation, which is no longer a deterministic value given z (number of users) and other model parameters. In the simulations presented below, we calculate and display the mean value of the social innovation as well as the values at the 25^{th} and 75^{th} percentiles of the x distribution.

To illustrate the volatility in the level of social innovation when a random component in the utility model is embedded, let us start with the deterministic case as in the baseline model for a given set of parameter values. Now imagine that there is an uncertainty (in a positive or negative direction) that influences the success of the social innovation process for a reason or another and the utility of the innovator is no longer certain and includes a random component that has a probabilistic distribution. We first start with a small enough standard deviation and simulate the level of social innovation over the number of users for given parameter values. In the uncertainty case, we display the level of social innovation at the 25th and 75th percentile of its distribution over z. In a way, the percentile graphs mimic the confidence interval of a randomly distributed variable.

Figure 12 shows the level of social innovation in the deterministic (continuous line) and uncertain case with dashed lines, where dashed lines above and below representing the 75th and 25th percentiles, respectively. Statistically, the percentile graphs are read as follows: the graph of x will be at the p-th percentile line or below with p% (where in our case, p can be 25 or 75). The next figure displays the same graph after further increasing the volatility parameter. These two figures basically show how the level of social innovation shifts—in a positive or negative way—when there is even a slight volatility in the social innovation process. For example, we observe that for a given number of users and model parameters and with high volatility, the level of social innovation is much lower in a "bad" scenario, which happens with a (low) probability of 25%, compared to a "better" scenario. In other words, the range of possible values for the level of social innovation expands largely with the extent of the uncertainty in the model.

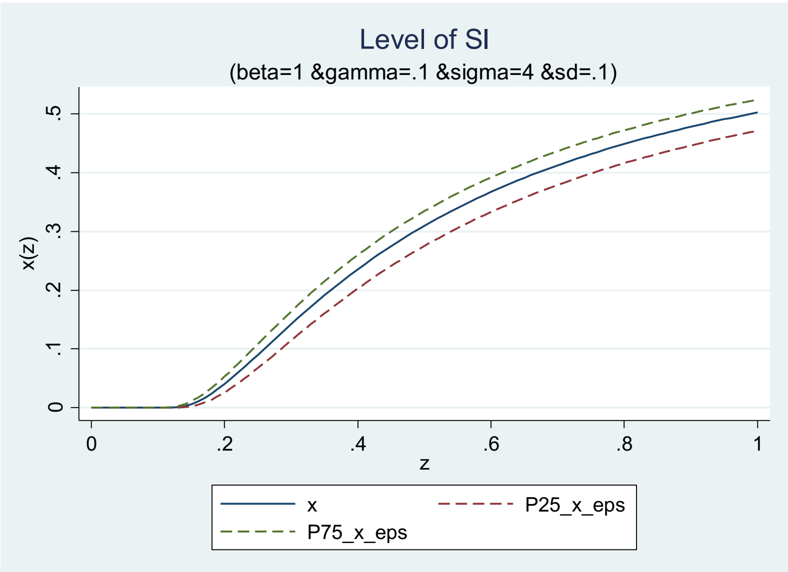

Figure 12. SI Level with Uncertainty (1)

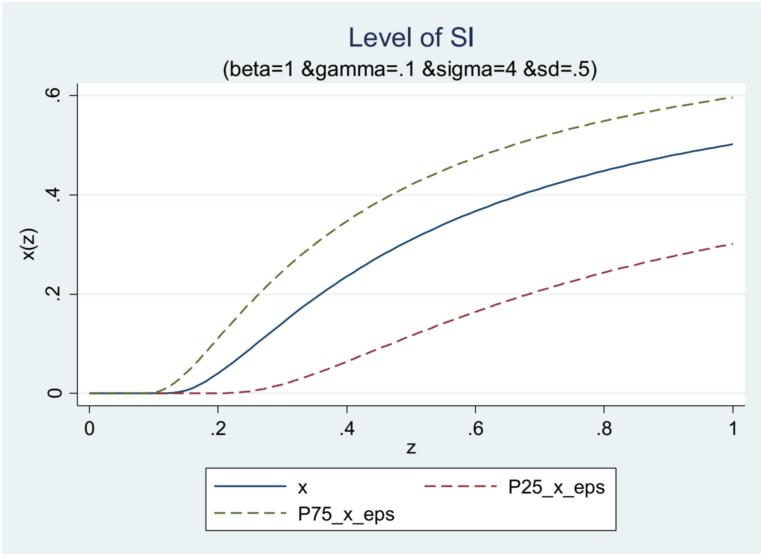

Figure 13. SI Level with Uncertainty (2)

Moreover, we can continue the comparative static exercise in this extended case as well. For example, Figure 14 displays the level of social innovation in the uncertainty case as displayed in Figure 13, but now when costs of innovation (or diffusion) also rises. This last graph shows how chances of social innovation are decreased with high volatility faced with higher financial costs or more resource-intensive innovations.

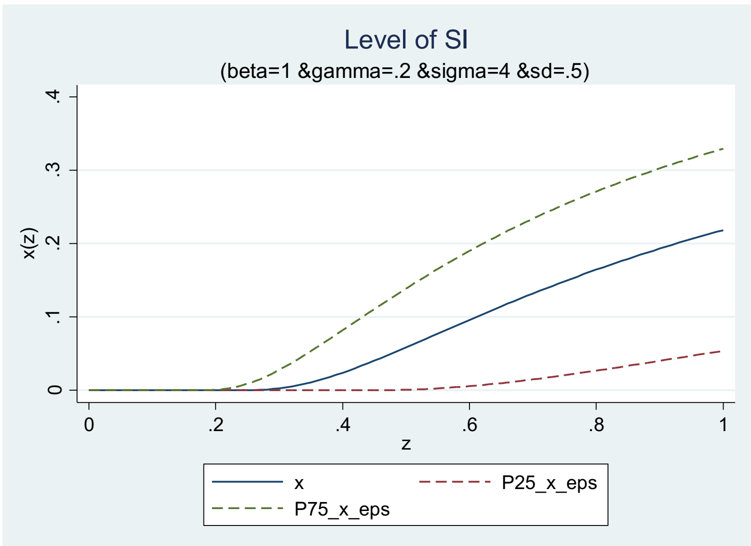

Figure 14. SI Level with Uncertainty and Higher Costs

The issue of uncertainty of social innovation has been highlighted in various discussions during the stakeholder experiments as well. As any innovation activity involves risks in terms of success or failure, this scenario was considered as an added value in the simulation model reflecting the unpredictability of social innovation initiatives in certain context.

Before moving into the next social innovation scenario, we note that in none of the cases with uncertainty, we do not need to identify specifically the cause of the volatility or randomness in the social innovation process; therefore, in that sense our model is flexible enough to accommodate various settings. Nevertheless, what this scenario shows is that innovation can be a risky endeavour, with positive or negative shocks happening along the onset or process, whereby these shocks impact the overall level of the social innovation accordingly.

6.3 Scenario III: Bureaucratic Barriers, Managerial Burden and Implications for Scalability of SI

In this extension, we address the issue of scalability of social innovation. The scalability or diffusion of social innovation is an important element in the theoretical understanding of social innovations as it relates to how various solutions offered by social innovation could be transferred or adapted to other places with different targeted groups (or simply extending the coverage of the initial targeted group) facing a similar social challenge or problem.

While the scalability is a highly discussed issue when we think of social innovation in the public debate, we also acknowledge that a social innovation sometimes starts as a response to a specific and local challenge and hence the proposed approach is relevant only in that context without the need to necessarily scale it up. At the same time, some socially innovative solutions aiming at vulnerable groups can be adapted to other local contexts and applied elsewhere when similar social challenges arise in other places.

Bearing these aspects in mind and taking a positive—rather than a normative—approach, we simulate scenarios of situations, where there is the possibility to scale up the social innovation and we try to understand what factors have an impact and if yes, how, in this process using our modelling approach. We also note that the context dependency of social innovation implies that scalability could take many different forms such as conditional transferability, "copy-paste" adoption, adaptation and so on reflecting local, regional, or national characteristics as regards the social problem to be addressed and relevant vulnerable target groups.

In the context of the theoretical model of this paper, we use the notion of scalability as the situation where the solution offered by social innovation (or social innovator) can reach out a larger user base or target group. For example, in our model's conceptualization of scalability, each of the following two cases can be counted as a another social innovation: the same social innovation applied to additional target groups, say, in different regions, and a different social innovator addressing the same social problem of the target group in a different way. So far, the utility model assumes that social innovators get utility from the impact of the social innovation on the targeted groups using it. This implies, as shown in the graphs so far, that the level of social innovation is increasing – even though it gets flat at some point – when the number of users increase.[4] Imagine now the case where the utility of the social innovator does not monotonously increase as more people use this socially innovative solution. One way to think of why the utility of a social innovator can be non-increasing even though the number of people benefiting from her/his social innovation increases might be due to the issue that at first the innovator enjoys as s/he touches the lives of people via the social innovation addressing a social challenge. At this initial stage with relatively small number of beneficiaries, social innovator can benefit from the direct impact of the innovation to the others. However, as more and more people become part of the solution, the social innovator loses the immediate contact with the users, which in turn can generate a disutility or it can become managerially so cumbersome to deal with a larger-than-initially-expected number of users that the intrinsic utility of having a social innovation to help others in vulnerabilities is not large enough to satisfy the equilibrium condition of the social innovator's threshold utility determining the level of social innovation. This possible disutility to the social innovator of having a too large number of users implies that there would be limits to scaling the social innovation across a population.

This issue of non-increasing utility in "demand" also implies a deviation from the classical innovation models, in which case the utility of the innovator is mainly profit-driven, and thus profits normally increase when there is a higher demand for the product. In the context of social innovation, which does not necessarily involve profit-maximising objectives, this need not be the case. In that sense, this extension is helpful in illustrating the different nature in scalability or diffusion of social innovation compared to market-driven innovation. Given that different utility function—hence different preferences—of the two types of innovators and their likely self-selection into different kinds of innovation (social innovation versus profit/market-oriented innovation), the size of the "demand" does not necessarily increase the "production" of social innovation, as it would be in a market-oriented innovation.

In terms of the model equations, one way to incorporate this extension is to redefine the intrinsic utility function $r(x, \sigma)$ of the social innovator and make it dependent on two more elements: z, size of the target group benefiting from social innovation, and μ, a parameter that measures the degree of (managerial) bureaucracy in the management of

[4] This is a natural result as the x function is concave in z.

social innovation directly related to the size of the users.[5] We modify the initial intrinsic utility function as follows (we denote the new one with r'):

$$(12) \quad r'(x, z; \sigma, \mu) = \frac{r(x,\sigma)}{z^{\mu}}$$

With this functional form, we posit that the intrinsic utility function is decreasing vis-à-vis z (the size of the users of social innovation) for given $\mu \in [0,1]$.

Until now, the baseline model assumes that $\mu = 0$, i.e. there is no additional bureaucratic or managerial burden together with the size of the target group negatively affecting the intrinsic utility of the social innovator. However, once this is the case ($\mu > 0$), then the threshold utility of the social innovator determining the level of social innovation will be modified, hence affecting the onset of social innovation.

We illustrate this extension on the limits to scalability of social innovation with our model simulations and using similar parameter values as previously taken in the following graphs. Figure 15 starts with the baseline case (including the volatility extension) without the addition of the bureaucracy parameter—i.e. we assume that $\mu = 0$.

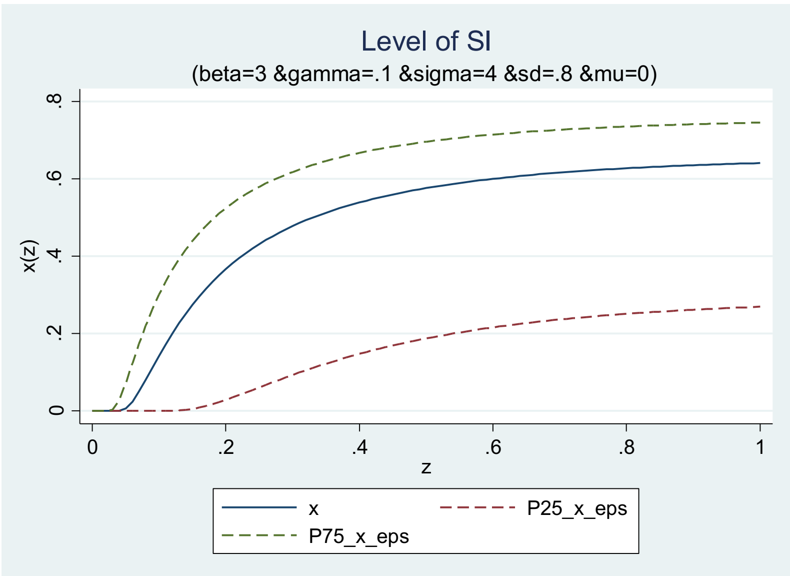

Figure 15. SI Level in the Baseline Case

Now imagine that it is no longer the case that the larger the number of individuals that can be addressed by the social innovation, the higher the intrinsic utility the innovator can get, mainly because a large number of potential beneficiaries of the social

[5] We assume that $\mu \in [0,1]$.

innovation also requires a more complex management, involve possible bureaucratic barriers, or other kinds of bottlenecks in terms of the provision of the socially oriented solution aimed at these individuals. In terms of our model, we can summarize all such barriers with a positive value of the μ parameter. Using this approach, the following Figure 16 displays the re-simulated baseline model after incorporating the managerial burden or bureaucracy parameter, starting with a relatively low value.

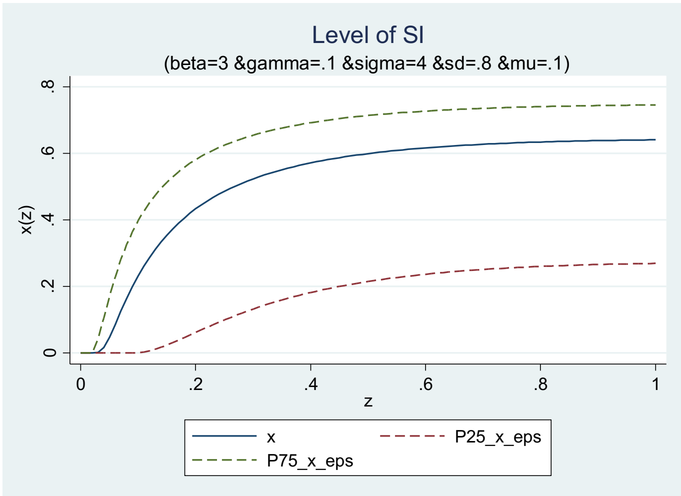

Figure 16. SI Level with Low Managerial/Bureaucratic Burden

We observe that at a relatively low level of the bureaucracy parameter, the model almost does not change in terms of the predicted level of social innovation. This can be related to the motivation and perseverance of the social innovator dealing with multiple complexities, as it is generally the case, such as lack of funds, uncertainty of the innovation process, and bureaucratic barriers to expansion. However, when the latter issue becomes more considerable in magnitude such that the threshold level of utility is impacted more strongly, then we might observe a halt of provision of the social service provided at larger number of user base. The following Figure 17 describes this scenario, where the managerial or bureaucratic burdens to accommodate the needs of a large target group is much higher. The simulation of the level of social innovation in this case suggests that these factors can actually serve as barriers to scale up social innovation and can prohibit the latter to expand further to accommodate more vulnerable groups after a threshold value of the size of the users.

In further simulations that we conducted (not reported here, but available upon request from the authors) where the managerial burden parameter is further increased, the resulting outcome is that the level of social innovation stops at an earlier point over the grid of the number of users. This means that when the level of such burden is very high, there are correspondingly less number of social innovation happening.

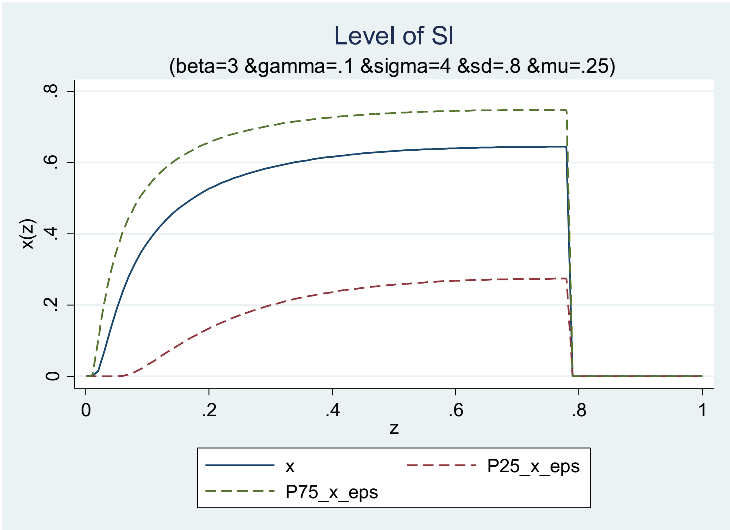

Figure 17. SI Level with High Managerial/Bureaucratic Burden

Overall, with this extension we illustrated the scalability or diffusion of social innovation process and how the model can be augmented to incorporate such issues. We did this by adding a managerial or bureaucratic burden parameter, which plays a role in determining whether the social innovation can be scaled up. In particular, each potential innovator enjoys creating a social innovation, as there are more users to benefit from it up to a point; however, the level of social innovation can come to a halt if the disutility of dealing with too many people outweighs the benefits from helping them. In reality, such situations might arise when new innovators might decide not to pursue (or adapt an already existing one to a new target group) a socially innovative idea due to such bureaucratic burdens coupled with scarcity of resources—including managerial resources. Mulgan (2006) also asserts that organizational capacity to grow together with a propitious environment is two necessary conditions to scale up social innovations.

A related important issue raised by the participants in SIMPACT's stakeholder workshops is related to the knowledge aspect of social innovation. In particular, there was an agreement that social innovators are not only expected to be strong experts of social problems and committed to a social problems, but at the same time, they should also be experts of managerial aspects and know the industry and sector specificities for their social innovation (Pelka and Markmann, 2015). The importance of managerial knowledge or capacity for the sustainability and scalability of social innovations is in line with the current scenario extension of the theoretical model presented in this sub-section.

Nevertheless, once the fundamental question of whether scalability of social innovation makes sense in the first place is dealt with (*extensive margin*), the second-level issue on the barriers to scalability could be somewhat overcome (*intensive margin*). This depends on the social innovation context, given the pace of technological advance and increasing usage of ICT, internet and web-based platforms, each of which can help scale-up social innovations at relatively low costs these days. Nevertheless, we note that such tools may not be relevant for all social innovation contexts.

6.4 Summary of SI scenarios based on simulation model extensions

We summarize the extended version of the baseline simulation model in the following scenarios:

SI Scenarios	Implications for social innovation
Enabling factors and ecosystem (e.g. efficiency, trust – social and/political)	By increasing solidarity and efficiency in society, enabling factors such as social trust works as a catalyst for social innovation
Uncertainty in the process or success of SI	Uncertainty and volatility are mostly present in social innovation initiatives leading the socially innovative solution towards various trajectories depending on the extent and type of the risks faced along the social innovation process
Bureaucratic barriers; managerial burden	The bureaucratic and managerial barriers could prevent social innovations from extending to larger target groups

Table 1 SI Scenarios and Simulation Results

7 CONCLUDING REMARKS

This report presented a theoretical approach to economically underpin social innovation. The theoretical economic model developed in this context is an attempt to understand what we can learn from a modelling perspective to understand the processes that leads to social innovation initiatives. The model incorporates elements like individual preferences (risk preferences, caring for others etc.), intrinsic values, network effects, resource constraints, institutional efficiencies, uncertainty and bureaucratic issues within the context of social innovation targeting disadvantaged individuals facing social challenges and other vulnerabilities in order to come up with solutions that can empower them.

The model is built in a way that the main equation of interest summarizes the level of social innovation as a function of all the other model parameters and variables. Accordingly, some of the model predictions suggest that the level of social innovation is positively associated with the risk-lovingness of the innovator, efficiency or other facilitating factors such as social trust. The social innovation simulation model is fed with feedback from empirical findings from SIMPACT as well as from stakeholder experiments by conducting a reality check of the results enables to elaborate different behaviour scenarios.

In particular, the report presents various possible scenarios of the extended simulation model covering issues such as enabling factors in the form of social trust, uncertainty in the process of social innovation and the existence of bureaucratic and managerial barriers to scaling up social innovation. In particular, the scenarios predict that the level of social innovation is negatively associated with costs of innovation (or resource scarcity) and managerial burden or bureaucratic barriers faced when there are too many users targeted by the social innovation, which could also be interpreted as the issue of capacity constraint of the social innovation in addressing the totality of the target group. As confirmed with the stakeholder feedback, these scenarios bring the theoretical and simulation model of SIMPACT closer to the reality.

The value added of a theoretical modelling and simulation approach mainly comes from its complementary nature to other methods (such as sociological approach, case study analysis, and so on), its flexibility to adapt to different scenarios, simplicity for a tractable solution and availability for empirical validation. It also gives an *ex ante* idea on what kind of situations could be expected when certain model parameters are modified. The output of such an approach, when communicated in a non-technical manner to ensure to pass the main ideas, can inform in advance the relevant actors involved in social innovation process. Moreover, this can also help generate public awareness about the social innovation.

With this attempt, we are aware that more research needs to be done in order to get further insights towards "theorizing" social innovation process. In that sense, economic theory and simulations provide an interesting set of toolbox, whereby one can get useful information and assess hypothetical scenarios to inform decisions and policymaking.

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ANNEX

Calculation of the actual relative risk aversion parameter and its relation with σ

When describing the risk preferences of the social innovator, we simply used σ as the parameter summarising the risk attitudes. However, given the functional form of the intrinsic utility function and the definition of the risk aversion based on Arrow-Pratt-De Finetti, the true relative risk aversion parameter is not σ, but $\frac{\sigma-1}{\sigma}$ which is calculated as follows:

$$r'(x,\sigma) = -\frac{1}{\sigma}x^{\left(\frac{1-\sigma}{\sigma}\right)}$$

$$r''(x,\sigma) = -\left(\frac{1-\sigma}{\sigma^2}\right)x^{\left(\frac{1-2\sigma}{\sigma}\right)}$$

$$RRA = -x\frac{r''}{r'} = -x\left(\frac{-\left(\frac{1-\sigma}{\sigma^2}\right)x^{\left(\frac{1-2\sigma}{\sigma}\right)}}{-\frac{1}{\sigma}x^{\left(\frac{1-\sigma}{\sigma}\right)}}\right)$$

$$RRA = -x\left(\frac{1-\sigma}{\sigma}x^{-1}\right)$$

$$RRA = \frac{\sigma-1}{\sigma}.$$

However, because $\frac{\sigma-1}{\sigma}$ is an increasing function of σ (i.e. $\frac{\partial\frac{\sigma-1}{\sigma}}{\partial\sigma} > 0$), the interpretation of relative risk aversion, $\frac{\sigma-1}{\sigma}$, is the same as the interpretation of the parameter σ.

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