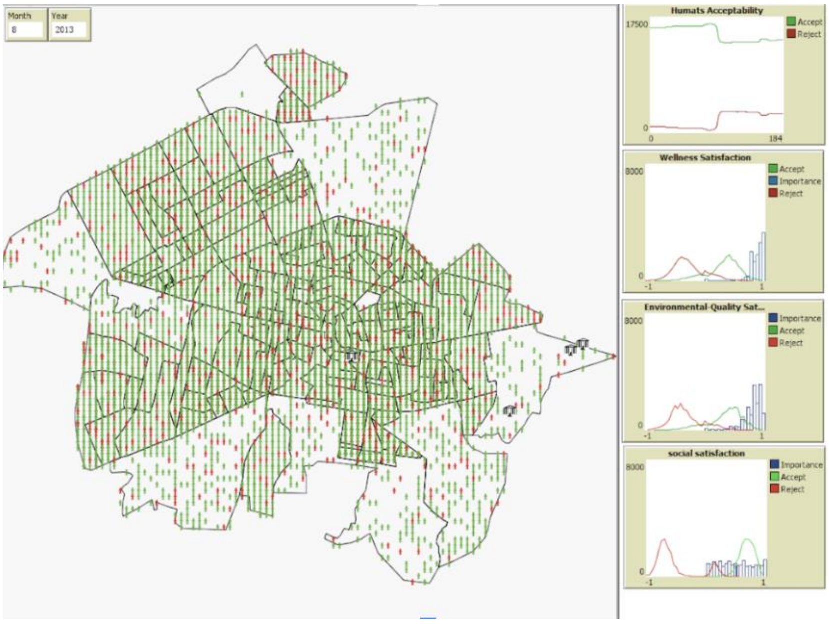
SMARTEES
local social innovation

SMARTEES: Updated Deliverable 7.4 (Final Report)

Report on scenario development and experiments for selected cases

October 2021



Screenshot of the Vitoria-Gasteiz policy model

Authors: Loes Bouman, Patrycja Antosz; Wander Jager; Gary Polhill; Doug Salt; Andrea Scalco; Amparo Alonso-Betanzos; Noelia Sánchez-Maroño; Bertha Guijarro-Berdiñas; Alejandro Rodríguez-Arias

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 763912

Project Full Title	**Social innovation Modelling Approaches to Realizing Transition to Energy Efficiency and Sustainability**
Project Acronym	SMARTEES
Grant Agreement No.	763912
Coordinator	Norwegian University of Science and Technology (NTNU)
Project duration	May 2018 – October 2021 (32 months)
Project website	www.local-social-innovation.eu
Work Package	WP7 Social Simulation of Social Innovation Scenarios
Deliverable	D7.4 Reports on scenario development and experiments for selected cases
Delivery Date	31.10.2021 (month 42)
Authors	Loes Bouman, Patrycja Antosz; Wander Jager; Gary Polhill; Doug Salt; Andrea Scalco; Amparo Alonso-Betanzos; Noelia Sánchez-Maroño; Bertha Guijarro-Berdiñas; Alejandro Rodríguez
Reviewer(s)	Christian Klöckner (NTNU)
Dissemination level:	Public (PU) — **X**
	Confidential, only for members of the consortium (CO) —

Keywords
agent-based model, social innovation, HUMAT, social simulation

This document has been prepared in the framework of the European project SMARTEES – Social Innovation Modelling Approaches to Realizing Transition to Energy Efficiency and Sustainability. This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 763912.

Table of Contents

Executive summary

This report presents a number of policy scenario experiments for the reference cases of Groningen, Vitoria Gasteiz, Aberdeen Barcelona, Stockholm, Stockholm, Malmö, Samsø and El Hierro, and the following cases of Budapest and The Western Isles. In the previous deliverable 7.3 we presented the agent based simulation models that have been developed for different cases. These models have been discussed in workshops with policy developers (deliverable 5.2). For the different cases it was discussed what types of policy scenario analysis could be tested in the simulation models. This report presents the policy experiments that we ran on the simulation models.

The Groningen case addresses a referendum on closing a park for car traffic. This referendum took place in 1994, and was won with 51% of the votes by the pro-closing citizens. This referendum has been replicated with our simulation model. The policy experiments that we conduct explore (1) how sensitive the outcome of the referendum would be for an opinion-affecting event such as an accident in the park, and (2) if the outcome of the referendum would be sensitive for a pro or anti closing informational campaign at different stages of the process.

The Vitoria-Gasteiz case is about the implementation of city-superblocks, where a local neighborhood is closed for transit traffic. Policy experiments focusing on communicating different benefits of an increase in parking costs demonstrated that for example emphasising comfort would result in a more positive attitude towards the plan. An increased interaction between citizens, as is the case in e.g., neighborhood meetings, did not result in significant changes in the opinions of the citizens.

In the Energy poverty case of Aberdeen on heat networks different policy scenarios were tested, such as economic pricing policy, behavioral policy focusing on awareness of the population, and more socio-technical policies related to phasing out gas and introducing hydrogen.

In the Stockholm case the focus was on renovating houses. The analysis revealed the complexity of this case, where for example crime rates play an important role in the experienced safety and reputation of a neighborhood, which will affect the The Stockholm case. The model requires data for this, but these are not publicly available. This case also demonstrates how modelling contributes to an interdisciplinary perspective on social innovation, as energy use and crime are usually not often coupled in studies on energy savings

In this final report we include a number of follower cases that have been modelled. The cases of Budapest, Barcelona, Stockholm, Malmö, The Western Isles, El Hierro and Samsø have been implemented to test if the existing modelling approach that we have developed can be easily transferred to different cases. The development of the lead cases obviously required considerable time, because we had to develop and fine-tune the theoretical basis of the models, develop experience with how to use different data types in parameterising the model, and obviously run many experiments to debug the models and test the robustness of the models. In the current report, we also report on a number of additional policy experiments

that have been conducted on the main cases. For example, for the Groningen case we added experiments in which we tested the effect of organising neighborhood or town hall meetings on the social dynamics in the wider community. Such types of policy experiments, addressing second order effects of interventions, are a typical strength of the agent based modelling approach we use. Agent based models are capable of demonstrating how the effects of interventions grow over time through a community as a result of the informative and normative driven interactions taking place in social networks.

For the follower cases we had the advantage of the existing main case models and the experiences with the implementation of the data into the models. This means that it was easier to develop models for the follower cases. However, because we also had high ambitions to push the main cases forward, and demonstrate the unique capabilities of the agent based simulation, we had to balance the efforts in making the main cases as insightful as possible whilst demonstrating the capacity to develop follower models in a faster way. As a result, the follower models have been implemented quicker and are in some cases more "quick-and-dirty" than would have been possible with less time restrictions. However, the key advantage of this is that we gained experience with the fast developments of models for new cases using limited available data and very restricted resources in terms of time and/or money. This demonstrates that the agent based simulation framework we developed for social innovation is relatively quick to implement for new cases for which some basic insights are needed concerning the possible social dynamics that can emerge in a process of social innovation. The policy sandbox tool will serve here as a first instrument to select what type of case models serve as a template for new social innovation cases to model.

Obviously, reflecting on the policy experiments presented in this report, many more policy experiments can be thought of, and the authors have many more ideas of implementing policy scenarios in the several case simulations that have been developed. As such, this report is primarily demonstrating the capacity of agent based simulations to contribute to the identification of how policies interfere with complex social dynamics in processes of local social innovations. Having artificial populations running on a computer that represent the population of a real city is a new powerful tool to explore and experiment with the social dynamics associated with many policies. Hence in the context of the "green deal", where much is expected from changes at the community level, the use of such dedicated simulation models offers a promising perspective. However, a warning is also in place. The involvement of the population in the development and use of these models is needed to foster an ethically responsible democratic process. Using such models as a tool to test policies in advance to stimulate the population to support a certain plan without consultation can be seen as a manipulative strategy that can backfire on the legitimacy and support it receives by the population involved, and hence nullify the societal value of such models. Therefore, we strongly recommended to involve the general public in the development and use of such models. Whereas agent based models, such as developed within the SMARTEES project, contribute to the understanding of social dynamics, the general public is usually less aware of these mechanisms that apply to their own social lives. Especially the non-linear processes that describe how debates on plans can escalate towards societal chasms that are hard to bridge are difficult to recognise by a community in the beginning of a planning process as potential hazards. Simulations would provide a helicopter view of societal processes of the community people take part in, and as such would support reflection on possible developments, and on people's own role and responsibility regarding the social dynamics associated with a plan. When people in a workshop-like setting are observing agents that represent their own position, and becoming aware of how such agents respond to agents having a different perspective, they may become more aware of the social dynamics and different perspectives that are relevant in the implementation of a plan or project. Such an awareness may contribute to avoiding counterproductive debates, and foster a more dialogue driven process. This contributes to the awareness and responsibility people have in maintaining and contributing to a healthy democratic process. Hence it is expected that agent based models of local communities dealing with innovative projects, when used in a co-creative context, can contribute to a more inclusive democratic process in local social innovation.

1. Case cluster 1: holistic, shared and persistent mobility plans

1.1 Overview

In this description we will focus on the case of Groningen, for which we developed an elaborated model for which we ran sensitivity analysis and conducted policy scenario experiments.

1.1.1 Groningen case

Groningen is an old, compact city originating from the third century with around 200.000 inhabitants, including a student population of around 60.000. Since the early 1970's the city planning has focused on facilitating cyclists and pedestrians in the city, and de-intensifying car-use in the city. The Traffic Circulation Plan, implemented in 1977, was the start of holistic traffic planning, and several developments and plans followed in the years after. We specifically focussed on the case of the closure of the Noorderplantsoen park for cars starting in 1993. In this park, the traffic situation had become more problematic over the years. In particular, sharing of the road by cars and cyclists turned out to be unsafe. Moreover, the quality of the park decreased due to NOx, particulate matter and sound emissions, and a lower safety, especially for playing children. The situation brought the local population and policy makers together in organising a referendum on closing the Noorderplantsoen for car traffic. In October 1994, after a test closure of one year, a majority vote of 50.9% decided in favour of a permanent closure. Currently, about 95% of respondents of the SMARTEES questionnaire indicated to be in favour of keeping this park car free. Because of the interesting social dynamics in this case, and the fact this was the first ever advising referendum organised in the Netherlands, we focussed on modelling this case for the Groningen case study.

1.1.2 Modeling the case of Groningen model in HUMAT

The HUMAT integrated framework is used to develop an agent-based model to replicate the past of the Groningen Referendum aimed at studying the acceptance of a social innovation that consists of a new mobility plan in local communities. In short: HUMAT is a dynamic architecture that consists of two processes: *attitude formation* and *information exchange*, and here implemented to replicate the Groningen case and simulate counterfactual scenarios. The humat framework, the foundations of the groningen agent based model and the calibration processes are described in deliverable 7.3 in section 1 (Antosz et al, 2020).

The agent-based model focuses on diffusion of acceptance of a new organization of traffic in the city's main artery connecting the east to the west - the Noorderplantsoen park. The agent-based simulation starts with the idea of the referendum on a car-free park, when Groningen residents exchange information with alters in their social networks on their preferred voting decision. The process from initiation of the referendum until the voting day is represented. In this period agents interact and obtain information and here is where attitudes are formed and information is exchanged. On the basis of acquired knowledge, those residents assess how satisfied they would be if the park was open for cars, compared to how satisfied they would be if the park was closed for cars. The model runs through 38 steps and where one time step of the model is an abstract unit and represents the trigger for discrete eventsIn steps 1 through 38 of the model run. In step 38, a referendum takes place, when motivated individuals cast their votes. The model will be evaluated positively if it is able to correctly reproduce the pattern of voting results by city district under a scenario representing the history of the case. Figure 1.1 displays the map of Groningen and the residential districts, named and numbered. The model is developed to represent the process of residents deciding whether to have car traffic in the Noorderplantsoen park or not. Figure 1.2 shows the interface of the Groningen model.

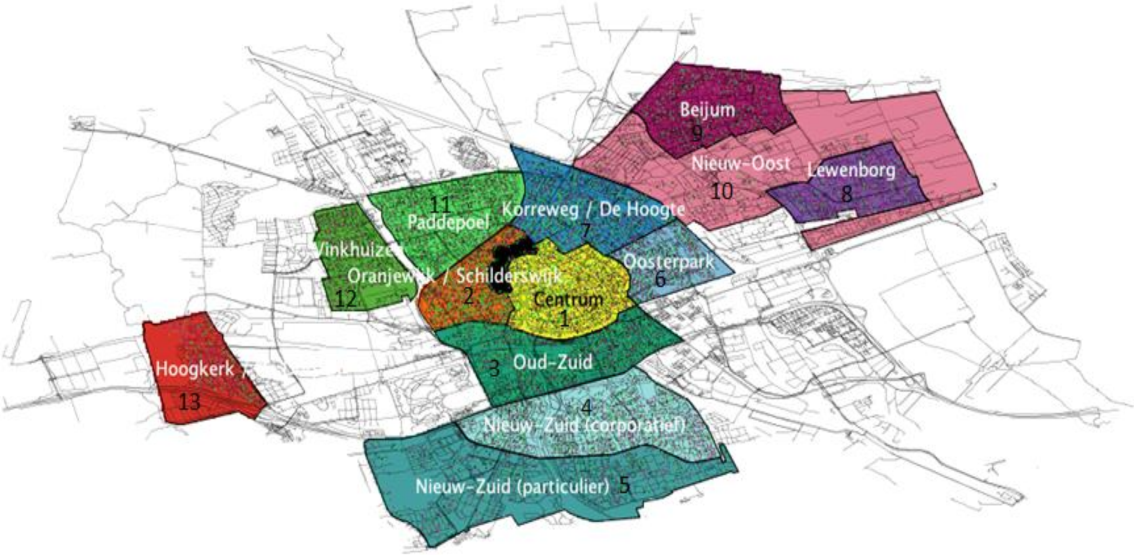


Figure 1.1. Map of Groningen and districts

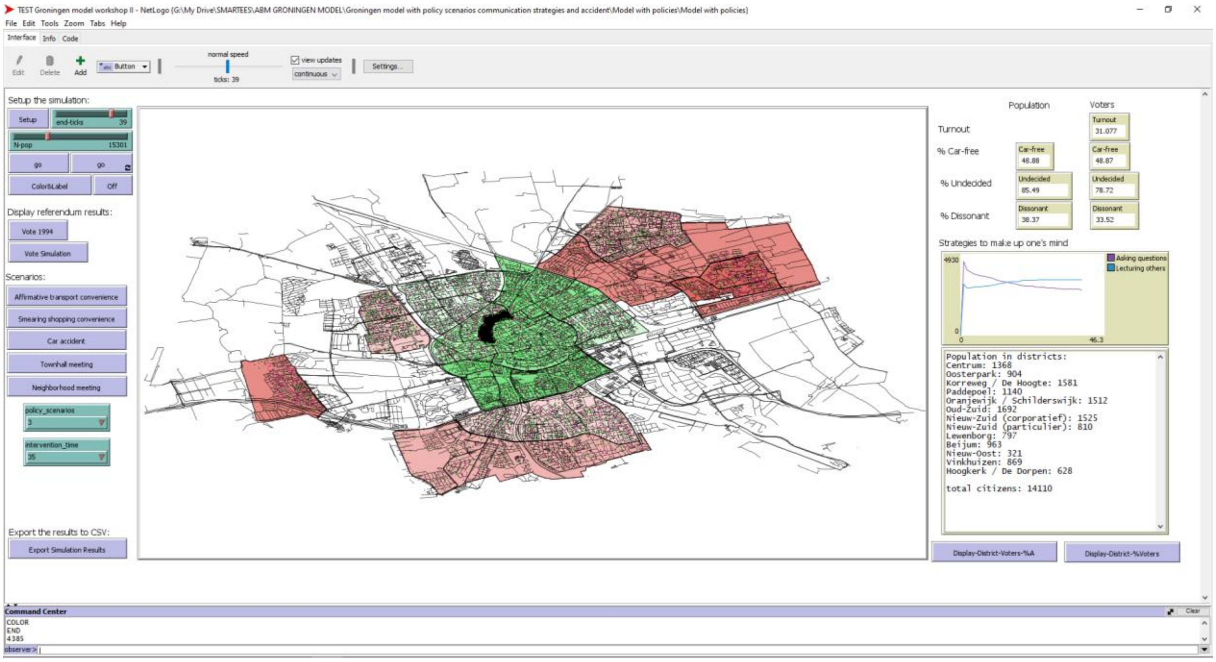


Figure 1.2 Interface for the model of the Groningen case

1.1.3 Groningen model simulations and results

In this section we report the results of the first simulated results of the baseline model for the Groningen case. We demonstrate simulated results aimed at an artificial replication of the historic referendum case in Groningen, where residents had the opportunity to cast their vote in favour or against the closure of the park for through car traffic, which yielded a division of 51% in favour and 49% against (Municipality of Groningen, 1994). THe model is evaluated positively if it is able to correctly reproduce the pattern of voting results by city district under a scenario representing the history of the case.

Simulations for the baseline model were carried out in the BehaviorSpace of Netlogo 6.2.0 (Wilensky 1999). The specified simulation consisted of 1000 runs. The simulations indicate that the model replicates the empirical history in returning the 50-50 division between votes for or against closing the park for cars. The simulations on the referendum yield an average 49.54%, (Standard Deviation = 0.73, N=1000) votes for closing the park for cars. Figure 1.3 shows a distribution of simulated results over 1000 repetitions at tick 38 (this is the moment where the referendum occurs in the artificial city of Groningen. Figure 1.4 presents the same fraction in thirteen districts of the city.

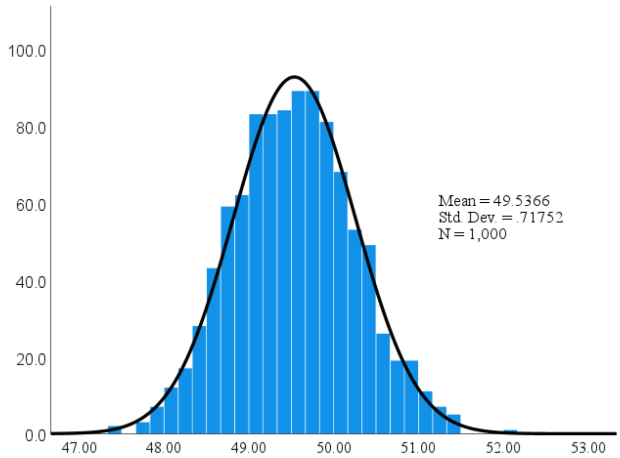


Figure 1.3. Distribution of referendums simulation results over 1000 repetitions at tick 38

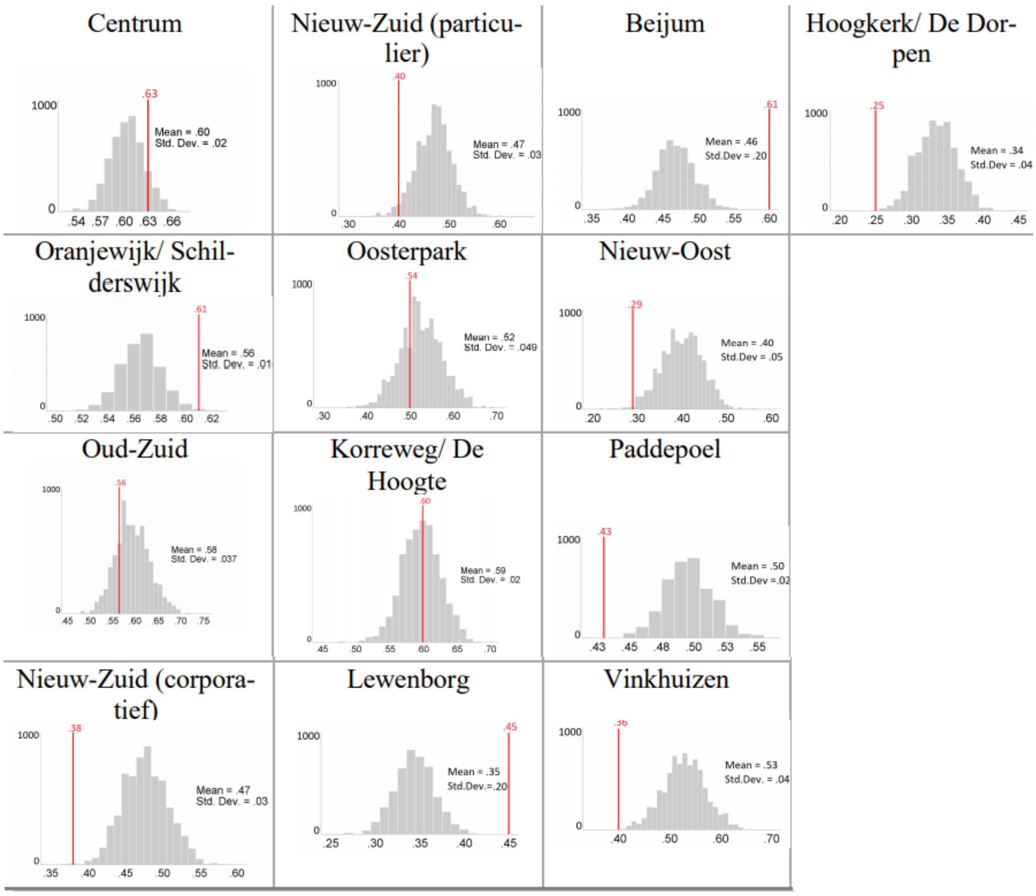


Figure 1.4. Distribution of the fraction of residents in favour of a car-free park over 1000 runs by district. Red line indicated the actual result in the 1994 referendum.

As can be observed, the model is quite accurately reproducing the vote of the whole city. When we look at the simulation results for the different districts, we observe more deviations between the simulated results and the actual vote. This suggests that the actual motives and social dynamics may have been stronger than as represented in the model. This means that the effects produced by the model may be on the conservative side.

The referendum simulations show a distribution of open versus close voters ranging between 48 and 52%, which is covering the actual 51% of close voters. Interestingly, whereas in reality the referendum resulted in a victory for the pro-closing for cars voters, in the simulation runs in a majority of runs the open-voters win the referendum. This also indicates that it would have been very realistic that the referendum was won by the park-open-for-cars voters. Given that the referendum was addressing a tipping point due to the almost equal number of people voting in favour or against the closure of the park, it is well imaginable that small events, such as a deliberate persuasive act, or a coincidental event (e.g. biking accident in the park), could have resulted in a different outcome of the referendum. Simulations of future social innovations are expected to contribute to forecasting if tipping points are present, and what factors play a key role in the volatility of such tipping points. ABMs often demonstrate that small changes in the parameterisation of some variable settings in the model may produce social dynamics that differ, sometimes considerably, from the empirical data. Whereas from a traditional predictive paradigm one would identify this as a problem of the model, from a complexity paradigm the argument can be reversed: the sensitivity of models illustrate that the reality could have been really different, and that, to paraphrase Lorentz, a tip of a butterfly's wing may indeed have caused a different world to have emerged (e.g. Jager, 2021). Furthermore, the difference between the simulation results and the empirical district results suggest indeed that the reality might have been more volatile than the model is conservatively demonstrating. In developing these kinds of experiments, where a local community is being modelled, a key ethical issue relates to the involvement of the people being modelled. Involving people from the local community in developing the model and running experiments is more likely to contribute to the quality of the model and its use in supporting democratic processes at the local level (see Dumitru & Wendling, 2021b and Deliverable 5.2 in Dumitru et al, 2021a).

1.2 Policy scenario development

1.2.1 overview policy scenario workshops

Policy scenario workshops have been organised to discuss the simulation model and possible policies to test with the model. In Deliverable D4.2 and Deliverable D5.2 an elaborated description can be found on the workshops and the policy scenarios that have been identified as interesting to conduct with the Groningen case model. The following four policy scenarios have been identified in the workshop.

Sensitivity for unexpected events

The first scenario we discussed addressed how sensitive the simulated social dynamics are for unexpected events. It seems that even coincidental events that happen may determine the developments in the simulated social system. In particular because the outcome of the referendum was close to 50/50, we can imagine that such events may serve as a tipping point in the social system. The case we discussed at the workshop as interesting was the event of an accident with a cyclist being hit by a car before the referendum, which would strengthen the safety motive of the people. The question is how sensitive the case is for such unexpected events. In this policy scenario experiment we will explore how sensitive the referendum outcome is for such an unexpected event.

The impact of information and discussion meetings

The second scenario type we discussed relates to the organisation of meetings to discuss the opening or closing of the park. A distinction can be made between town hall meetings versus neighbourhood meetings. Town hall meetings require more effort (time) to attend, and can be perceived as more elitist. Hence, in a simulation, this would mean that more involved and educated people having more time are more likely to attend. This can be implemented as having a selected time step in the model where a selected group of agents is interacting with one another. This selection will be on a high education level, higher age, and high involvement. The opinion dynamics generated in such a meeting may have an impact on the attitudes of these people, and after the meeting they may share their opinions with other people. The question is how such townhall meetings can affect the discussions/opinions in the wider city.

Alternatively, neighborhood meetings can be organised. It was discussed that although such a meeting would be more accessible for people, timing may also serve as an additional bias. Meetings scheduled during the day will result in an underrepresentation of working people, whereas meetings in the afternoon may result in an underrepresentation of (young) parents. Basically this policy scenario can be implemented by having a time step in which a randomly selected group from a particular neighborhood will be placed together in a discussion. This can be done in particular for a neighborhood that displays properties of a “swing state”, and we can explore if such a meeting can contribute to “tipping” the referendum.
If this group demonstrates a change in opinion, thus may subsequently spread over the wider community.

Communication strategies

The third scenario relates to communication strategies in the form of holding campaigns or spreading news/advertisements. We discuss two variants. The first variant focusses on affirmation. In reality citizens NGO’s, municipality, and cyclists unions worked together on the referendum, but had not actively advertised and reported in newspapers promoting citizens to vote pro closure. Given that the referendum results yielded a borderline majority vote, it is not unlikely that the outcome could have been different. It is of interest to explore if such a media campaign is capable of making a serious change in voting behavior and the outcome of the referendum. Operationally the communication strategy can be implemented by making the pro-closing beliefs of the agents more important. Because we have no data on the precise susceptibility of different citizens of Groningen. We also include an experiment on the timing of the campaign in how close to the referendum date it is casted, in the beginning when the government announces the referendum, in the middle of the process and right before the referendum. The second variant focuses on communication strategies of citizens and shopkeepers that are against closing the park for through closure. In reality, shopkeepers were advertising in local newspapers, however, but there were no clear media campaigns held. In this scenario we implement this influence by creating a city-wide influence of advertising against the closure of the park for cars. It is of interest to explore if such a media campaign is capable of making a serious change in the discussions taking place, and the outcome of the referendum. Operationally the communication strategy can be implemented by making the anti-closing beliefs of the agents more important. Because we have no data on the precise susceptibility of different citizens of Groningen, for this policy experiment we make no difference in the extent to which the agents are changing the importance of their beliefs.

Another city
The last scenario we discussed was related to the composition of the population. Groningen is a student city, and as a consequence the population is younger and more educated than other comparable cities. As such it would be interesting to explore the scenario of "what if Groningen was a regular city". This can be done by changing the population characteristics, and explore what the impact will be on the resulting social dynamics concerning the referendum. Operationally this will mean that the proportion of younger people in the city will be reduced to represent a non-university city. Because age and education are related in our dataset, this will already have an impact on the average education level too. If needed, also the education level can be reduced by having a certain proportion of higher educated agents change their education level to a lower level.

1.3 Experimentation with policy scenarios

1.3.1 Description of experiments

For the experimentation we selected two policy scenarios that could be implemented straightforwardly in the model. First we decided to experiment with a simulated accident having an impact on the importance of different outcomes, and see if this would have affected the referendum outcome. Second we experimented with a communicative policy, which was either supporting or resisting the closure of the park for cars, and manipulated the timing of this communicative strategy in whether it would be casted after initiation of the referendum, in the midst of the process or right before the referendum (at tick 5, 20 and 35 respectively. The experimental setup yields a 3x3 design of 9 models that we each repeated for 100 times.

1.3.2 Results from experiments

1.3.1.1 Policy scenario 1: sensitivity to unexpected events, an accident in the park.
Overall, the experimental simulations show that an accident in the park - bike hit by car - leads agents to be more likely to vote pro-closure compared to our baseline model.

Referendum results if an accident happens at tick=5
Figure 1.5 shows the distributions of the average percentage of agents that voted pro-closure at the referendum over 100 simulated runs, the experimental results here show that if an accident happens relatively early in the process to the referendum, on average 54.33% (Standard Deviation = 0.73, N=100) agents vote for closing the park for cars. Table 1.1 shows the referendum results per district. Here it can be seen that there is quite a difference in opinions and also in turnout for the referendum per district. Of interest is also the bimodal distribution in the outcome, indicating that in a minority of runs the % votes for closing the park is much higher.

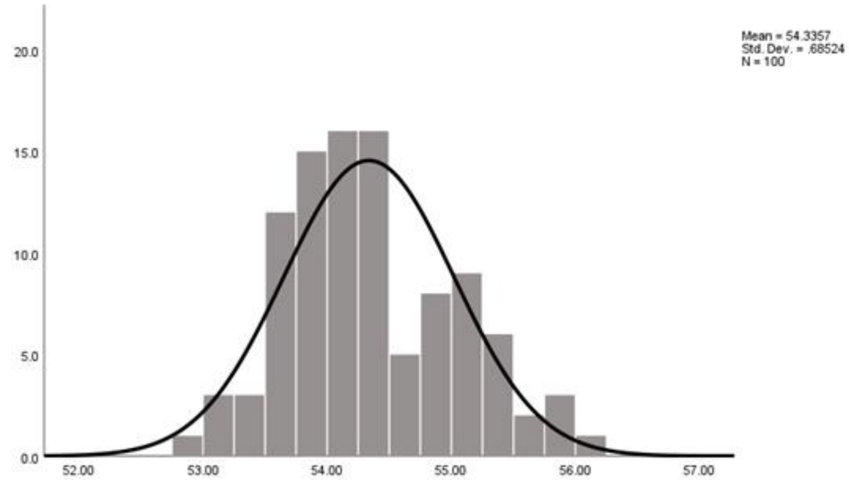


Figure 1.5 Average percentage of agents voting pro-closure, if accident happens at tick=5

Table 1.1 District results if an accident happens at tick=5 (n=100).

District	Percentage of agents voting pro-closure		Turnout	
	Mean	Std.dev	Mean	Std.dev
1	64.10	1.97	.41	.01
2	57.59	1.71	.63	.01
3	74.55	2.57	.15	.01
4	54.62	2.88	.15	.01
5	50.17	3.46	.23	.02
6	63.86	4.58	.11	.01
7	68.93	2.25	.23	.01
8	36.15	2.32	.68	.02
9	49.46	2.67	.35	.01
10	43.38	5.02	.34	.03
11	52.64	1.80	.55	.01
12	59.48	4.01	.16	.01
13	36.27	2.83	.54	.02

Referendum results if a car accident happens at tick 20

Figure 1.6 shows the distributions of the average percentage of agents that voted pro-closure at the referendum over 100 simulated runs, the experimental results here show that if an accident happens in the midst of the process to the referendum, on average 54.75% (Standard Deviation = 0.73, N=100) agents vote for closing the park for cars. Table 1.2 shows the referendum results per district.

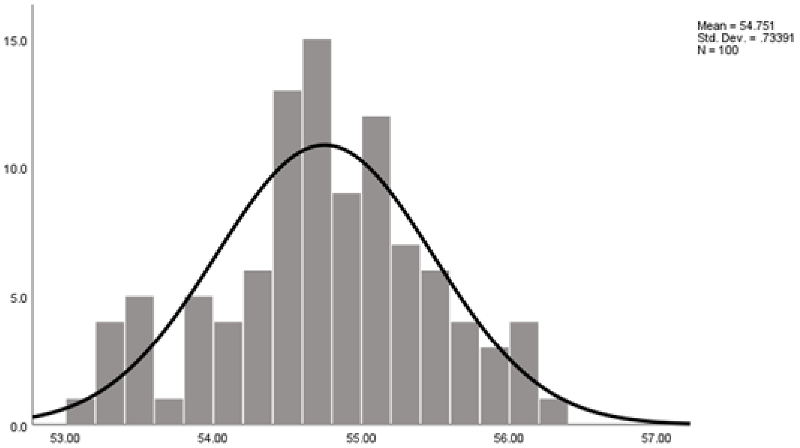


Figure 1.6 Average percentage of agents voting pro-closure, if accident happens at tick=20

Table 1.2 District results if accident happens at tick 2 (n=100)

district	Percentage of agents voting pro-closure		turnout	
	mean	Std.dev	mean	Std.dev
1	64.46	2.06	.41	.01
2	57.72	1.59	.64	.01
3	75.78	2.52	.15	.01
4	55.34	3.65	.16	.01
5	50.98	3.49	.23	.01
6	65.56	4.66	.12	.01
7	69.94	2.41	.23	.01
8	35.99	2.63	.68	.02
9	49.35	2.60	.35	.02
10	44.27	4.93	.35	.03
11	53.38	1.96	.55	.02
12	60.85	3.48	.16	.01
13	35.52	2.99	.54	.02

Referendum results if a car accident happens at tick 35

Figure 1.7 shows the distributions of the average percentage of agents that voted pro-closure at the referendum over 100 simulated runs, the experimental results show that if an accident happens relatively late in the process to the referendum, on average 54.87% (Standard Deviation = 0.76, N=100) agents vote for closing the park for cars. Table 1.3 shows the referendum results per district.

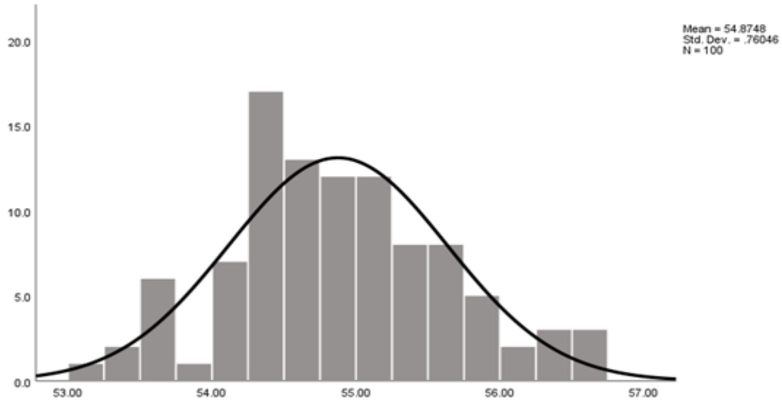


Figure 1.7 Average percentage of agents voting pro-closure, if accident happens at tick=35

Table 1.3: District results percentages voting pro closure and turnout, if campaign is held at tick=35, (n=100)

district	Percentage of agents voting pro-closure		turnout	
	mean	Std.dev	mean	Std.dev
1	64.75	2.06	.42	.01
2	58.19	1.63	.63	.01
3	74.80	2.67	.16	.01
4	54.79	3.45	.16	.01
5	50.72	3.83	.24	.02
6	64.86	4.49	.13	.01
7	69.53	2.14	.23	.01
8	35.78	2.13	.68	.02
9	49.06	2.64	.35	.02
10	43.57	4.95	.34	.03
11	54.28	1.82	.55	.01
12	60.14	4.31	.17	.01
13	35.33	2.76	.54	.02

The experiments of Policy Scenario 1: “Sensitivity to unexpected events, an accident in the park” show that the outcomes of the referendum are not very sensitive to the timing of the unexpected event. The result for all experiments is that due to the incident about 4% more agents voted in favour of closing the park for cars. Considering that the actual social dynamics might have been more powerful, we can imagine that a less conservative model might reveal dynamics where in some instances an incident may result in a self-amplified process resulting in a strong and persistent effect, whereas in other conditions (e.g. the attention of the general public is derived to another issue) the incident may result in a brief discussion and the effect may dampen out quickly. Further experimentation may focus on the bimodality of outcomes that can be expected if sensitivities for self amplifying social processes exists, and we hypothesise that these bimodalities may be more extreme if an incident is early and indeed a self amplifying process emerges.

1.3.1.2 Policy scenario 2: The impact of information and discussion meetings, townhall and neighborhood meetings

The second scenario type identified in the workshop, relates to the organisation of meetings to discuss the opening or closing of the park. This is an important policy exercise, because here a policy can be tested that addresses the social dynamics of a specific group of people, subsequently influencing other people in their networks. This is an experiment that can only be done using an agent based modelling approach. Whereas the effects of informational campaigns and pricing for example are addressing individuals that subsequently can influence others in their network, here a much more dynamic, and less predictable policy process takes place. In this policy scenario we make a distinction between town hall meetings versus neighbourhood meetings.

Town hall meetings, where we expect more educated and involved attendants, may result in a specific group developing more strong opinions on a plan, especially when confronted with a convincing communication on the plan. As a consequence, they may have an important role in spreading this information and opinion further in their networks. Neighborhood meetings may attract a more heterogeneous group of attendants. Especially in neighborhoods with more mixed interests, polarisations may emerge, which subsequently may affect the wider local community. A question is under what conditions information beings shared in such groups may contribute to developing a more shared perspective and the avoidance of polarisations.

The implementation of this type of policy adds another layer of complexity to the simulation model. On top of the existing social dynamics we need to organise a setting where a selected group of agents is attending a specific meeting where they will interact with one another. Also information can be shared with this specific group, resulting in an attitudinal change. In the meeting the group can shift their opinion. This can be a shift in one direction, but also a divide in opinions can emerge or be strengthened by the group discussion.

Due to the complicatedness of this policy scenario we are not capable yet of demonstrating this in the current report. In an updated report to be published at the end of the project we plan to have experiments completed. Reflecting on the modelling ideas we have for this type of experiment we start with the idea of defining a number of ticks in the model where only a selected group of agents can interact. Whilst the normal ticks represent longer time periods (e.g. months) where all agents can interact, having e.g. 10 ticks of interaction between the selected group would represent an intensive discussion meeting of e.g. 2 hours.

To implement this in the Groningen case model, we propose "freezing" the interactions between all agents, except for the agents selected for the meeting. This allows us to compose subgroups with specific characteristics to engage in a group discussion meeting. In this way we have perfect experimental control over the composition of these discussion groups. From the workshop we got qualitative information on the composition of different groups attending such types of meetings, and the (sometimes agitated) processes that took place. To represent town hall meetings we will have to select higher educated, usually elderly men that have high importance scores. For neighborhood meetings, we can simulate an afternoon meeting, where mainly non-working and highly involved agents living in this neighborhood attend, whereas for an evening meeting more working agents can attend, but agents having small children are less likely to attend. The simulation model allows us to precisely decide what types of agents will join the meeting and in what proportion. When a large number of such agents can be selected, a limited number of these, e.g. 50, will actually join the meeting, to represent the actual size of the meetings. However, it can be considered to leave this more open, so that a higher importance of a plan also results in a higher attendance. The selected agents will discuss for 10 time-steps. Just like in the communication policy scenario, we can implement an informational campaign here to simulate the impact of information sharing on the dynamics in this subgroup. After the 10 ticks we can "unfreeze" the interactions between the non-attending agents, and the simulation will continue to run over the whole population. The effects of the meeting on the attending agents now can transpire through the population as a whole.

Whereas this policy scenario can be tested for a large difference of varieties of group compositions, in this report we will focus on the proof of concept of testing the possible impact of different types of group meetings on the dynamics of social innovation processes. In the final version of this report, to be delivered in October 2021, we will share the outcomes of this set of policy scenario analysis.

1.3.1.3 Policy scenario 3: communication strategies, Shopkeepers campaign

Alternative scenario 3 on a shopkeepers campaign shows a very different dynamic compared to the accident. In this case, it can immediately be observed that this campaign that underlines shopping convenience and that park-through traffic facilitates that, makes the majority of agents more prone to vote to keep the park open for cars. Also the results in the districts are drastically different. Below we show the results for three models of the scenario where we experiment with the timing of campaign

Referendum results if campaign is casted at tick 5

Figure 1.8 shows the distributions of the average percentage of agents that voted pro-closure at the referendum over 100 simulated runs, the experimental results here show that if the campaign is casted relatively early in the process to the referendum, on average 49.52%

(Standard Deviation = 0.76, N=100) agents vote for closing the park for cars. Table 4 shows the referendum results per district. Districts 1 and 13 are especially reactive to this campaign compared to our baseline model.

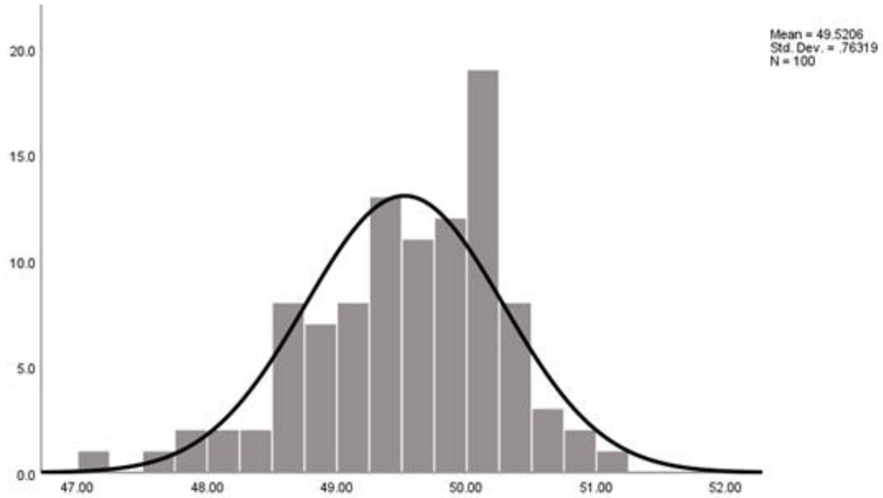


Figure 1.8 Average percentage of agents voting pro-closure, if campaign is held at tick=5

Table 1.4: District results percentages voting pro closure and turnout, if campaign is held at tick=5, (n=100).

district	Percentage of agents voting pro-closure		turnout	
	mean	Std.dev	mean	Std.dev
1	60.29	2.59	.36	.01
2	56.26	1.66	.60	.01
3	58.21	4.70	.09	.01
4	52.42	2.79	.14	.01
5	54.83	3.77	.23	.02
6	51.76	5.10	.09	.01
7	58.88	3.19	.16	.01
8	89.60	1.58	.68	.02
9	68.27	2.59	.34	.02
10	77.57	4.21	.33	.03
11	47.63	1.88	.51	.02
12	52.06	4.03	.15	.01
13	80.96	2.61	.53	.02

Referendum results if campaign is casted at tick 20

Figure 1.9 shows the distributions of the average percentage of agents that voted pro-closure at the referendum over 100 simulated runs, the experimental results here show that if the campaign is casted in the midsts of the process to the referendum, on average 49.57% (Standard Deviation = 0.81, N=100) agents vote for closing the park for cars. Table 5 shows the referendum results per district. Districts 1 'Centrum' and 13 'hoogkerk/de dorpen' are especially reactive to this campaign compared to our baseline model.

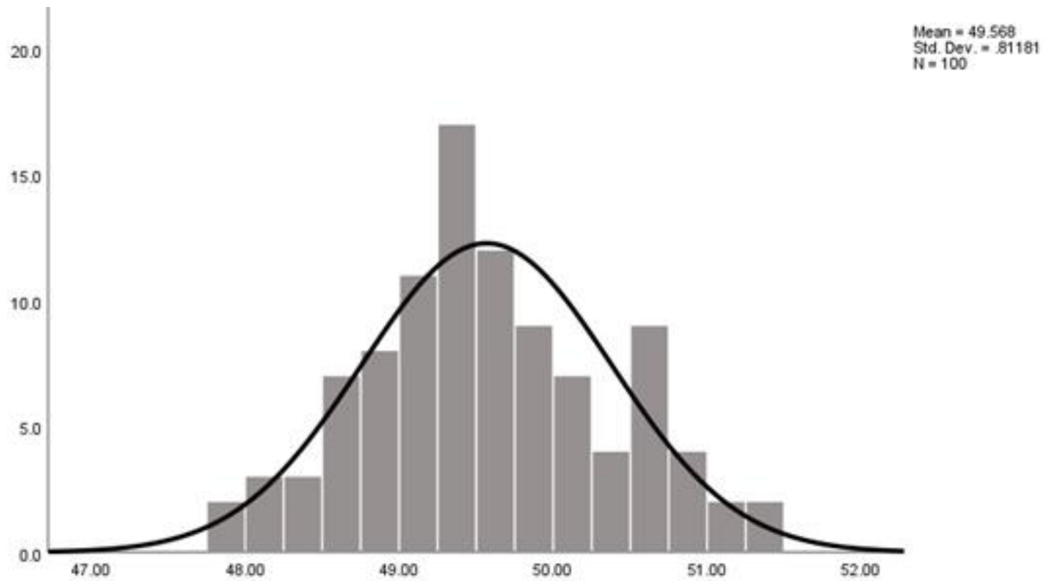


Figure 1.9 Average percentage of agents voting pro-closure, if campaign is held at tick=20

Table 1.5: District results campaign is held at tick=20, percentages of actors voting pro closure and percentage of turnout, if (n=100)

district	Percentage of agents voting pro-closure		turnout	
	mean	Std.dev	mean	Std.dev
1	60.19	2.46	.36	.01
2	56.36	1.70	.60	.01
3	58.44	3.76	.09	.01
4	52.69	3.39	.14	.01
5	56.44	3.45	.23	.02
6	52.26	5.38	.09	.01
7	59.25	3.03	.16	.01
8	83.12	2.10	.68	.02
9	68.46	2.74	.35	.02
10	73.79	4.39	.34	.03
11	48.16	1.89	.51	.01
12	52.78	4.35	.15	.01
13	76.43	2.72	.54	.02

Referendum results if campaign is casted at tick 35

Figure 1.9 shows the distributions of the average percentage of agents that voted pro-closure at the referendum over 100 simulated runs, the experimental results here show that if the campaign is casted right be for the referendum, on average 49.57% (Standard Deviation = 0.78, N=100) agents vote for closing the park for cars. Table 1.6 shows the referendum results per district. Districts 1 and 13 are especially reactive to this campaign compared to our baseline model.

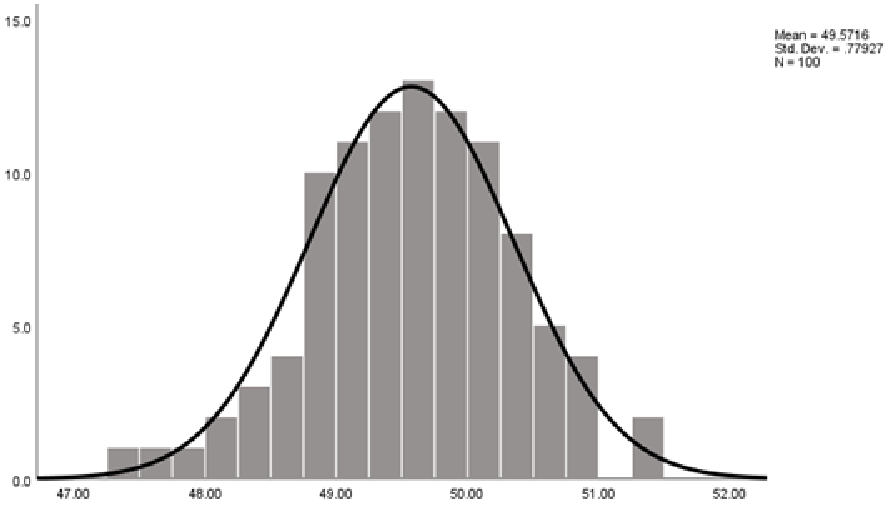


Figure 1.10 Average percentage of agents voting pro-closure, if campaign is held at tick=35

Table 1.6: District results percentages voting pro closure and turnout, if campaign is held at tick=35 (n=100)

district	Percentage of agents voting pro-closure		turnout	
	mean	Std.dev	mean	Std.dev
1	60.28	2.22	.36	.01
2	56.33	1.80	.60	.01
3	58.87	4.08	.09	.01
4	53.36	3.95	.14	.01
5	55.62	3.63	.23	.01
6	52.99	5.95	.09	.01
7	59.95	3.09	.16	.01
8	75.66	2.58	.68	.02
9	66.84	3.13	.34	.01
10	68.92	5.13	.33	.03
11	48.98	1.79	.51	.02
12	53.93	4.21	.15	.01
13	67.27	3.41	.54	.02

The shopkeepers campaign does not have a serious impact on the voting of the simulated population. The campaign does not seem to make many agents more motivated to vote against the closure of the park. Timing also does not seem to have much impact on the efficacy of the campaign. What is interesting to observe is that the distribution of outcomes is less normally distributed than the base case experiment (Figure 1.3). This suggests that the shopkeeper campaign in some runs generates more social dynamics than in other runs. It can be imagined that, given the assumption that in reality the social dynamics could have been stronger, that the campaign could have elicited stronger effects in certain districts.

1.3.1.3 Alternative scenario 3b: communication strategies, a affirmative car-free park campaign

Alternative scenario 3 on an affirmative car-free park campaign shows a strong effect on the referendum results compared to our baseline model. In this case, it can immediately be observed that with this campaign, voters are influenced and become more convinced that having a car-free park is an optimal outcome, regardless of the timing of the campaign the overall majority vote for closure of the park shifts in each case from around 54% to 62%. The referendum results across districts do not seem to be very different from the baseline model. In the distribution of the results we do observe a bimodal distribution, which indicates that in a few runs the impact of the campaign is larger, indicating the emergence of social dynamics propagating a closure of the park. More detailed analysis and following individual agents in their opinion-change process (process validation) is needed to explain these results from a micro-macro dynamical perspective. This requires a next level in-depth analysis of the data, as these dynamics require a trace following technique in following the social influence, in a comparable way that is being done with tracing the spread of a virus. The development of such analytical tracing tools was beyond the scope of this project, however, the simulation results suggest the potential value of developing such analytical instruments.

Below we show the results for three models of the scenario where we experiment with the timing of the unexpected event.

Referendum results if campaign is casted at tick 5

Figure 1.11 shows the distributions of the average percentage of agents that voted pro-closure at the referendum over 100 simulated runs, the experimental results here show that if the campaign is casted relatively early in the process to the referendum, on average 62.90% (Standard Deviation = 0.77, N=100) agents vote for closing the park for cars. Table 1.7 shows the referendum results per district. Interestingly, we observe a bimodal distribution here, indicating that in some runs the impact of the campaign is much higher than in other runs. This indicates that a social tipping point is present in this case.

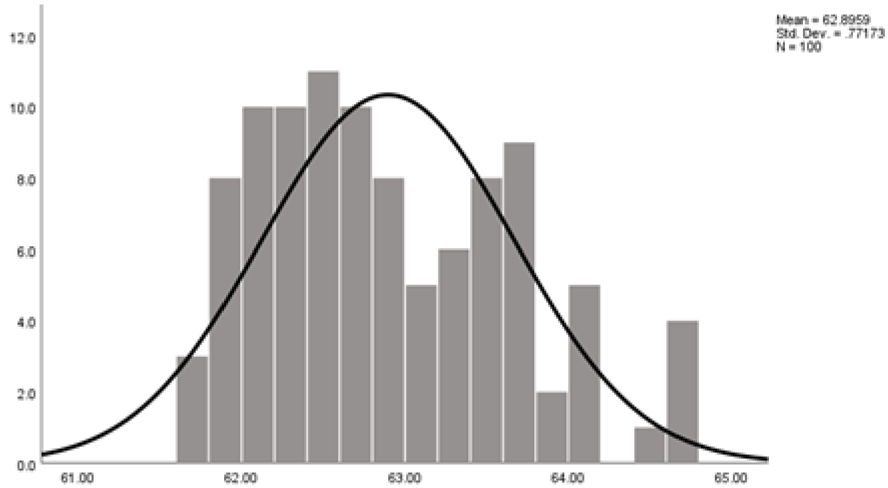


Figure 1.11 Average percentage of agents voting pro-closure, if campaign is held at tick=5

Table 1.7: District results percentages voting pro closure and turnout, if campaign is held at tick=5 (n=100)

district	Percentage of agents voting pro-closure		turnout	
	mean	Std.dev	mean	Std.dev
1	60.10	2.15	.36	.01
2	56.52	1.58	.60	.01
3	58.14	3.88	.09	.01
4	47.71	3.43	.14	.01
5	46.93	3.62	.23	.02
6	51.97	5.39	.09	.01
7	60.22	3.66	.16	.01
8	34.63	2.25	.68	.02
9	47.37	2.72	.34	.02
10	40.05	5.12	.34	.03
11	49.63	1.66	.51	.02
12	52.65	4.70	.15	.01
13	33.53	2.51	.54	.02

Referendum results if campaign is casted at tick 20

Figure 1.12 shows the distributions of the average percentage of agents that voted pro-closure at the referendum over 100 simulated runs, the experimental results here show that if the campaign is casted in the midst of the process to the referendum, on average 61.88% (Standard Deviation = 0.80, N=100) agents vote for closing the park for cars. The distribution is deviating from a normal distribution, indicating that the social dynamics are sensitive for campaign, and can grow in different directions. Table 1.8 shows the referendum results per district.

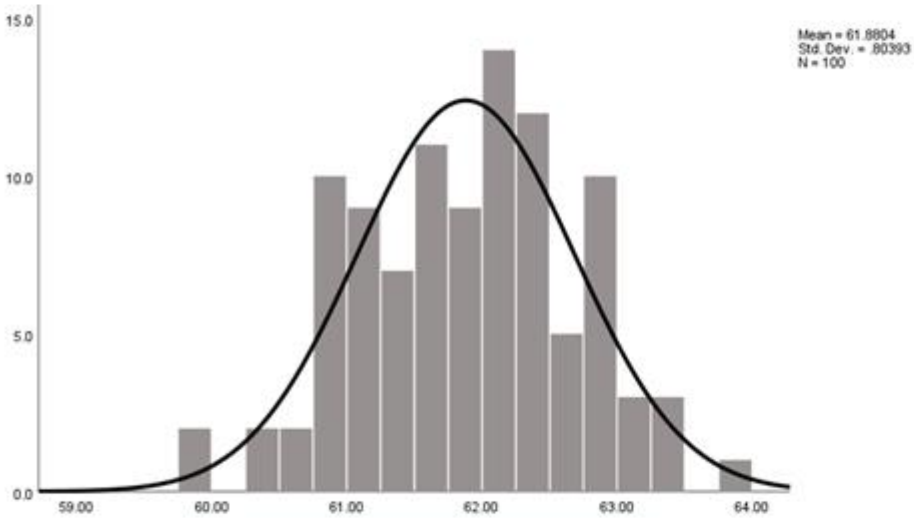


Figure 1.12 Average percentage of agents voting pro-closure, if campaign is held at tick=20

Table 1.8: District results campaign is held at tick=20, percentages of actors voting pro closure and percentage of turnout (n=100)

district	Percentage of agents voting pro-closure		turnout	
	mean	Std.dev	mean	Std.dev
1	60.12	2.54	.36	.01
2	56.49	1.64	.60	.01
3	59.41	3.58	.09	.01
4	47.62	3.23	.14	.01
5	47.14	3.73	.23	.01
6	52.02	4.80	.09	.01
7	59.81	3.11	.16	.01
8	34.58	2.36	.68	.02
9	46.85	2.73	.35	.01
10	39.77	3.98	.33	.03
11	49.52	1.89	.51	.02
12	53.19	4.47	.14	.01
13	34.23	2.54	.54	.02

Referendum results if campaign is casted at tick 35

Figure 1.13 shows the distributions of the average percentage of agents that voted pro-closure at the referendum over 100 simulated runs, the experimental results here show that if the campaign is casted right before the referendum, on average 61.88% (Standard Deviation = 0.80, N=100) agents vote for closing the park for cars. Table 1.9 shows the referendum results per district.

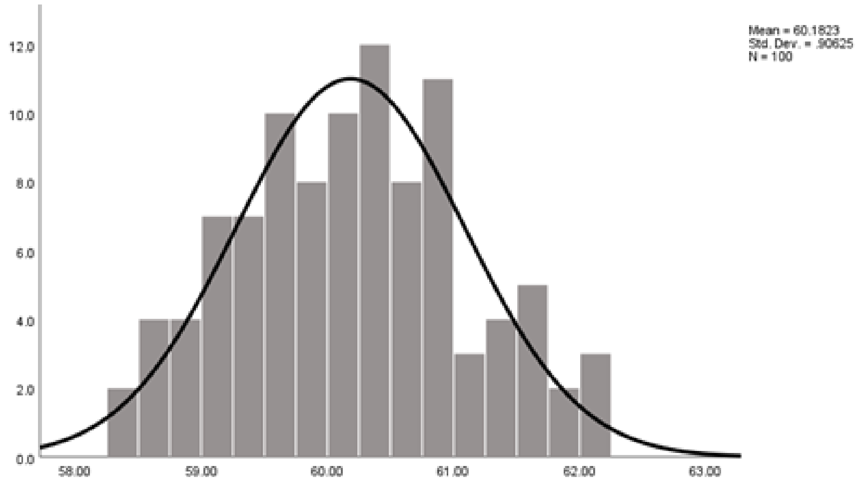


Figure 1.13 Average percentage of agents voting pro-closure, if campaign is held at tick=35

Table 1.9: District results percentages voting pro closure and turnout, if campaign is held at tick=35 (n=100)

district	Percentage of agents voting pro-closure		turnout	
	mean	Std.dev	mean	Std.dev
1	60.64	2.36	.36	.01
2	56.62	1.72	.59	.01
3	58.92	3.77	.09	.01
4	47.70	3.36	.14	.01
5	46.83	3.88	.23	.01
6	52.08	6.01	.09	.01
7	59.29	3.02	.16	.01
8	34.52	2.17	.68	.02
9	47.09	2.62	.35	.02
10	39.89	4.99	.34	.03
11	49.69	1.76	.51	.01
12	53.06	4.61	.14	.01
13	33.81	2.53	.54	.02

The results of the policy scenarios testing an affirmative car-free park campaign demonstrate that this policy is having a significant effect on the outcome of the referendum, and these effects are observed for early, middle and late campaigns. The variance within the three timing conditions is larger than the systematic difference between the three timing scenarios. Also we observe that the distributions of outcomes are less smoothly normally distributed than in the default experiment. This suggests that the campaign is producing more volatility in the community, indicating that social dynamics start playing a stronger role in the referendum. Considering that the impact of social effects are expected to be conservatively represented in the model, these experiments indicate that a positive campaign can elicit self amplifying social processes in the community.

1.3.1.4 Alternative scenario 4a: Neighborhood meeting

The previous policy scenarios addressed policies that basically targeted the population as a whole. The additional value of the agent based model here resides in the fact that not only the impact of the policy on different individuals can be simulated (first order effect), but also how the change of position of agents transpires through further social interactions taking place in the community (second order effect).

In the current Neighborhood meeting scenario we employ policy scenario tests that are uniquely possible using agent based models. We simulate meetings where a subset of the agents living in a neighborhood shows up. During this meeting, the agents can adjust their opinions and beliefs on the pro's and con's of closing/opening the park for cars. After the meeting, they return to their neighborhood, and their adjusted opinions can be communicated through their social networks (second order effect).

In the model we draw a stratified sample of 50 citizens of age 18 and older living in districts located directly adjacent to the park (Centrum, Oranjewijk/Schilderswijk and Korreweg/De hoogte) who can attend the meeting in a community centre in the park. In this meeting, the attending humats update their motives on safety in the park, transport convenience, values on park activities, and environmental awareness. In this scenario, the humats change their opinions by a maximum of 10% towards the mean of the attendees in the meeting.

Referendum results if the meeting is held at tick 5

Figure 1.14 shows the distributions of the average percentage of agents that voted pro-closure at the referendum over 100 simulated runs, the experimental results here show that if the campaign is casted in the beginning of the process to the referendum, on average 49.71% (Standard Deviation = 0.71 N=100) agents vote for closing the park for cars. This result is similar to the distribution of the baseline model and indicates that the meeting does not significantly impact actors preferences and referendum results. Table 1.10 shows the referendum results per district.

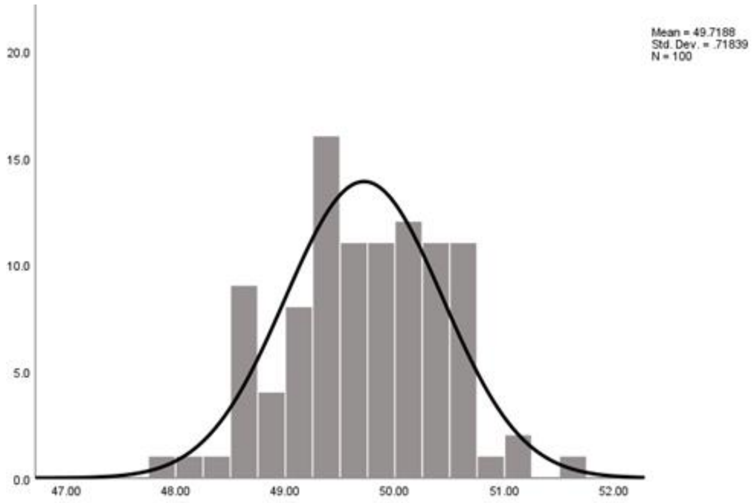


Figure 1.14 Average percentage of agents voting pro-closure, if a meeting is held at tick=5

Table 1.10: District results percentages voting pro closure and turnout, if meeting is held at tick=5 (n=100)

district	Percentage of agents voting pro-closure		turnout	
	mean	Std.dev	mean	Std.dev
1	60.47	2.24%	35.88%	1.23%
2	56.44	1.75%	60.10%	1.17%
3	58.78	3.80%	9.19%	0.73%
4	47.93	3.51%	14.34%	0.92%
5	46.86	3.51%	22.72%	1.39%
6	52.64	5.60%	9.35%	1.01%
7	60.27	3.07%	16.27%	1.00%
8	35.04	1.99%	68.15%	1.62%
9	47.50	2.98%	34.41%	1.47%
10	40.41	4.92%	33.61%	2.92%
11	49.65	2.01%	51.15%	1.39%
12	52.75	3.65%	14.78%	1.17%
13	33.91	2.70%	54.11%	2.04%

Referendum results if the meeting is held at tick 20

Figure 1.15 shows the distributions of the average percentage of agents that voted pro-closure at the referendum over 100 simulated runs, the experimental results here show that if the meeting is casted in the midst of the process to the referendum, on average 49.68% (Standard Deviation = 0.81 N=100) agents vote for closing the park for cars. This result is similar to the distribution of the baseline model and indicates that the meeting does not significantly impact actors preferences and referendum results. Table 1.11 shows the referendum results per district.

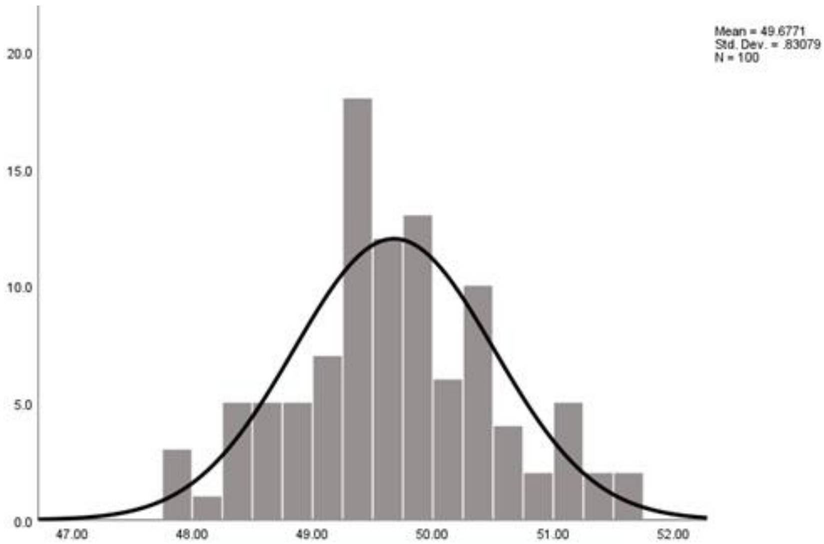


Figure 1.15 Average percentage of agents voting pro-closure, if a meeting is held at tick=20

Table 1.11: District results percentages voting pro closure and turnout, if a meeting is held at tick=20 (n=100)

district	Percentage of agents voting pro-closure		turnout	
	mean	Std.dev	mean	Std.dev
1	60.43%	2.39%	35.80%	1.29%
2	56.63%	1.68%	59.77%	1.23%
3	59.32%	4.17%	9.26%	0.72%
4	47.63%	3.31%	14.33%	1.03%
5	46.88%	3.64%	22.59%	1.33%
6	51.72%	5.09%	9.30%	1.02%
7	59.75%	3.07%	16.35%	0.90%
8	35.19%	2.45%	68.08%	1.61%
9	47.07%	3.07%	34.36%	1.54%
10	40.05%	4.97%	33.61%	2.54%
11	49.57%	1.78%	51.25%	1.46%
12	53.17%	4.63%	14.62%	1.37%
13	33.65%	2.70%	53.62%	2.06%

Referendum results if the meeting is held at tick 35

Figure 1.16 shows the distributions of the average percentage of agents that voted pro-closure at the referendum over 100 simulated runs, the experimental results here show that if the meeting is planned at the end of the process to the referendum, on average 49.64% (Standard Deviation = 0.72 N=100) agents vote for closing the park for cars. This result is similar to the distribution of the baseline model and indicates that the meeting does not significantly impact actors preferences and referendum results. Table 1.12 shows the referendum results per district.

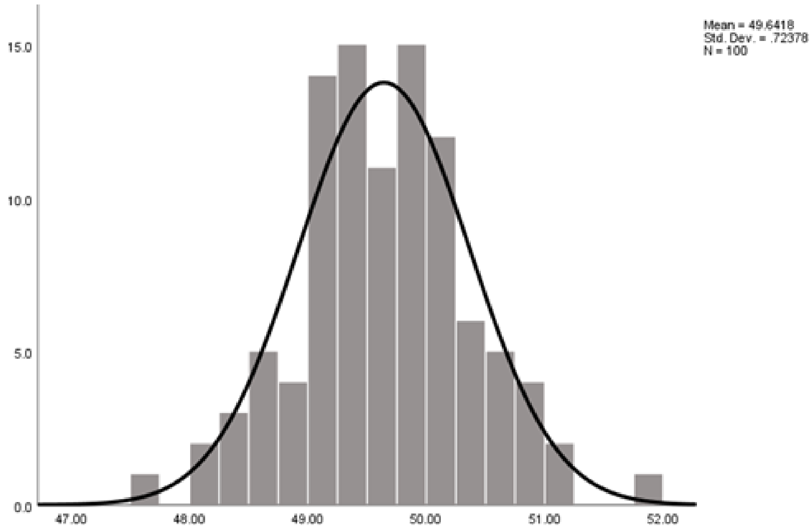


Figure 1.16 Average percentage of agents voting pro-closure, if a meeting is held at tick=35

Table 1.12: District results percentages voting pro closure and turnout, if a meeting is held at tick=35 (n=100)

district	Percentage of agents voting pro-closure		turnout	
	mean	Std.dev	mean	Std.dev
1	60.24%	2.23%	35.60%	1.42%
2	56.75%	1.52%	59.72%	1.17%
3	59.27%	3.67%	9.17%	0.75%
4	48.40%	3.07%	14.43%	0.91%
5	46.93%	3.60%	23.00%	1.64%
6	52.59%	5.33%	9.21%	1.08%
7	59.95%	3.21%	16.33%	0.94%
8	34.61%	2.00%	67.92%	1.63%
9	46.65%	2.88%	34.76%	1.37%
10	40.80%	5.33%	32.74%	2.62%
11	49.35%	1.73%	51.31%	1.42%
12	53.84%	5.09%	14.32%	1.29%
13	33.73%	2.70%	53.68%	1.87%

In the experimental runs the simulated neighborhood meetings do not have a significant impact in changing citizens preferences and referendum results. This is due to the conservative assumption that the agents shift their opinion maximally 10% in the direction of the group average. Obviously we can also implement situations where groups shift collectively in a pro or anti-plan position, or where polarised positions emerge. These larger shifts are expected to have more impact on the general population when group members share their changed opinions within their networks.

Obviously many assumptions can be made concerning the citizens that attend the neighborhood meeting. It can for example be imagined that a meeting scheduled during daytime will attract less working people, whereas an evening meeting may attract less citizens having young families. Further empirical case studies are required to get an idea of under what conditions a more representative group of citizens will attend the meeting.

1.3.1.5 Alternative scenario 4b: City Hall meeting

Reflecting on the previous discussion on the representativeness of the citizens attending the group meeting, from our interviews we concluded that the neighborhood meetings attracted a more representative group of citizens than a town-hall meeting. Town hall meetings require more effort to go to, and may be perceived as a more high-brow setting, intimidating to especially people with a lower educational background. As such, we implemented a town-hall meeting by replicating the neighborhood meeting, but now having city wide citizens attending that were highly motivated, and more likely to be highly educated.

In the model we draw a stratified sample of 50 high-educated citizens of age 25 and older to attend the meeting in the city town hall in the centre of Groningen. In this meeting the attending humats update their motives on transport circulation and convenience, values on park activities and environmental awareness. In this scenario, thehumats change their opinions by a maximum of 10% towards the mean of the attendees in the meeting.

Referendum results if the meeting is held at tick 5

Figure 1.17 shows the distributions of the average percentage of agents that voted pro-closure at the referendum over 100 simulated runs, the experimental results here show that if the campaign is casted in the beginning of the process to the referendum, on average 49.66% (Standard Deviation = 0.71 N=100) agents vote for closing the park for cars. This result is similar to the distribution of the baseline model and indicates that the meeting does not significantly impact actors preferences and referendum results. Table 1.13 shows the referendum results per district.

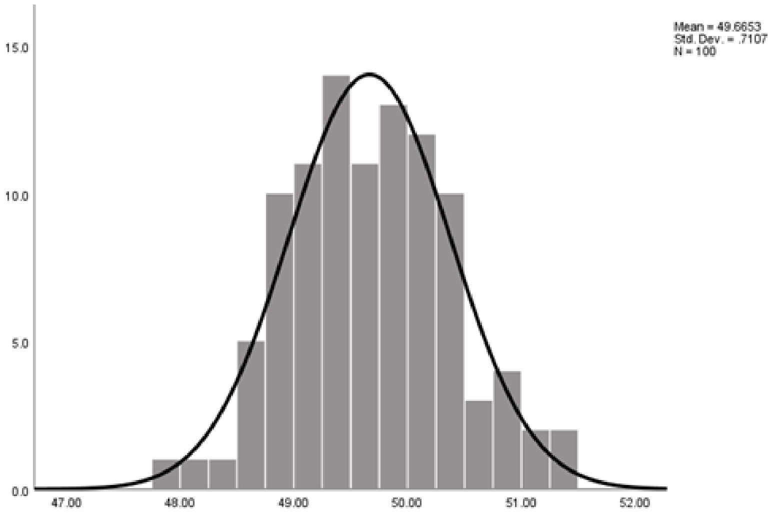


Figure 1.17 Average percentage of agents voting pro-closure, if a meeting is held at tick=5

Table 1.13: District results percentages voting pro closure and turnout, if a meeting is held at tick=5 (n=100)

district	Percentage of agents voting ro-closure		turnout	
	mean	Std.dev	mean	Std.dev
1	60.53%	2.63%	35.80%	1.18%
2	56.33%	1.73%	59.63%	1.40%
3	59.44%	3.98%	9.10%	0.90%
4	47.80%	3.96%	14.31%	0.84%
5	46.83%	3.30%	22.70%	1.45%
6	52.56%	4.90%	9.17%	0.95%
7	60.38%	3.13%	16.34%	0.95%
8	34.73%	2.05%	68.02%	1.55%
9	47.18%	2.80%	34.43%	1.79%
10	40.50%	4.75%	33.40%	2.66%
11	49.57%	1.67%	51.18%	1.45%
12	52.65%	3.66%	14.53%	1.24%
13	34.17%	2.80%	53.83%	2.14%

Referendum results if the meeting is held at tick 20

Figure 1.18 shows the distributions of the average percentage of agents that voted pro-closure at the referendum over 100 simulated runs, the experimental results here show that if the meeting is organised in the midst of the process to the referendum, on average 49.49% (Standard Deviation = 0.69 N=100) agents vote for closing the park for cars. This result is similar to the distribution of the baseline model and indicates that the meeting does not significantly impact actors preferences and referendum results. Table 1.14 shows the referendum results per district.

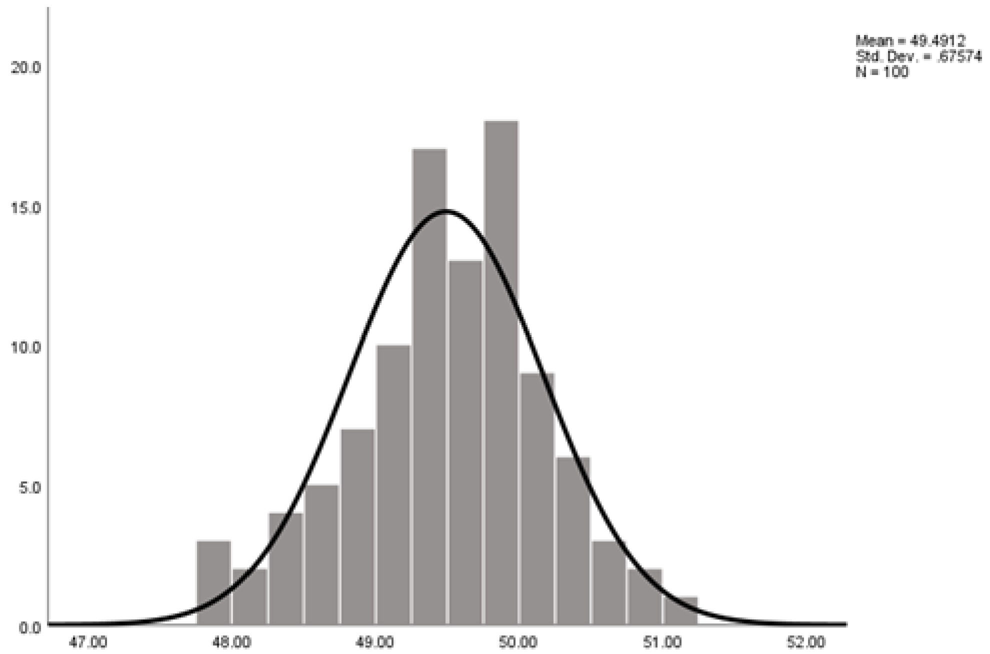


Figure 1.18 Average percentage of agents voting pro-closure, if a meeting is held at tick=20

Table 1.14: District results percentages voting pro closure and turnout, if a meeting is held at tick=20 (n=100)

district	Percentage of agents voting ro-closure		turnout	
	mean	Std.dev	mean	Std.dev
1	60.53%	2.25%	35.61%	1.24%
2	56.33%	1.71%	59.68%	1.25%
3	58.70%	3.75%	9.34%	0.82%
4	47.26%	3.44%	14.20%	0.98%
5	47.24%	3.27%	22.79%	1.35%
6	53.11%	5.81%	9.36%	0.99%
7	59.63%	3.16%	16.29%	0.90%
8	34.63%	2.20%	68.24%	1.78%
9	46.90%	2.75%	34.26%	1.55%
10	39.96%	4.97%	33.05%	2.56%
11	49.39%	1.75%	51.20%	1.58%
12	52.95%	4.01%	14.50%	1.19%
13	33.77%	2.62%	53.93%	2.17%

Referendum results if the meeting is held at tick 35

Figure 1.19 shows the distributions of the average percentage of agents that voted pro-closure at the referendum over 100 simulated runs, the experimental results here show that if the campaign is casted at the end of the process to the referendum, on average 49.53% (Standard Deviation = 0.85 N=100) agents vote for closing the park for cars. This result is similar to the distribution of the baseline model and indicates that the meeting does not significantly impact actors preferences and referendum results. Table 1.15 shows the referendum results per district.

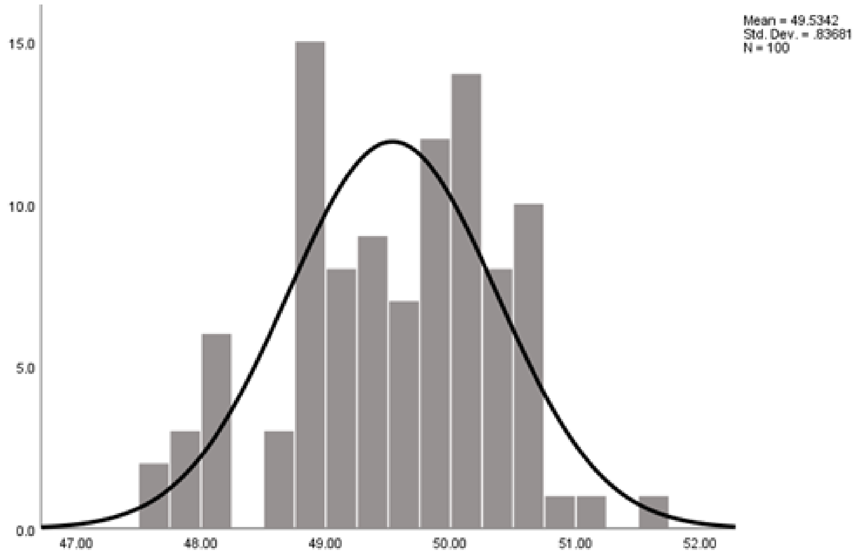


Figure 1.19 Average percentage of agents voting pro-closure, if a meeting is held at tick=35

Table 1.15: District results percentages voting pro closure and turnout, if a meeting is held at tick=35 (n=100)

district	Percentage of agents voting pro-closure		turnout	
	mean	Std.dev	mean	Std.dev
1	60.14%	2.33%	35.53%	1.35%
2	56.06%	1.83%	59.57%	1.24%
3	59.59%	3.74%	9.24%	0.81%
4	47.67%	3.43%	14.19%	0.97%
5	48.11%	3.79%	22.81%	1.66%
6	53.47%	5.47%	9.33%	0.96%
7	59.73%	3.28%	16.22%	0.84%
8	34.67%	2.06%	68.10%	1.79%
9	47.31%	2.69%	34.66%	1.42%
10	40.44%	5.04%	32.87%	2.52%
11	49.39%	1.99%	51.35%	1.43%
12	53.05%	4.14%	14.51%	1.17%
13	33.58%	2.92%	53.87%	2.00%

Overall we can conclude that the impact of the meetings on the plans to close the park for car-traffic, be it a neighborhood meeting or a town-hall meeting, is limited. However, when we look more at the distribution of outcomes we again observe that the distribution becomes less normal, indicating that the meetings did have some impact on the social dynamics. The more bimodal distributions indicate that these effects can be both positive and negative, hence cancelling each other out when aggregated over all runs. In light of the earlier mentioned conservative estimation of the social dynamics in the simulation model, and the observation that the effects of the current policy experiments cancel each other out, we can hypothesise that the impact of group meetings in reality can be larger. In future experiments we can explore the effect of different types of group meetings and test what the impact is if the participants of such a meeting collectively support or reject a plan. In the current experiments, the social influence has been implemented in such a way that the Humats change their opinions with a maximum of 10% towards the average of the group. However, in reality in group meetings major shifts in opinion can happen, especially when certain information is being presented and discussed in a compelling and convincing way. Oftentimes the sentiments in group meetings can cause a major shift in a group towards either enthusiasm for a plan. However, strong resistance can emerge if the argumentation of a plan is fiercely rebutted by a few influential attendees. Also it is possible, given attendees having opposing interests, that a group meeting results in a further polarisation and conflict. Much anecdotal evidence can be found for group meetings to have different types of outcomes on the resulting opinions. Within the current experiments we conservatively only tested situations where group meetings contributed to a convergence of the existing opinions. Because the opinion changes are modest, this means that the attendees upon return to their neighborhoods will not have a profound impact on the networks they have. This explains the very modest effects in the experiments. We hypothesise that if a group of participants changes in a certain direction during a meeting, and is composed of reputable people, this can have profound effects on the wider society and create a tipping point in the support for a plan and the development of a social innovation process. Large scale experiments can be conducted to systematically explore the potential societal second-order impact of the opinion dynamics emerging in group meetings.

1.4 Budapest follower case

In Budapest increasingly discussions take place on reducing car traffic in the inner city. The Budapest case focuses on the plans to close down a road through the city park (Városliget) for car traffic, and hence very much reflects the Groningen case where also the closure of a park for car traffic was investigated. However, the case of Budapest differs from the Groningen case because of a much larger population, and thus a larger proportion of the citizens living further away from the park. Also the population demographics are different from Groningen.

The Városliget park and the Kós Károly street that is proposed to close for car traffic can be seen in the middle of the map below (Heroes' Square), and the Kós Károly street runs from where the M3 connects with the Hungária ring road around the city center.

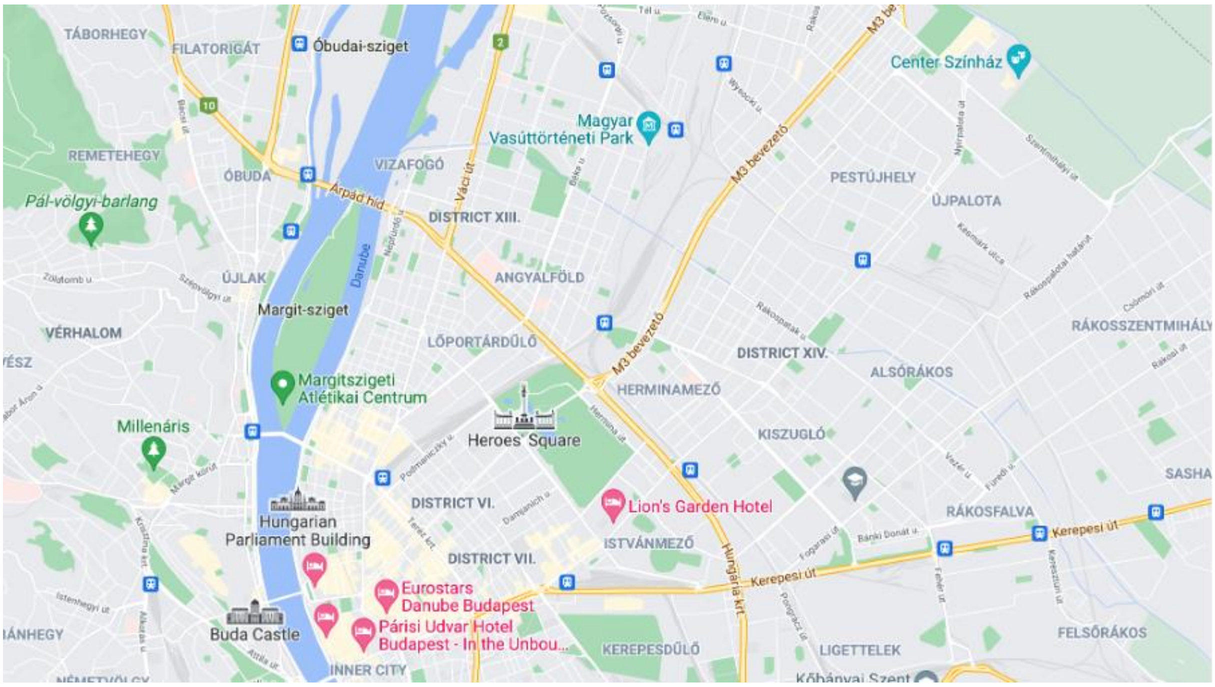


Figure 1.20: map of the city center of Budapest

The road through the Városliget park is primarily being used by people from the north eastern parts of Budapest to enter the city center.

The following districts have been included in the simulation model of the Budapest case:

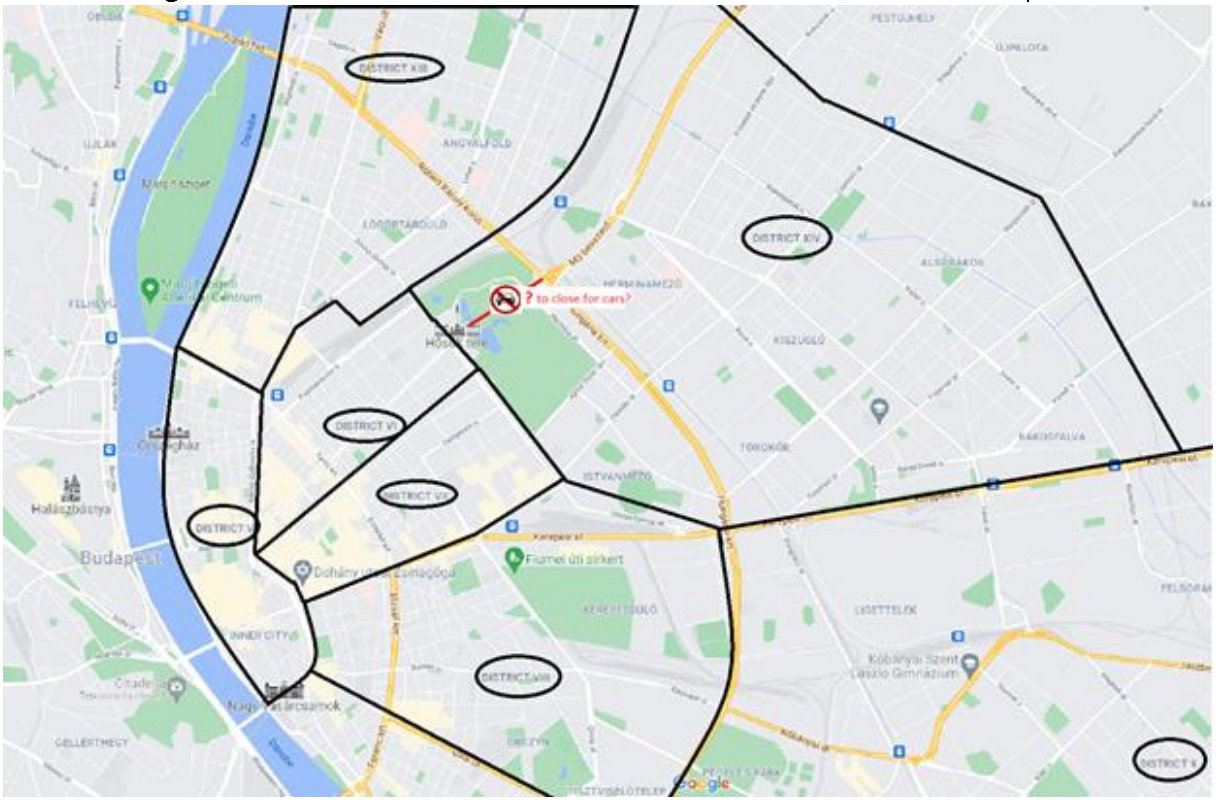


Figure 1.21: map of the districts in the city center of Budapest

For the Budapest case we use the Groningen model as a template, and change the composition of the neighborhoods in such a way that it resembles the Budapest case concerning population distribution and importances of outcomes. The quick parameterisation (a matter of days) demonstrates how fast the model can be adjusted for new cases. We decided not to use a spatial map for Budapest, although that would have been a possibility. Because we could use the Groningen map as a rough template of the Budapest neighborhoods by changing the number of citizens inhabiting the different neighborhoods, we are capable of including the motives of people living more nearby the Városliget park and the motives of the large numbers of people that are living in more distant neighborhoods.

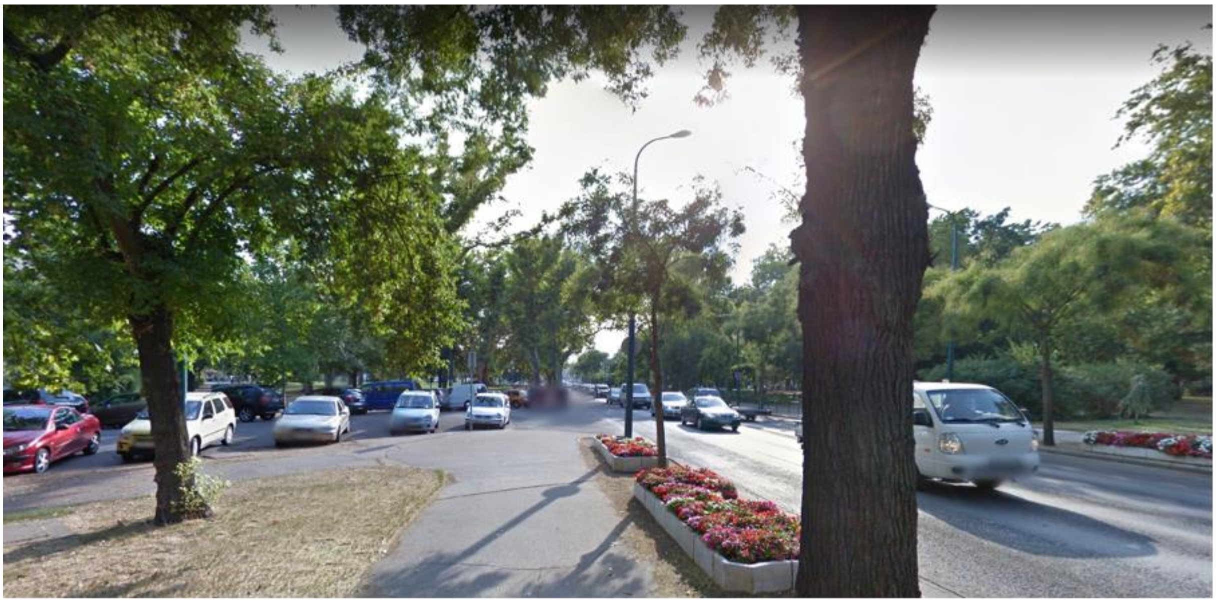


Figure 1.22: Screenshot of Google Maps showing traffic at the Kós Károly street.

For the population demographics we included the following demographics in the Budapest model:

- age (18-24, 25-64, 65+),
- gender (male - female),
- main economic activity (student, worker, inactive/unemployed, retired)
- city district (informations where individuals live, as distance to the park plays a role in motives)

We used census data and micro census data from the statistical yearbook from Budapest of 2016 (Hungarian Social Statistical Office, 2016). Figure 1.23 depicts the composition of social demographics per districts in age composition, educational attainment and the proportion of students

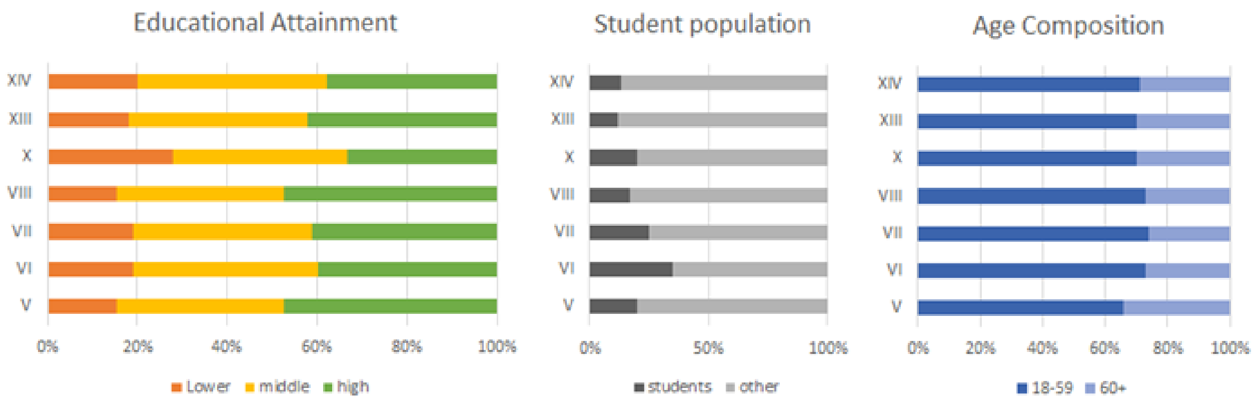


Figure 1.23 Composition of social demographic characteristcs per district included in the ABM

For the motives of the population we distinguish

- enjoyment of the park
- importance to have access by car to inner city
- value towards a sustainable future of Budapest

For the motives we used data from the Surveys on Resilience and Sustainable Developments in Budapest (Eurobarometer, 2016), Survey on City Park development (Ipsos, 2016) and Survey on urban development in Budapest (Publicus Research, 2021)

Budapest differs significantly from Groningen. Firstly, with its 1.750.000 inhabitants, Budapest is almost 10 times larger than Groningen. Next, the distribution of education, income and private car ownership are different (Hungarian social statistical office, 2016). For example, in Groningen about 30% of the population are students, making Groningen a highly educated and young city. In Budapest, the percentage of students is less than 20%, which makes a significant difference to the Groningen case. Moreover, the values concerning the ownership of cars and biking culture differ significantly (Eurobarometer, 2016).

1.4.1 Budapest baseline model simulations and results

In principle, the same social dynamics can emerge in the Budapest model as in the Groningen model. However, because of the different population, Budapest will have different characteristics and preferences than the Groningen population. To test this, we first replicated the default run as presented for the Groningen case in section 1.1.3.

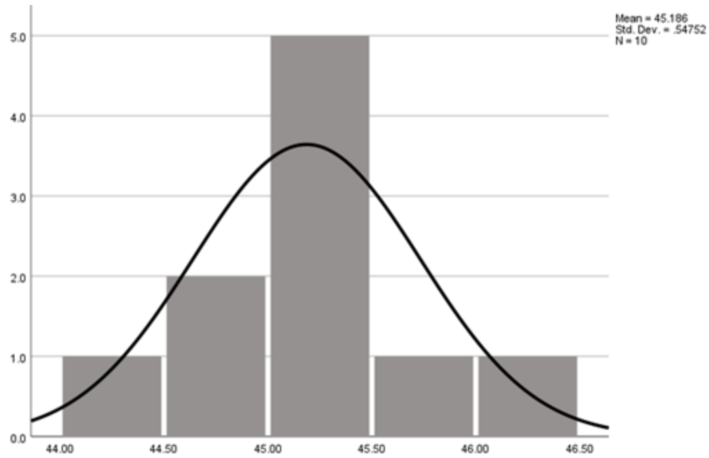


Figure 1.24 Distribution of pro-closure votes over 10 repetitions at tick 38

Table 1.16 districts results

district	Percentage of agents voting pro-closure		turnout	
	mean	Std.dev	mean	Std.dev
I	0.45%	0.03%	0.57%	0.02%
V	0.63%	0.06%	0.09%	0.01%
VI	0.56%	0.01%	0.56%	0.02%
VII	0.60%	0.04%	0.33%	0.01%
VIII	0.54%	0.03%	0.09%	0.01%
X	0.40%	0.02%	0.69%	0.01%
XIII	0.48%	0.02%	0.48%	0.01%
XIV	0.59%	0.02%	0.14%	0.01%

As can be seen, a minority of about 45% of the simulated population of Budapest is in favour of closing the Városliget park for car traffic. Compared to the Groningen case, in Budapest more simulated citizens vote for keeping the park open for car traffic. This can be explained by the relatively smaller student population and the larger population, especially in the North Western district of Budapest, that adhere more value to the mobility outcomes of the vote.

1.4.2 Budapest policy experiments

For the Budapest case we also conducted a series of policy experiments in line with the experiments we conducted for the Groningen case. We conducted experiments where we had an affirmative campaign supporting the closure of the road for cars.

Affirmative campaign

Referendum results if the campaign is held at tick 5

Figure 1.25 shows the distributions of the average percentage of agents that voted pro-closure at the referendum over 100 simulated runs, the experimental results here show that if the campaign is casted in the beginning of the process to the referendum, on average 59.38% (Standard Deviation = 0.77 N=10) agents vote for closing the park for cars. This result is significantly higher than the baseline model, indicating that the campaign has a strong impact on agents voting preferences and referendum results. Table 1.17 shows the referendum results per district.

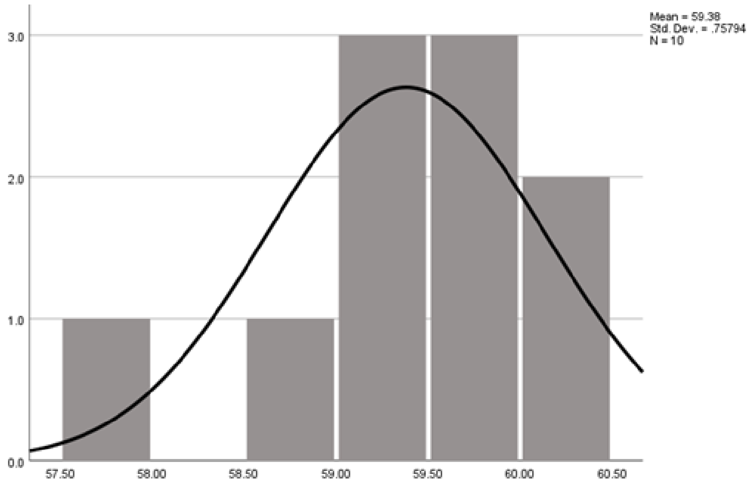


Figure 1.25 Average percentage of agents voting pro-closure, if campaign is held at tick=5

Table 1.17 Average percentage of agents voting pro-closure, campaign at tick=5

district	Percentage of agents voting ro-closure		turnout	
	mean	Std.dev	mean	Std.dev
I	0.45%	0.03%	0.59%	0.01%
V	0.63%	0.06%	0.08%	0.01%
VI	0.56%	0.01%	0.56%	0.02%
VII	0.60%	0.04%	0.32%	0.01%
VIII	0.51%	0.03%	0.09%	0.01%
X	0.31%	0.01%	0.68%	0.01%
XIII	0.50%	0.01%	0.48%	0.01%
XIV	0.59%	0.02%	0.14%	0.01%

Referendum results if the meeting is held at tick 20

Figure 1.26 shows the distributions of the average percentage of agents that voted pro-closure at the referendum over 100 simulated runs, the experimental results here show that if the campaign is casted in the midst of the process to the referendum, on average 58.30% (Standard Deviation = 0.49 N=10) agents vote for closing the park for cars. This result is significantly higher than the baseline model, indicating that the campaign has a strong impact on agents voting preferences and referendum results. Table 1.18 shows the referendum results per district.

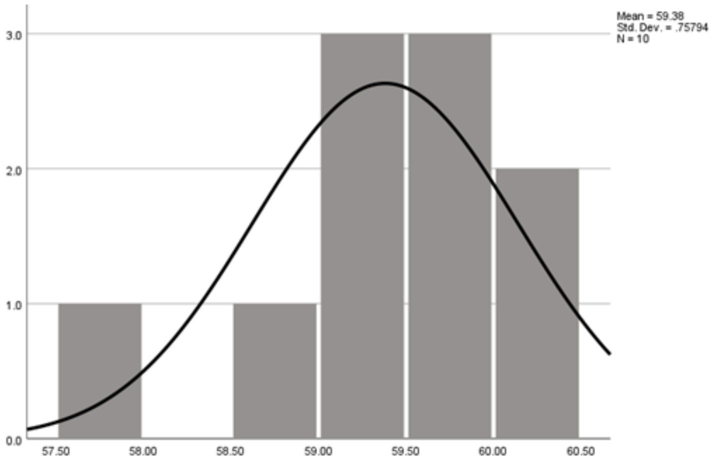


Figure 1.26 Average percentage of agents voting pro-closure, if campaign is held at tick=20

Table 1.18 Average percentage of agents voting pro-closure, if campaign at tick=20

district	Percentage of agents voting ro-closure		turnout	
	mean	Std.dev	mean	Std.dev
I	0.45%	0.03%	0.59%	0.01%
V	0.63%	0.06%	0.08%	0.01%
VI	0.56%	0.01%	0.56%	0.02%
VII	0.60%	0.04%	0.32%	0.01%
VIII	0.51%	0.03%	0.09%	0.01%
X	0.35%	0.02%	0.68%	0.01%
XIII	0.48%	0.02%	0.48%	0.01%
XIV	0.59%	0.02%	0.14%	0.01%

Referendum results if the meeting is held at tick 35

Figure 1.27 shows the distributions of the average percentage of agents that voted pro-closure at the referendum over 100 simulated runs, the experimental results here show that if the campaign is casted at the end of the process to the referendum, on average 58.30% (Standard Deviation = 0.49 N=10) agents vote for closing the park for cars. This result is significantly higher than the baseline model, indicating that the campaign has a strong impact on agents voting preferences and referendum results. Table 1.19 shows the referendum results per district.

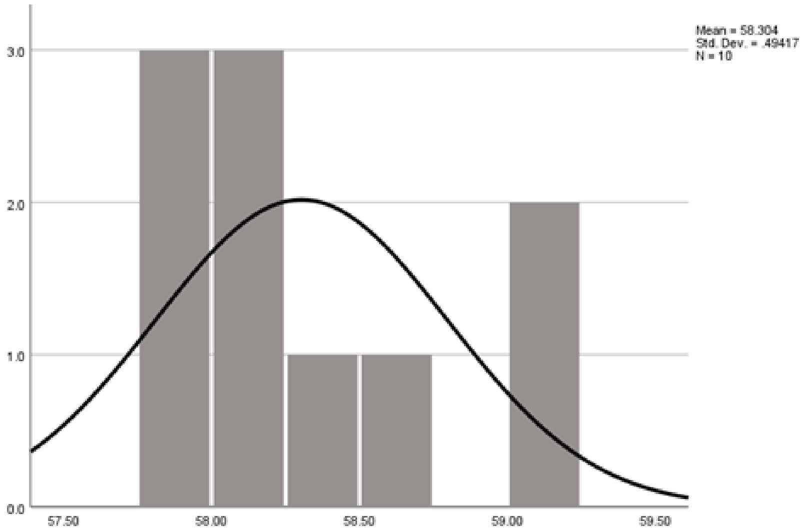


Figure 1.27 Average percentage of agents voting pro-closure, if campaign is held at tick=35

Table 1.19 districts Average percentage of agents voting pro-closure, campaign at tick=35

district	Percentage of agents voting ro-closure		turnout	
	mean	Std.dev	mean	Std.dev
I	0.45%	0.03%	0.59%	0.01%
V	0.63%	0.06%	0.08%	0.01%
VI	0.56%	0.01%	0.56%	0.02%
VII	0.60%	0.04%	0.32%	0.01%
VIII	0.51%	0.03%	0.09%	0.01%
X	0.35%	0.02%	0.68%	0.01%
XIII	0.48%	0.02%	0.48%	0.01%
XIV	0.59%	0.02%	0.14%	0.01%

1.5 Conclusions and discussion

This section demonstrated a replication of a real-life social innovation case of mobility plan changes in the city of Groningen, The Netherlands, and a similar follower case in Budapest. In Groningen, an important park at the heart of the city was closed for through car traffic as a result of a referendum. The simulation mimics the process of attitude formation, information exchange and casting the vote among 1994 Groningen residents. We reported simulated results aimed at recreating an artificially replication of the historic referendum case in Groningen, where residents had the opportunity to cast their vote in favour or against the closure of the park for through car traffic, which yielded a division of 51% in favour and 49% against (Municipality of Groningen, 1994).

The simulations on the referendum yields an average 49.54%, (Standard Deviation = 0.73, N=1000) votes for closing the park for cars. This also indicates that it would have been very realistic that the referendum was won by the park-open-for-cars voters.

Policy scenario workshops have been organised to discuss the simulation model and possible policies to test with the model. For the experimentation we selected four policy scenarios that could be implemented straightforwardly in the model. First, we experimented with the sensitivity of referendum results if it is subjected to an unexpected event, that is, we simulated whether a car-accident in the park would have an impact on the referendum results and manipulated the timing of the event. Results of these experimental simulations show that a car-accident in the park leads agents to be more likely to vote pro-closure compared to our baseline model, it seems that this tendency to vote pro-closure is there regardless of timing. Once it happened, actors leaned more towards voting for closing the park for cars.

Second, we experimented with a communicative policy, which was either affirmative or resisting the closure of the park for cars, and manipulated the timing of this communicative strategy in whether it would be casted after initiation of the referendum, in the midst of the process or right before the referendum (at tick 5, 20 and 35 respectively).

In the case of the pro-opening campaign held by shopkeepers, the results from the experimental simulations show very different dynamics compared to the accident and the affirmative campaign. In this case, it can immediately be observed that this campaign that underlines shopping convenience and that park-through traffic facilitates that, makes the majority of agents more prone to vote to keep the park open for cars, also if the campaign is casted in later stages it has this result. Furthermore the results in the districts are drastically different, here districts 1 and 13 (districts that are closest to the shopping areas) are very much affected by the campaigns.

In case of the affirmative campaigns; can immediately be observed that with this campaign, voters are influenced and become more convinced that having a car-free park is an optimal outcome, regardless of the timing of the campaign, the overall majority vote for closure of the park shifts in each case from around 54% to 62%. An important observation is that the simulations often display a bimodal distribution of outcomes, or a distribution that deviates from a normal distribution. This is a strong indication that the impact of a campaign works on two levels.

In the group meeting policy experiments we tested the effect of organising neighborhood or town-hall meetings. The results indicate that such meetings can have an impact on the social dynamics, however, in the current set-up the effects could be both positive or negative for the plan (as shown by the more bi-modal distributions). Hence we expect that the effects of a group meeting that creates a more unanimous positive or negative sentiment about a plan will have much stronger effects on the population as a whole. Here we are referring to the "second order" effects that follow from the interactions the group meeting attendants have at a later stage with people in their network. Especially when they have a positive reputation in their local networks, their opinion on a plan may have a significant impact on the opinion dynamics in their networks.

An important contribution of the agent based methodology is their capacity to address such second order effects. If a campaign would only have impact on the first level of the individual, one would expect that the distribution as displayed in Figure 1 would move as a whole more to the "open for cars" versus "close for cars" position. If particular groups of agents would be more susceptible for the campaign, this would result in a more stable shift of the average vote, and the normal distribution would basically move. However, in the simulation we have second order effects resulting from agents that have changed their opinions due to the campaign and in turn also influence the other agents they are interacting with. And when these agents change their opinion, too, complex cascading effects may happen in the simulated community. If this indeed results in more turbulent behaviour in the simulated community, the sensitivity of the model for initial conditions will increase, resulting in a wider variety of simulation run outcomes. Interestingly, when bimodal outcomes appear, this is an indication that the social system displays so-called attractors in the system. In deliverable 7.2 section 2 (Antosz et al, 2019), the complexity of such social dynamics is explained. For policy makers this means that the impact of a campaign is sensitive for second order social interactions. Whereas in these simulations the outcomes did not display real radical differences in outcomes, it can be imagined that a situation can arise where a campaign can either be a success or a real failure, depending on the second order effects of reputable people in the community supporting or resisting the campaign.

2. Case cluster 2: Island renaissance based on renewable energy production

In this section we will discuss the two cases of island renaissance of respectively Samsø and El Hierro. The two models for these cases are significantly different, reflecting the variability of the two cases. The Samsø case is focussing on the bottom up process of participating in a heat network project. The purpose of the model is to explore under what conditions a tipping point can be found where the local community builds up a motivation to join a heat network and abandon the old oil fueled heating technology. In the El Hierro case, contrary to Samsø, the social innovation was primarily top-down. The purpose of the model is to study the acceptability of the expansion of the Renewable El Hierro project, once the citizens have experienced the first phase of the project. Moreover, the El Hierro agent-based model is very similar to the Vitoria Gasteiz agent-based model with respect to design and contents, with small variations to account for differences in data sources, entities and actors involved in the model and their policy strategies. In the following we will discuss first the Samsø case, followed by the El Hierro case.

2.1 Overview Samsø case

2.1.1 Introduction Samsø case

Samsø is a Danish island in the Kattegat 15 km off the Jutland Peninsula. The community has 3,724 inhabitants and is 114 km^2 in area. Samsø is in the Central Denmark Region. Agriculture has been the primary occupation on Samsø for millennia and nearly the entire island comprises cultured landscapes. Ecological agriculture and production is growing on Samsø, with a broad network of cooperating associations. It comprises farming of a large variety of vegetables, grains and fruits, livestock meat and products, a dairy, a brewery, restaurants and cafés, candy production, permaculture and forest garden experiments. Three hundred years ago, the island of Samsø had hundreds of operating windmills (therefore, there is a long tradition of using wind energy on the Island).

In the case of Samsø, seven interviews were conducted with respondents falling in the following categories: ‘promoters and pioneers’, ‘third parties group’ (a category including business-private sector, local authorities’ officials, civil society representatives, and other stakeholders), ‘key supporters’ (stakeholders, social actors and public authorities which developed a significant role at any moment of the process), ‘recipient and beneficiaries of the initiative’, and finally ‘experts in social innovation’.

The key findings of Samsø are drawn mainly from the analysis conducted in D6.1 (Pellegrini-Masini et al., 2019) of the interviews and from the research previously conducted on secondary data and reported in deliverables D3.1 and D3.4.

2.1.2 The Samsø heat network case

Originally the plan was to model the wind farm transition that made Samsø famous as a case. At a later stage of the project it was decided to focus on the social innovation case of joining a heat network, though. From a social innovation point of view this was more interesting to simulate because in this case the individual decision-making of the inhabitants was more important.

On Samsø, three successive projects involved the establishment of district heating plants, two of which were straw-fired (same as Samsø's original plant which preceded the REI project) and one powered by wood chips and solar panels (2500 m^2 solar panel system).

The Samsø model has been described in SMARTEES Deliverable 7.3 (Antosz et al, 2020). The agent-based model focuses on mobilizing residents of the Samsø town of Onsbjerg to participate in a district heating network project implemented in their neighbourhood. This was one example of district heating implemented on the island, along the Nordby-Maarup and Ballen-Brundby cases. The main elements of the heat network project, also characteristic for the entire social innovation (Caiati et al. 2019), and reflected in the agent-based model include:

- A bottom-up approach, driven by a small number of active members of the local community building an alliance with expert organization of Samsø Energy Academy (Energiakademiet),
- Progressive character of the consensus building through negotiation and dialogue to overcome conflicts and resistance,
- Credible and transparent communication (e.g., open minutes from the meetings and open budget documents),
- Resident co-ownership of the district heating infrastructure and the related economic gains,
- Energy Academy's capitalization on the experience (and lessons learned) through the set-up of three district heating networks in different parts of the Island.

Typical nodes/agents present in the model are residents of Samsø, divided into two groups. Residents of the Onsbjerg district where the heat network is installed, and residents of other districts. Individual residents have a set of needs that includes the motives of:

- Affordability (experiential need),
- High air quality (experiential need),
- Safety (experiential need)
- Renovation inconvenience (experiential need),
- Social need,
- Ecological values,
- Islander identity (value),
- Aesthetics (value).

Moreover, Islanders have a set of beliefs (cognitions) about how their current heating system and the new district heating satisfies those needs. For example, a resident might believe that the new district heating will be more affordable than the old system, and that it will be less polluting for the air. Agents residing on the virtual version of the Samsø island differ with respect to the degree to which these needs are important to them, and with respect to beliefs about how satisfying it is to continue to use the default heating mode, and how satisfying it will be to switch to the district heating network. Residents also have their individual cognitive dissonance tolerance threshold, which if exceeded by the preferred alternative, requires them to take action to reduce it. This means that for example when an agent is convinced of the advantages of joining the heat network, but most of their linked others are not supporting the heat network, the agent experiences a (social) dissonance. This dissonance can be reduced by either convincing the other agents about the advantages of joining the heat network, or by adjusting their own opinions in the direction of being less positive about joining. Moreover, residents are characterised by gender, age group, education, and income levels. Finally, individual residents form households.

Critical nodes/agents include:

Promoters of the social innovation:

- a small group of active community members (e.g., Onsbjerg district heating working group)
- Supporters of the social innovation:
- Samsø Energy Academy
- Expert working with the Energy Academy

Opponents of the social innovation; depending on the heat network implementation, those were:

- A local plumber (Nordby-Maarup case),
- A local priest (Onsbjerg case)
- NRGi energy company (Ballen-Brundby case)
- Media.

Originally, we envisaged implementing the Samsø model in a GIS model, so we would have the spatial representation of the island as a basis for the model. However, given time constraints we decided to use the Groningen model as a template for modelling the Samsø case. Just like the Budapest follower case, the advantage of this is demonstrating the flexibility of the model to adjust one model quickly for another case. Assuming that the precise spatial layout is not the most critical aspect determining the social dynamics, we expect that transplanting the population characteristics of Samsø into the Groningen model will result in a model capable of demonstrating the social dynamics playing a role in the success or failure of heat network projects.

Considering the calibration and the data being used for the Samsø model, we rely on the basic statistics on the population, data on the attendance to the group meetings in the three respective cases, and on qualitative interview data regarding the importance of motives of the different people in the case. On the basis of these data we implemented an artificial population of Samsø. The ten districts of Groningen are merged into 3 districts that represent the three different heat network cases in Samsø.

2.2 Policy scenario development for Samsø case

Because the Samsø case was redirected at the heat network case, the workshops did not directly focus on this case. Also the modelling was delayed, and as a consequence the last workshop with the people from Samsø did not specifically address different model runs of a Samsø model. As a consequence, the policy scenarios we discuss here are based on the experiences of the other workshops, and focus on policy experiments that we imagine to be relevant in this and comparable cases of social innovation.

2.2.1 An incident with the heat plant

In this scenario, we explore how sensitive the social innovation is to random events that may have an impact on the perception of the social innovation. In the Groningen case on the referendum on a car-free park, an accident between a car and a bike was assumed to emphasise the safety need in the simulated population. Considering that in the Samsø case the safety of the heat plant was an issue mentioned by the people, we included this in a policy scenario experiment by emphasising the importance of the safety needs in the agents.

2.2.2 The impact of pricing

The financial costs associated with joining the heat network are related to investment costs and operational costs. It is first possible to change the costs of joining the heat network, for example by subsidising the costs of joining a heat network. The more the agents perceive that fuel prices may rise considerably in the future, the more they may be motivated to join the heat network and invest now to save money in the long run.

2.2.3 Informational campaign

Informational campaigns can be implemented by making certain needs more important in the agents. Different possibilities are available here, addressing experiential needs, social needs or value needs. For example, an information campaign can emphasise (1) the improvement of the air quality when the heat network is implemented (experiential outcome), (2) the success of similar earlier project where a majority of people joined (social outcome), or (3) emphasising the islander value of being independent from the mainland (value outcome). The approach here is similar to the informational campaign in the Groningen policy experiment case.

2.2.4 Group meetings

Finally we consider just as in the Groningen case to implement group meetings in the Samsø case. As we consider such group meetings as a social policy where due to social interactions relevant dynamics can emerge, this is typically a policy scenario where computer simulations can contribute to understanding the potential complex effects. Just as in the Groningen policy scenario experiments on group meetings, we simulated the opinion dynamics of a selected group of agents discussing joining the heat network, and the subsequent impact of that on the wider population. We were not capable of implementing the plumber and the priest as reputable agents having a negative perspective on joining because no clear data were available. The same applies to the impact the representative of the Energy Academy had as a proponent of joining the heat network. Just as in the Groningen policy scenario on group meetings, we combined this with an informational campaign.

2.3 Samsø simulation results

2.3.1 Samsø main model

In this section we report the results of the first simulated results of the baseline model for the Samsø case. Simulations for the baseline model and models with policy interventions and alternative scenarios were carried out in the BehaviorSpace of Netlogo 6.2.0 (Wilensky 1999). The baseline model simulation consisted of 10 repeated runs. The baseline model is a situation in which there are no interventions implemented to affect humats decisions on joining the heating network. The baseline model simulations indicate that the majority of the population is interested in joining the heat network. The simulations on households joining the heating network yield an average 50.26%, (Standard Deviation = 3.06, N=10). Compared to the available historical data on district heating's popularity among Onsbjerg household residents (Antosz et al., p.23), the simulation models show a lower popularity among artificial residents in the Samso ABM. More extensive investigations on the model need to be carried out to pinpoint the difference between dynamics in the empirical case versus the artificial model. Figure 2.1 shows a distribution of simulated results over 10 repetitions at tick 38 (this is the moment where citizens decide to join).

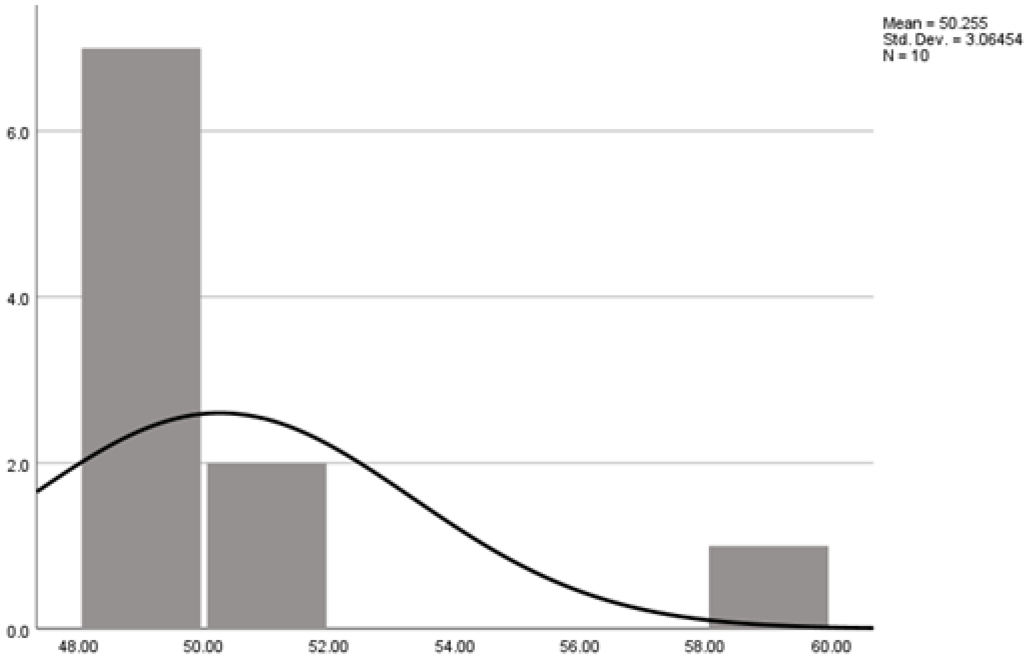


Figure 2.1 Average percentage distribution of citizens joining the heat network (10 repetitions) at tick 38

2.3.2 Results from experiments

1.3.2.1 Policy scenario 1: An incident with an oil fueled heating system.

In this scenario, we explore how sensitive social innovation is to random events that may have an impact on the perception of the social innovation. In the Groningen case on the referendum on a car-free park, an accident between a car and a bike was assumed to emphasise the safety need in the simulated population. Considering that in the Samsø case the safety of oil burners was an issue mentioned by the people, we included this in a policy scenario experiment by emphasising the importance of the safety needs in the agents.

The experimental simulations show that an accident in the plant does not have a strong effect on the agents joining the heat network. We see a polarization in this experiment, although we have to be careful with the interpretation of this due to the very limited number of runs. A majority of 55,33% would refrain from joining the heat network if an incident would happen (see figure 2.2). However, we see also that in one run, 61% of the citizens would refrain from joining the heat network. These results are in alignment with the non-normal distribution of the default run in Figure 2.1. This indicates that the social dynamics may have an important role in the emergence of support for the heat network. Also this indicates that an incident will not affect the specific group of citizens with very strong motives for joining the heat network, causing that the generic opinion remains positive.

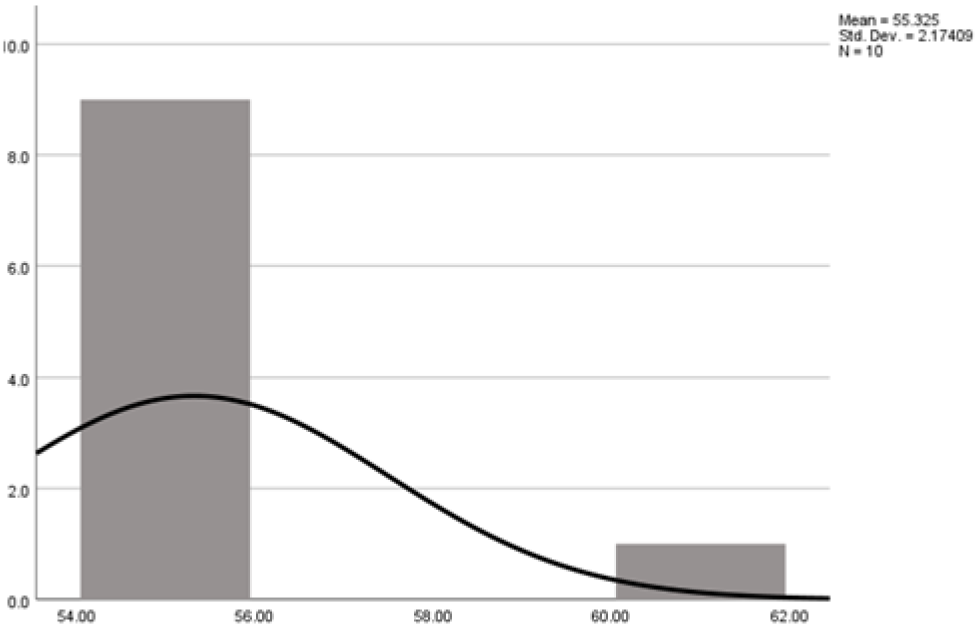


Figure 2.2 Average percentage distribution of citizens not joining the heat network (10 repetitions) if an accident happens at tick 35

1.3.2.2 Policy scenario 2: Pricing

In this scenario, we explore to what extent the financial costs associated with joining the heat network are related to investment costs and operational costs. We implemented a case where the local government subsidizes installment costs at tick 35, thereby the weight of motives of agents regarding pricing are lowered as the costs may become a smaller issue for some households. The experimental simulations show that, averaged over 10 runs, in this scenario a majority of 50,86% (Std Dev = 3.00) does not join the heating network (figure 2.3). The scenario does not seem to have a significant effect. Moreover, in this scenario only 0.60% more citizens are joining the heating network compared to the baseline model where no policy invention is implemented. This indicates that the weight of the motives may not have been lowered enough or that other motives weigh stronger. More substantial work (various analyses and extensive simulations with many more repetitions) has to be conducted to get more insight into this dynamic. Also here we see that for a small proportion of citizens the policy does not affect their willingness to join as they were already very convinced that they wanted to join.

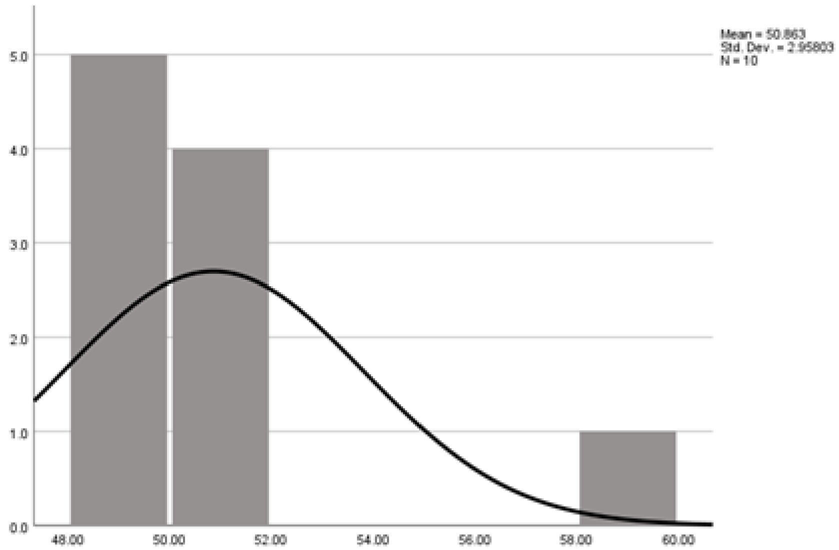


Figure 2.3 Average percentage distribution of citizens joining the heat network (10 repetitions) if local government subsidizes installment costs at tick 35

1.3.2.3 Policy scenario 3: Information campaign

In this scenario, we explore how an informational campaign can be implemented by making certain needs more important in the agents. We focussed on a case where an information campaign emphasises (1) the improvement of the air quality when the heat network is implemented (experiential outcome), (2) emphasising the value of being independent from the mainland (value outcome) and (3) how the plant promotes sustainability as this option decreasing carbon emissions (experiential outcome). The informational campaign is held at tick 35, close to the moment where humats decide if they want to join the heating network, tick 38.

The experimental simulations show that, averaged over 10 runs, in this scenario 61,65% (Std Dev = 1.78) of the citizens would now join the heating network (figure 2.4). This experiment shows that the overall outcome increases significantly even if some motives for joining the network are increased with 10% after the informational campaign.

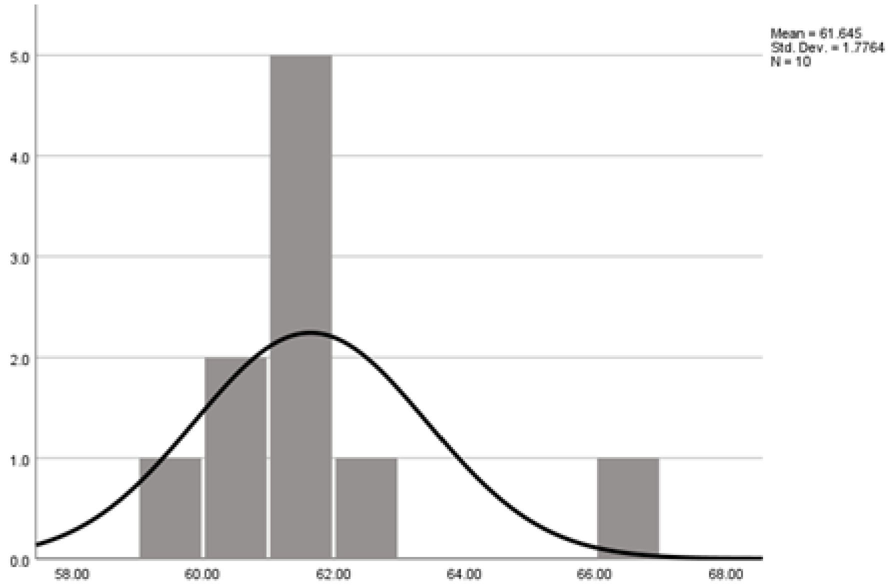


Figure 2.4 Average percentage distribution of citizens joining the heat network (10 repetitions) if informational campaigns are held at tick 35

1.3.2.4 Policy scenario 4: group meetings

Finally we consider just as in the Groningen case to implement group meetings in the Samsø case. As we consider such group meetings as a social policy where due to social interactions relevant dynamics can emerge, this is typically a policy scenario where computer simulations can contribute to understanding the potential complex effects. Just as in the Groningen policy scenario experiments on group meetings, we simulated the opinion dynamics of a selected group of agents discussing joining the heat network, and the subsequent impact of that on the wider population.

In the model we draw a stratified sample of 50 high-educated citizens of age 25 and older to attend the meeting, at tick 35. In this meeting the attending humats update their motives on the improvement of the air quality, being independent from the mainland and sustainability. In this scenario, the humats change their opinions by a maximum of 25% towards the mean of the attendees in the meeting

The experimental simulations show that, averaged over 10 runs, in this scenario 51,94% (Std Dev = 5.07) of the citizens would now join the heating network, compared to the baseline model in which no policy intervention is implemented, we see only an increase of 1.70% more humats joining the heating network (figure 2.5).

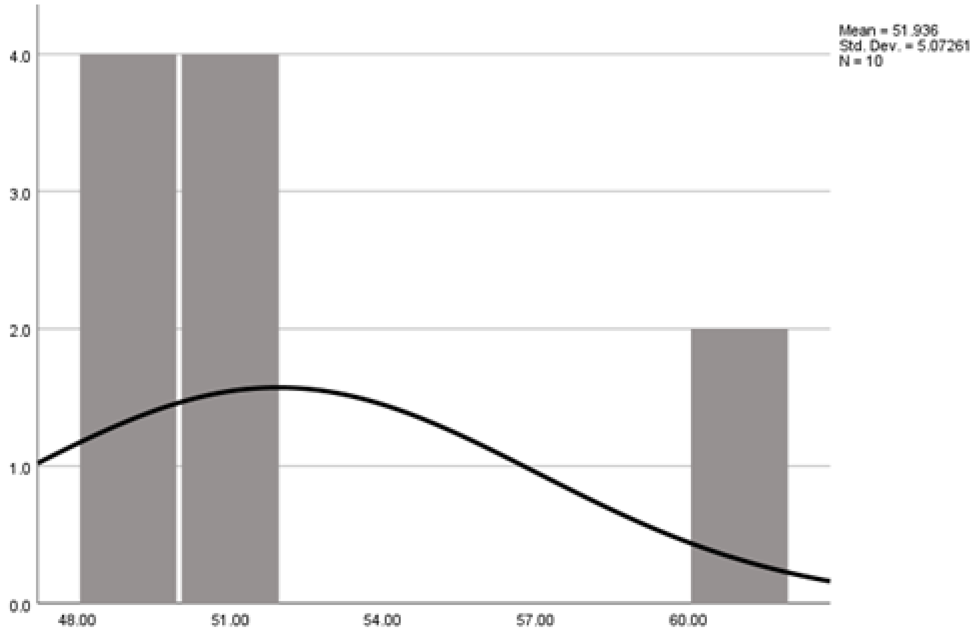


Figure 2.5 Distribution of citizens joining the heat network

2.4 Conclusions and discussion Samsø case

The Samsø case shows that it is possible to develop a simulation of a social innovation project on the basis of a basic data set being implemented in an existing model. This proves that the simulation tool is ready to be used in many practical settings where basic population data are available.

The results demonstrate that the social dynamics can result in considerable differences in the proportion of people joining the heat network. In several runs the support is around 50%, but we also see runs where about 60% of the people want to join the project. The number of runs is limited, but a bimodal distribution can be observed, indicating that social dynamics play an important role in such projects.

The policy scenarios show that an incident with the heat plant and subsidies have a positive impact on the number of people joining the project. Most interestingly an informational campaign focussing on the improvement of the air quality, the value of being independent from the mainland and sustainability has the largest effect on people joining the heat network. These policy experiments give a first indication of how policies may impact the social dynamics that are critical in the success or failure of social innovations.

Obviously, more detail can be included when specific information is available, in this case the role of some specific actors in the community. Especially for future projects it would be good to include specific spatial information in the model, as the implementation of a heat network typically requires a street-by-street approach in both the implementation of the technology (the connection with the heat pipes) as well as the discussions on street level concerning joining or not. This also opens the possibility to calibrate a model more specifically respecting the different characteristics of people living in different neighborhoods.

Also of interest for future projects is to develop a perspective on how a successful implementation of a heat network can have an impact on a next project in an adjacent neighborhood or village. We hypothesise that communicative strategies that demonstrate the success of one project may have a strong influence in the enthusiasm of people in a neighborhood that is also considering to adopt a heat network.

2.4 Overview El Hierro Case

2.4.1 Introduction El Hierro Case

El Hierro is an island of the Canarian archipelago in Spain, which covers an area of 278 km^2 and has a population of 10,679 inhabitants according to the ISTAC (acronym of the Canarian Statistics Institute in Spanish) in 2017, which for several decades has been characterized by the search for a sustainable growth model, favouring the conservation of its environmental wealth and the use of its own resources in the framework of development actions.

Also known as the Meridian Island, El Hierro rises 1,500 meters above sea level, which results in a unique landscape with steep slopes permanently hit by the wind. This is reflected in an annual average wind speed between 7.2 – 8.4 m/s and a maximum wind speed of 30.8 m/s.

El Hierro suffered from a double isolation due to its small size, low level of economic development, and strong dependence on the primary sector. Also, the lack of natural resources like water (e.g., desalination plants consume more than 45% of the total energy of the island) historically caused dramatic periods of emigration, decreasing the number of inhabitants on the isle (specifically younger generations that had to emigrate to the other islands in the archipelago or to other countries). In this context, it maintained a total external dependence on energy supply. Until the wind pumped hydro power station entered into operation in 2014, the generation of electricity was based on fossil fuels (diesel) with the consequent environmental and economical costs.

The challenges addressed throughout the project “El Hierro 100% renewable energy island” are twofold: (1) gaining resilience and autonomy in energy supply while (2) becoming a sustainable island substituting fossil fuel-based energy by renewable energy sources.

2.4.2 El Hierro model

In this case, the model is aimed to simulate the temporal evolution of citizens’ opinions about the project to answer the following question: Which percentage of citizens will be in favor and which percentage will be against the expansion of the 100% renewable El Hierro project based on a given policy scenario? Therefore, the specific purpose of this model is to study the acceptability of the expansion of the Renewable El Hierro project, once the citizens have experienced the first phase of the project.

The model follows the general HUMAT architecture presented in Section 3 of Deliverable 7.2 (Antosz et al., 2019). The foundations of the El Hierro agent based model are described in detail in Deliverable 7.3 in Section 3 (Antosz et al., 2020).

The main entity (agent) of this model is the citizen, which has two behavioural alternatives: either to accept or to reject the expansion of the project. The model also includes several critical nodes that played a relevant role during the implementation of the El Hierro social innovation project: the Cabildo (city council), the political opposition parties, local media, Gorona del Viento (the company responsible for the running the "Wind-Pumped Hydro Power Station") and other associations (environmental associations, tourism sector, etc.).

Different quantitative and qualitative procedures were used to collect relevant information in order to feed the system with case-specific data: analysis of the newspaper library, interviews with the promoters of the project, etc. Furthermore, a survey was conducted in 2020 to collect data directly from citizens about their needs, trust in different key actors, and socio-demographic aspects. After the analysis of these data, 6 categories of citizens needs (and the importance they give to every need) were identified and included in the model:

- Energy independence
- Environmental quality needs
- Economic sustainability
- Island prestige,
- Participation needs, referring to the possibility of participating in city decisions, and
- Social needs, referring to belongingness, social safety, social status, etc.

The evolution of citizens is guided by the HUMAT model in order to obtain the maximum overall satisfaction in one of the behavioral alternatives based on the partial satisfaction of each group of needs. When a behavioural alternative has both pros and cons for a citizen, it communicates with other citizens in their social network to reduce its cognitive dissonance through signaling and inquiring[1]. These communication processes are carried out through the social networks of neighbors and friends. In this case, a high number of citizens stated that they were undecided in their position both with respect to the initial project (around 30%) and in their support for the expansion of the project (50%). For this reason, a modification was made to the HUMAT model. Although the agents continue to take a (binary) position for or against the project based on a threshold, a third internal state of indecision is introduced. This state influences their behavior when interacting in the social network: both in the inquiring and in the signaling processes (see Antosz et al., 2020, for details of these processes) as the agents tend to prioritize communication with other agents who are in the same state (in favor, undecided, or against).

Critical nodes can also communicate with citizens to influence their decision. Table 2.1 contains an example to show how this communication has been parameterized to be injected into the model: supporter or opponent indicates being for or against the social innovation; reach is the percentage of agents of the social network affected by the communication act; finally, some communications are made indirectly through other critical nodes and this is indicated in the column Secondary Critical Node. During the implementation of the El Hierro project, critical nodes exerted their influence on citizens for and against the project through various communicative acts that were extracted from document analysis and injected in the model. In this model, the communication strategies applied by the critical nodes are crucial to allow citizens to evolve and change their position.

[1] Pseudocode is available at Sections 4.3.3.5 and 4.3.3.7 in Deliverable 7.3 (Antosz et al., 2019)

The main timeline implemented covers the three stages of the project:

- 2002-2008, period in which the “100% renewable El Hierro” project was launched.
- 2009-2014, period in which the execution works were carried out in Gorona del Viento, and
- 2015-2020, period in which the project came into operation

Table 2.1 Example of communication acts of critical nodes.

Primary Critical Node	Behaviour	Starting Month	Starting Year	Ending Month	Ending Year	Frequency	Reach	Secondary Critical Node
Other Associations	opponent	10	2013	10	2013	1	0.2	Local Media
Gorona Viento	supporter	11	2013	11	2013	1	0.2	Local Media
Local Media	supporter	12	2013	12	2013	1	0.2	Local Media
Gorona Viento	supporter	12	2013	12	2013	1	0.1	Local Media
City Council	supporter	3	2014	3	2014	1	0.1	City Council
City Council	supporter	9	2014	9	2014	1	0.1	City Council
Political Opposition	opponent	12	2015	12	2015	1	0.3	Local Media

All the communicative acts and their orientation along the three stages of the project were analyzed and the following conclusions have been drawn:

1. In the first stage of the project (2002-2008), communications were mainly oriented to energy independence in the speech of the promoters, and are present in 50-60% of the communications. Moreover, the frequency of communications between promoters and citizens is very low (around 2 per year). For this reason, and for the sake of simplicity, the model begins its execution in 2006, covering all the communications made during the years 2002-2008 in the period 2006-2008

2. In the second stage of the project (2009-2014), the orientation of the messages from the promoters was focused on different aspects. Although energy independence continues to be present in 100% of the messages, other aspects are also present such as prestige (50%), environmental quality (25%), and economic sustainability (25%). During

this period, the frequency of messages launched by promoters also increases. The voices against (influencers, Ecologist association) guide their communication to criticize the messages on energy independence (they deny the official message of being able to be 100% renewable), participation (they attribute a lack of transparency) and environmental quality (they denounce the impact plant/wind energy).

3. In the third stage of the project (2015-2020), energy independence continues to be present in 100% of the promoters' messages. The presence of the other aspects is also increased: environmental quality (50-100% depending on the year), prestige (50-100% depending on the year), economic sustainability (50-100% depending on the year). It should be noted that in 2015, after the start-up of the plant, communications were not focused on economic sustainability, and that in 2017 communications were not oriented towards prestige. In this period, the frequency of communications from one of the main promoters (Gorona del Viento) increases and, in addition, direct activities are carried out, such as the distribution of led bulbs, visits to the plant, etc.

The interface of the model is presented in Figure 2.6. In the center, the map of El Hierro island is shown with citizen agents placed in their corresponding census section, those in favor of the social innovation coloured in green and those against in red. As mentioned, in this case, the model also deals with undecided citizens that are represented with blue color. As the model evolves, and citizen agents change their position towards the El Hierro project, their color is appropriately varied.

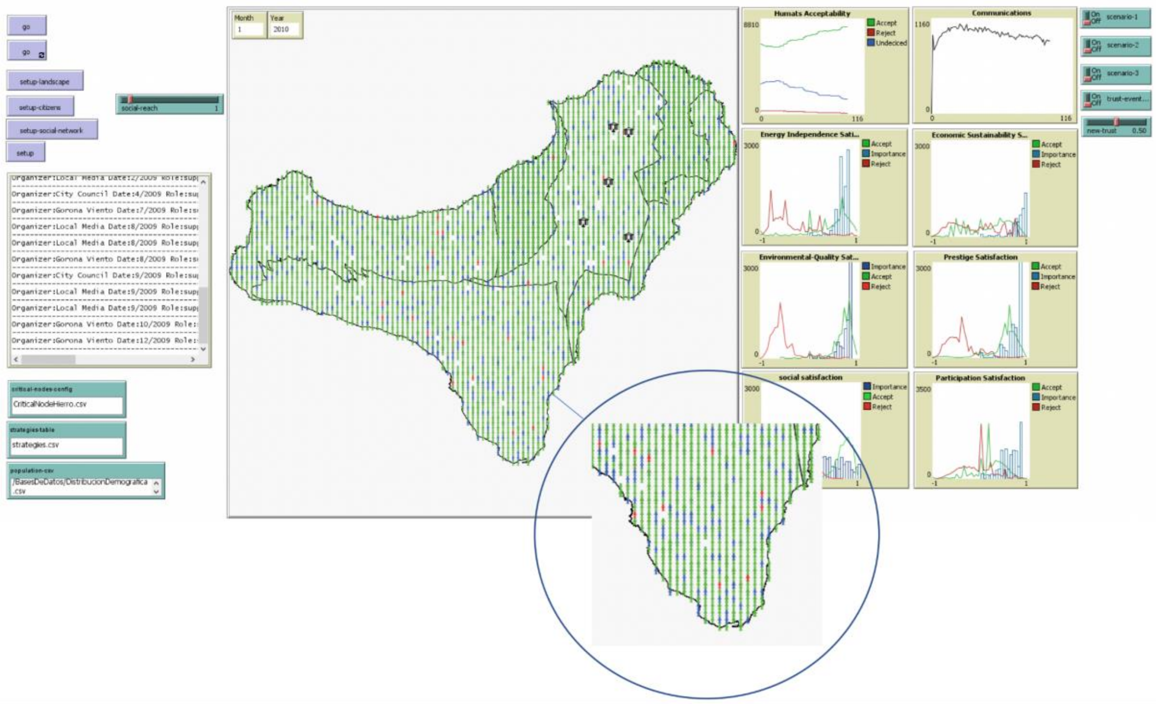


Figure 2.6. Interface of the model for the El Hierro social innovation case.

On the left side, in addition to configuration options, a text box is displayed showing information about the communication acts being launched by a critical node. On the right side, there are 8 graphics. The one in the upper left side shows the evolution of agents accepting (green), undecided (blue) or rejecting (red) the social innovation (see Figure 2.6 for details). The one in the upper right side shows the number of agents being communicating. The remaining graphs (see Figure 2.7 for a graph in detail) show data for every one of the six specific needs: the satisfaction achieved on that need for the agents accepting or rejecting the social innovation (using the same color pattern) and the importance of the need (histogram in blue).

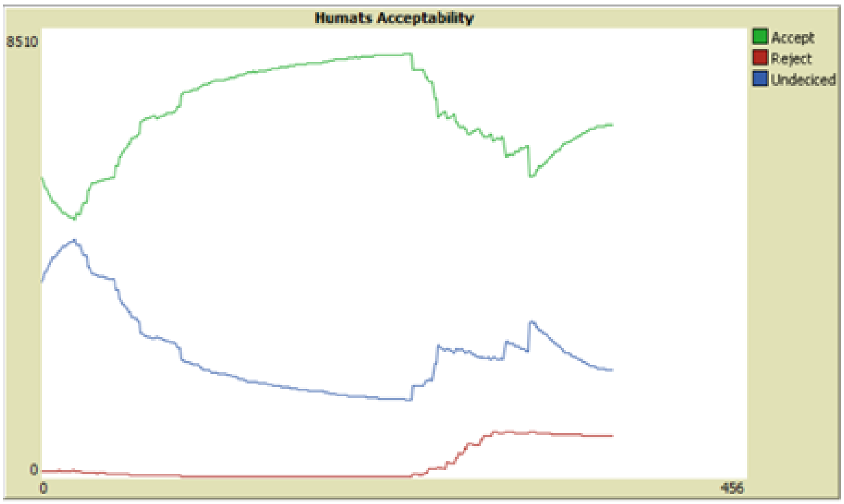


Figure 2.7. Graph of the evolutions of the global acceptance (green), undecided (blue) or rejection (red) levels of the project among the population of agents. The curves correspond to the basic timeline of the project, through years 2006 to 2021 (equivalent to 370 ticks of model run)

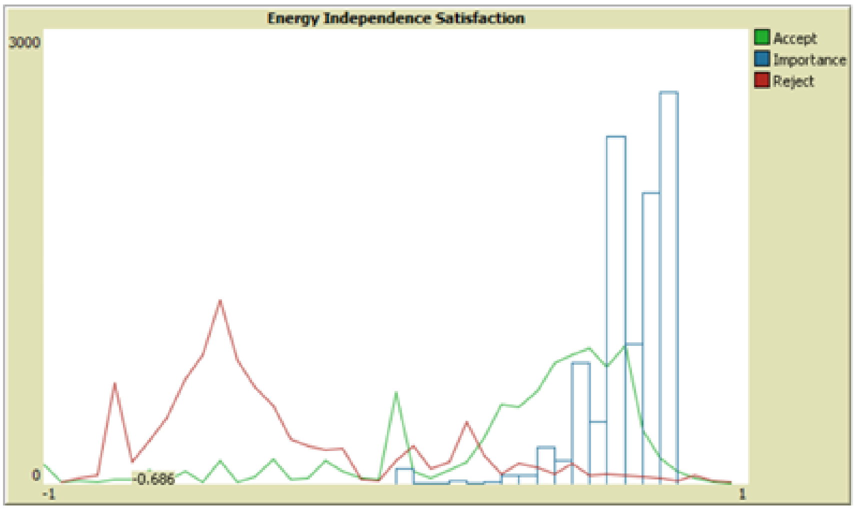


Figure 2.8. Graph of the evolution of global levels of satisfaction in one of the needs produced by the acceptance (green) or rejection (red) of the El Hierro project. The histogram (blue) refers to the importance of that need in the population of agents.

As stated in Deliverable 7.3 (Antosz et al., 2020), to reproduce the population of El Hierro in the model, first, the data from the questionnaires was used to directly feed data for the citizen agents. This gave us a total of 373 citizen agents (as many as questionnaires) that were replicated proportionally according to census and to the main population categories identified by using Decision Trees as relevant for the citizens to be in favour/against/undecided about the project (see Figure 2.8). Note that although more than a dozen socio-demographic variables were used to derive the decision tree, only 3 seem relevant for adopting a decision about the social innovation project: educational level, employment status, and gender. Finally, 9542 adult inhabitants were modelled for the island. The exact procedure is described in (Alonso-Betanzos et al., 2021).

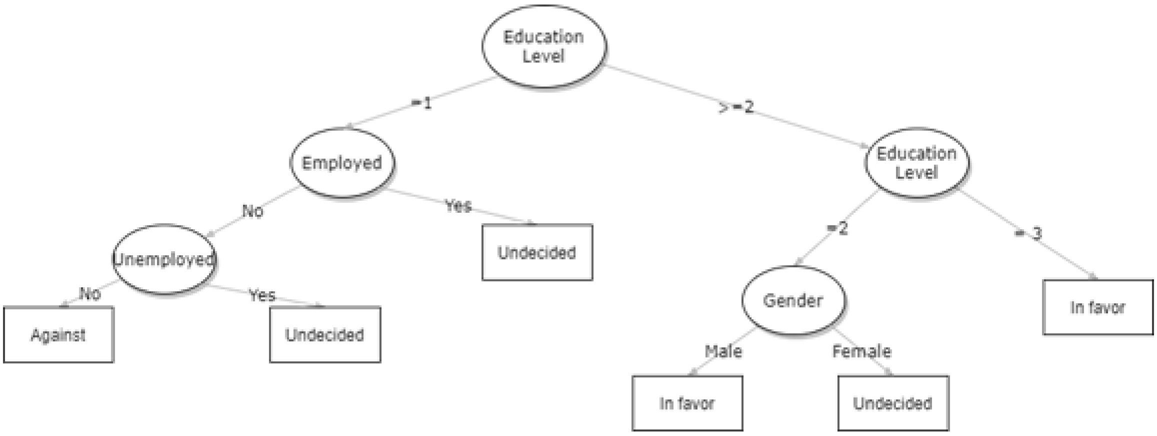


Figure 2.8. Population categories identified as relevant for the acceptance or rejection of the El Hierro project

2.4.2 El Hierro main model results and sensitivity analyses

The model has several parameters as listed in Deliverable 7.3 (Antosz et al., 2020). In the interest of model simplicity and to make it easier to use, the values of many of them have been derived by applying theoretical knowledge, some others underwent a sensitivity analysis and a calibration process in order to faithfully reproduce the basic timeline.

As mentioned, in this model, the citizens can be in one of three states of opinion: acceptance, rejection, or undecided. The sensitivity analysis was carried out to determine the impact of the threshold value on the model which determines whether the difference between the satisfaction provided by acceptance and that provided by rejection is large enough to consider that agents are not in an undecided state. This seems to be the most decisive parameter. Table 2.2 shows the mean results achieved after 100 runs for different threshold values. As can be appreciated, the best acceptability results are achieved when the threshold is low, showing a high sensitivity of the model to small changes in this parameter. After calibration, the value of 0.15 for this parameter was determined as the most appropriate to reproduce the case.

Table 2.2. Mean and Standard Deviation (over 100 different runs) of the number of agents that accepting, rejecting or undecided about the El Hierro 100% renewable project when varying the threshold used to determine the state of an agent.

	In favour		Against		Undecided	
Threshold	**Mean (%)**	**SD**	**Mean (%)**	**SD**	**Mean (%)**	**SD**
0.05	79.70	1.47	13.58	1.03	6.72	0.88
0.1	73.44	1.92	11.46	0.95	15.10	1.5
0.15	51.16	3.73	10.02	0.72	38.82	3.63
0.2	21.11	2.32	8.34	0.8	70.54	2.64
0.25	8.45	1.18	6.81	0.69	84.74	1.36

To calibrate the model, not only field data from the case of El Hierro has been used (surveys, in-depth interviews with key informants, press releases, local media analysis), but also some relevant items that emerged in discussion with promoters and the stakeholders during the policy scenario workshops (as described in Dumitru et al., 2021a). During these workshops, the results of the simulated timeline were presented in order to ensure that the real process was faithfully reproduced (validation through experts). One issue addressed was that, in the documentary analysis carried out of the entire timeline of the "El Hierro 100% renewable" project, hardly any opposition to it was detected. Furthermore, some bias of the survey results towards acceptability is suspected. All this means that, in the model, the agents lean in a very high percentage towards the acceptance of the project, which does not seem to correspond with reality. Nevertheless, in the discussion, some facts that generated the discontent of the population during the project implementation process came to light (not previously reflected in the documentary analysis), which were incorporated into the model, as it will be described in Scenario 2.

Once calibrated, the model was evaluated positively by the case researchers as it was able to correctly reproduce the pattern of acceptability as it was documented for the scenario representing the history of the case.

In this section, we show the results over this main timeline, taking into account that our desired outcome is to see how the number of agents accepting the social innovation project of El Hierro evolves.

Initially, the three stages of the project were implemented, however, as mentioned, in the first period, communicative acts are very scarce, especially during the first two years, and mostly in favor of the project. Therefore, the influence on the population is very little or not at all significant and there are no appreciable changes in the state of the model. For this reason, we have focused the playback of the timeline on years 2006-2008 of stage 1, and stages 2 and 3 as a whole.

Table 2.3 shows the results at the end of the timeline where it can be observed that the model ends in 2020 with a high percentage of the population undecided about the project, which is coherent with the data obtained with the surveys. Also, the blue curve in Figure 2.9 depicts the evolution of the number of agents accepting the social innovation from 2006 to 2020 showing that the model correctly reproduces the ground truth. As can be observed, a decrease in the acceptability started around 2016 that barely recovers at the end of the project in 2020. This circumstance coincides with the third stage of the project in which it was put into operation. As was explained by the stakeholders, the main reason for the public's disenchantment with the project was due to a misunderstanding since the majority of the population assumed that the project would lead to a reduction in the electricity bill.

Table 2.3. Mean percentage (and standard deviation, SD) of agents accepting, rejecting or undecided about the El Hierro project after running the model (average results of 100 runs).

Accept(%)	SD (%)	Reject(%)	SD (%)	Undecided	SD (%)
51.16	3.73	10.02	0.72	38.82	3.63

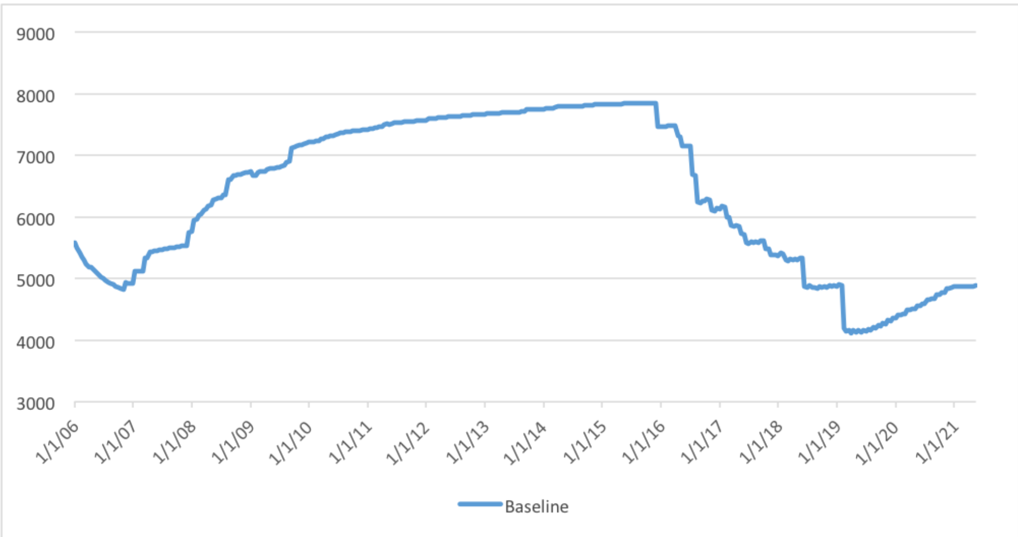


Figure 2.9. Evolution of the number of agents accepting the social innovation during the project's timeline from 2006 to 2021.

2.5 Policy scenario development for El Hierro case

During the workshops with stakeholders, several possible alternative scenarios were discussed among which, finally, they selected those for which it was possible to obtain all the necessary information to enter them into the simulation. Specifically, these were the considered scenarios, all of them devoted to investigate different policies to be applied in order to increase the acceptability of the project:

SCENARIO 1: Improve the dissemination strategy addressing specific social and experiential needs
A) Include **new communications** by the main promoter: focus on the dimension of **economic sustainability** B) Include **new communications** by the main promoter: focus on **economic sustainability, prestige and environmental quality**
SCENARIO 2: Increasing the island's prestige through a renewable energies event"
A) Creation of a new event focused on satisficing the needs of **prestige and economic sustainability** B) Repetition of this annual event for a three year period
SCENARIO 3: Enhancing citizenry participation in the island's energy renewable policies
A) Promote **meetings between cabildo and citizens** in census sections **in four significant periods** of the project B) **Meetings between cabildo and citizens** in census sections **during the whole project** with intensification of meetings in the **definition part of the project**
SCENARIO 4: Improve the dissemination strategy addressing economic sustainability and enhancing citizenry participation
Include communications focus on the dimension of **economic sustainability** and promote participatory meetings between citizens

All the simulated scenarios start from the original timeline of the project already presented and include new communication strategies from different critical nodes aiming at overcoming the conflictive situations. Analogously to the initial situation, 100 simulations have been carried out for all scenarios and the average results will be shown.

2.5.1 Scenario 1: Improve the dissemination of the project by promoters and focus it on specific social and experiential needs.

This scenario was already proposed in the 1st workshop with the stakeholders, who insisted on the need to improve the communication that the main promoter of the project (Gorona del Viento) made about it with the aim of "ensuring that the citizens perceive the project's benefit, as this is the most effective in terms of their acceptance ". The idea is to counteract the negative perception derived from a lack of direct communication between the promoters of the project and the citizens, due to which they misinterpreted that the Gorona plant was going to reduce their electricity bill. As a consequence, a high degree of mistrust was generated in the project when citizens did not receive any direct economic benefit.

The participant's perception matches the survey results, as the factor that most influences the decision of the citizens to vote in favor or against the project was its economical sustainability, followed by prestige, which is directly related (as the increasing in prestige of the island has a consequence in the number of visitors, tourists and economical income of residents). So, the idea with this scenario is to test the efficacy of new strategic communication policies to enhance how specific social and experiential needs that are relevant for people are addressed by the El Hierro project.

Two different situations (1.A and 1.B) were tested in scenario 1, for which the frequency of communicative actions from promoters is increased, specially in the 2014-2020 period, when a loss of support from citizenship to the project is identified. The difference among both situations is the focus of these communications:

- Scenario 1A: The focus is only economical sustainability
- Scenario 1B: The focus is economical sustainability, prestige and environmental quality, which are the three most relevant needs for inhabitants of El Hierro, according to the survey.

The specific details of how these two communications strategies were injected into the system are shown in Table 2.4. The communications column pinpoints how many communications are done and the direct/indirect term indicates if the communication is directly made by its promoter or local media are used instead (indirect). This is relevant as the reach, the percentage of potencial people affected by the campaign, will be that of the final sender, that is, if the Cabildo emits an indirect communication using local media, the reach will be the established percentage of the local media's social network.

Table 2.4. New communications in Scenario 1.

Sender	Communications (direct /indirect)	Reach (% social network)	Period
Gorona del Viento	42 (0/42)	high (30)	2014-2020 (1 communication every 2 months)
Cabildo de El Hierro	42(0/42)	low(10)	2014-2020 (1 communication every 2 months)

Table 2.5 illustrates the results of this Scenario. For the sake of comparison, the first row shows the base result obtained with the original timeline. Comparing with the original situation there is a notable increase in the number of agents accepting the innovation (from 51% to 71% in the best of the cases), mainly due to a notable decrease in the number of undecided (up to 19%), although there is also a slight decrement in the number of agents rejecting the social innovation (around 1%). This recovery of people's confidence in the project is also reflected in the acceptability curves in Figure 2.9, in which the basic timeline has also been included.

Table 2.5. Mean percentage (and standard deviation, SD) of agents accepting, rejecting or undecided about the El Hierro project after running the model (average results of 100 runs).

Scenario	Accept(%)	SD (%)	Reject(%)	SD (%)	Undecided	SD (%)
Base	51.16	3.73	10.02	0.72	38.82	3.63
1A	64.48	2.48	9.28	0.85	26.04	2.17
1B	71.45	2.28	8.91	0.79	19.64	1.80

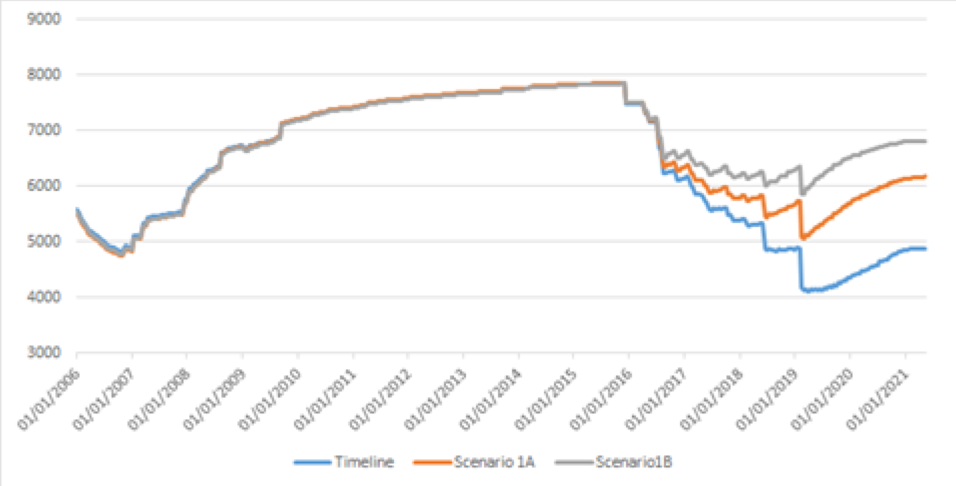


Figure 2.6. Evolution of the number of agents accepting the social innovation from 2006 to 2021. Comparison between the basic Timeline and scenarios 1A and 1B

2.5.2 Scenario 2: Increasing the island's prestige through a renewable energies event

This scenario is also based on a proposal during the 1st workshop, and it is focused on promoting a divulgative event in the island, a "renewable energy fair" in January, 2015. The fair would be organized by Gorona del Viento and is a relevant showcase that contributes to enhancing the reputation of El Hierro as a sustainable island, with an added economical benefit. The fair in January 2015 is a strategy to counteract the negative effect that the opening of the plant in June 2014 had and, in particular, an article published in the local press by two former engineers from Gorona del Viento. Although this article is from 2014, it had its greatest impact in 2016 when the press echoed it publishing several other highly critical articles. This corresponds with the tipping point with respect to the plant's perception by the citizenship shown by the model (see base timeline in Figure 2.7). From that moment on, the acceptability of the project descends. This scenario was implemented in two versions:

- Scenario 2A: Organization of 1 fair in January 2015 focused on the prestige and economic sustainability
- Scenario 2B: This scenario aims to test the effectiveness of repeating this type of fair events in the following years, with a duration of 3 years. The effectiveness will depend on whether or not influence on social acceptance is achieved.

It is assumed that the realization of a fair entails an explosion of communicative events in the press, between the assistants, between assistants and organizers. In the model, first, this translated into an exchange of views on social innovation among the HUMATS over a period of 3 months, i.e. the frequency of communications between agents increases during 3 months after the fair. In addition, the promoter of the fair launches a specific communication campaign accompanying the fair focused on the needs of prestige, economical sustainability, and environmental quality (the three most relevant according to the survey). Finally, a number of certain communicative events from the press and the Cabildo (reinforcing Gorona´s message, as usual in El Hierro) that are a consequence of the fair were also implemented. The specific details of how these communicative events were implemented in the system for simulations of Scenario 2A are shown in Table 2.6, note that for scenario 2B the communicative acts will be repeated three times, that is once a year during three consecutive years.

Table 2.6. New communications in Scenario 2A.

Sender	Communications (direct /indirect)	Reach (% social network)	Period
Gorona del Viento	6 (0/6)	high (30)	2 before the fair (one month each), 3 in January during the fair and 1 in February after the fair
City Council (Cabildo)	6 (0/6)	low (10)	2 before, 3 during and 1 after the fair
Local media	3 (3/0)	high (30)	1 before, 1 during and 1 after the fair

Table 2.7 shows the results of the simulations obtained in this case. Similar to the previous scenario, this one also significantly increases the acceptability in the social innovation (more than 16%) when compared to the original situation, although it does not reach levels as high as scenario 1. Again, this difference is due to a relevant percentage of undecided agents who are convinced by the actions and change to accept the social innovation in this scenario. Figure 2.7 shows the evolution of the level of acceptability. It is important to note that, although during the first years there is almost no difference between Scenarios 2A and 2B, at the end Scenario 2B achieves better results than 2A, which emphasizes the importance of holding communicative acts for a longer time.

Table 2.7. Mean percentage (and standard deviation, SD) of agents accepting, rejecting or undecided about the El Hierro project after running the model (average results of 100 runs).

Scenario	Accept(%)	SD (%)	Reject(%)	SD (%)	Undecided	SD (%)
Base	51.16	3.73	10.02	0.72	38.82	3.63
2A	54.47	3.59	9,82	0.87	35.71	3.43
2B	68.97	2.41	8.76	0.72	22.27	2.08

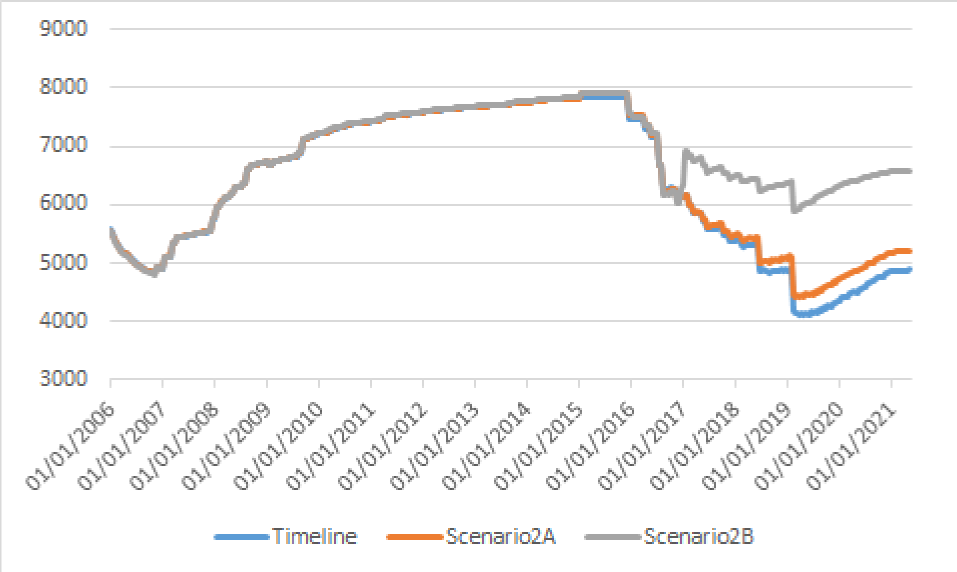


Figure 2.7. Evolution of the number of agents accepting the social innovation from 2006 to 2021. Comparison between the basic Timeline and scenarios 2A and 2B

2.5.3 Scenario 3: Enhancing citizenry participation in the island's energy renewable policies

This was a controversial proposal at the 2nd workshop. On the one hand, some participants recognized that at one point the Cabildo stopped (perhaps improperly) from actively informing residents about the evolution of the plant, especially when the money had already been obtained and the works were underway. On the other hand, some stakeholders mentioned that they intentionally avoided this type of action, considering that they would anticipate social unrest. Finally, it was concluded that modeling this scenario could be very interesting and one-day face to face meetings between the Cabildo and citizens in Census sections were simulated in the model. In this scenario, we have implemented what we called guided meetings. This type of meetings include a "trigger", which starts a conversational process, which is an act of communication from a critical node. As a consequence, it increases the number of random and spontaneous conversations between citizens. Specifically, each of the citizens that belong to a given census section will have a probability of 0.05% of communicating with others in the same census section. Note that we are mentioning a percentage for *each* citizen thus, in a census section with 100 inhabitants, each neighbor could talk to five of his/her neighbors, which significantly increases the total number of communications. The probability of having these conversations will progressively decrease (by default 20% each 15 days, although some scenarios could vary it), and so after three months the conversations will resume their usual course.

Again, the scenario was implemented in two versions:

- Scenario 3A. Promote guided meetings by the Cabildo to present the project in its different phases. These meetings will also facilitate communication between citizens. Given that this scenario was initially ruled out by the promoters for anticipating social unrest, it might be of interest for them to know what would have happened if these meetings had been promoted in relevant stages of the project. Specifically, these meetings will be implemented in the four following time points:
    1. January 2007, previous to the construction of the hydroeolic plant. Goal: to present the project.
    2. April 2014, period previous to the opening of the hydroeolic plant. Goal: to inform of the future functioning of the Gorona del Viento project and its benefits.
    3. January 2015, period after the start-up of the plant. Goal: to counteract criticism of the project management and its poor communication.
    4. June 2018, in which Gorona obtains revenues. Goal: to explain how are they distributed in the island.

- Scenario 3B. Similar to Scenario 3A but adding an intensification of the meetings at the beginning of the project in order to enhance the participatory strategy and promote a shared vision on the energy transition of El Hierro, as well as the appropriation of the project "El Hierro 100% renewable" by the citizens of the island. In addition, in this scenario, the idea is to reach almost all the inhabitants of the island through these meetings, which is why, unlike scenario 3A, they are organized periodically throughout the duration of the project, monthly during the most relevant stages and every 6 months during its development. Specifically, there are two relevant years (2009 and 2014, beginning and end of the construction of the plant, respectively) in which communications were made monthly throughout the year. In addition, in the previous, intermediate and subsequent years (that is, 2006-2008, 2010-2013 and 2015-2017) semi-annual meetings are held. Finally, once Gorona has some revenues (years 2018 and 2019), communication acts are held every summer month (June, July and August) to collect the opinion of citizens on how to invest the revenues on the island.

Some specific details of the communications for these two scenarios are shown in Table 2.8.

Table 2.8. Communications performed during relevant periods for Scenarios 3A and 3B

	Sender	Communications (direct /indirect)	Reach (% social network)	Period
SCENARIO 3A	City Council (Cabildo)	4 (4/0)	high (30)	2007-2018, one at each relevant point
SCENARIO 3B	City Council (Cabildo)	24 (24/0)	high (30)	monthly during 2009 and 2014
.	City Council (Cabildo)	20(20/0)	high (30)	2006-2008, 2010-2013, 2015-2017 semiannually
	City Council (Cabildo)	6(6/0)	high (30)	2018-2019 (monthly during June, July, August)

Figure 2.8 shows the large increase in citizen agents communicating (both in favor and against the social innovation) at the specified times (note that in a normal situation there are around 1000 agents communicating). This communicative overload considerably affects acceptability, as it can be seen both in Table 2.9 and Figure 2.9. The former shows the number of agents accepting the innovation and, similarly, the latter displays agents accepting the social innovation in the execution of scenarios 3A and 3B compared to the period of the basic timeline. Both table and figure reveal the same conclusion, scenario 3B clearly leads to more agents accepting the project, resulting in the idea that providing more information to the public and allowing citizens to participate will result not only in better acceptance at the end of the project, but also in less controversy during its development.

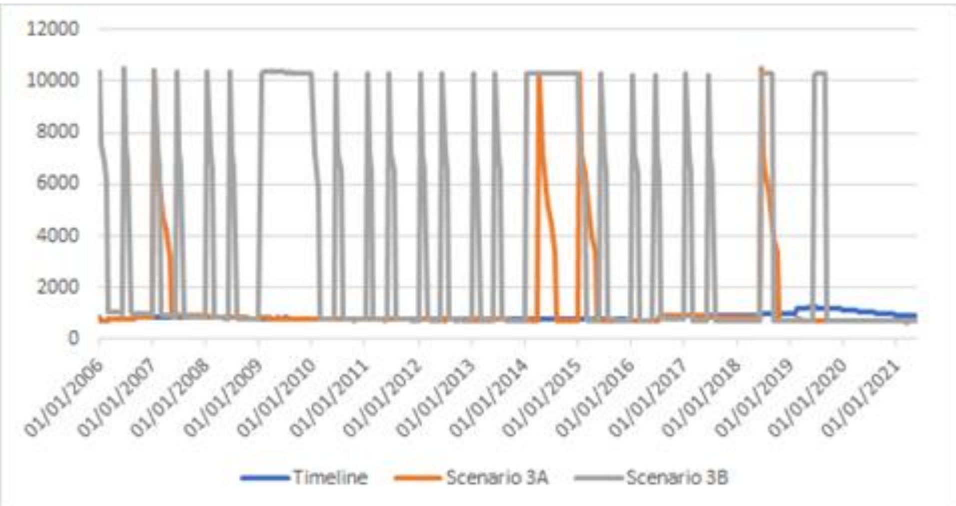


Figure 2.8. Scenario 3: Mean number of citizen agents communicating (average of 100 runs). X axis represents the temporal line, whereas Y axis indicates the number of agents.

Table 2.9. Mean percentage (and standard deviation, SD) of agents accepting, rejecting or undecided about the El Hierro project after running the model (average results of 100 runs).

Scenario	Accept(%)	SD (%)	Reject(%)	SD (%)	Undecided	SD (%)
Base	51.16	3.73	10.02	0.72	38.82	3.63
3A	62.40	2.38	9,88	0.76	27.72	2.13
3B	71.24	2.88	9.24	0.88	19.52	2.39

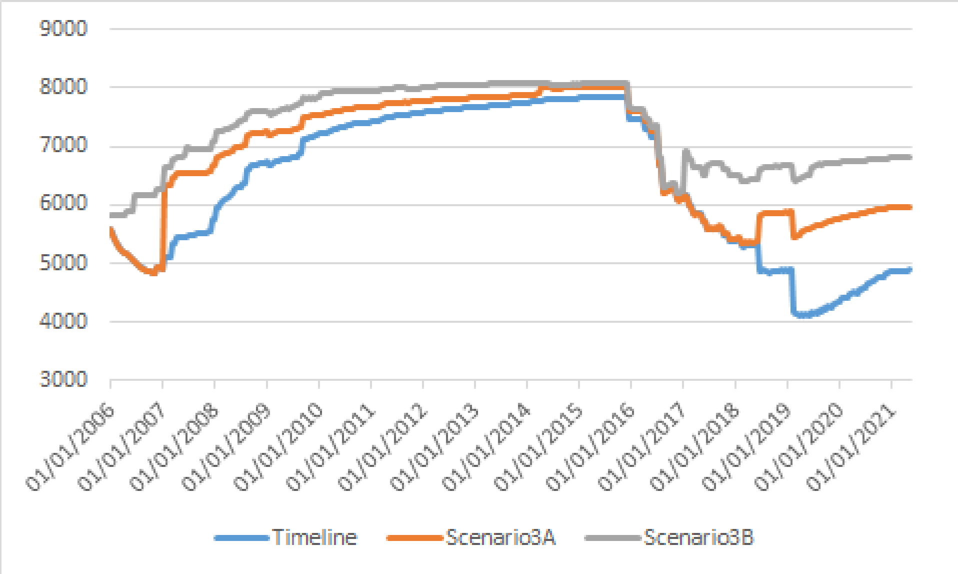


Figure 2.9. Evolution of the number of agents accepting the social innovation from 2006 to 2021. Comparison between the basic Timeline and scenarios 3A and 3B

2.5.4 Scenario 4: Improve the dissemination strategy addressing economic sustainability and enhancing citizenry participation

This scenario is inspired by an alternative proposed by some participants in the first and second policy workshop in El Hierro. It tries to address the need for the citizens of El Hierro to identify with the project, that it be something of their own and not only of the government. The workshops proposed the possibility of developing “participatory budgets” from the Cabildo, allowing the islanders to decide on the distribution of Gorona's revenues. In this sense, the scenario is proposed as a pilot project for the years 2018-2019 (before there were no revenues, and in 2020 the pandemic did not allow the call for social actions) consisting of two different measures: a) a communication campaign from the Cabildo focused on the needs of economic sustainability and participation, and b) to promote participatory meetings between citizens of each census area. Both measures would have repercussions in the local media. Details of these communications are shown in Table 2.10.

Regarding "participatory meetings", it has the same characteristics as "guided meetings" (explained in section 2.5.3) but the trigger is only temporal and not determined by an action from a critical node.

Table 2.10. New communications in Scenario 4.

Sender	Communications (direct /indirect)	Reach (% social network)	Period
City Council (Cabildo)	6(0/6)	high(0.3)	2018- 2019 (monthly during April, May and June)
Local Media	4(4/0)	high(0.3)	2018- 2019 (monthly during May and June)

Table 2.11 and Figure 2.10 indicate the results achieved by this scenario. It can be observed that the number of citizens accepting the social innovation increases (up to 13%) mainly due to the descent of undecided citizens. The results are very similar to those of Scenario 1A where the focus was also the need of economical sustainability but with a much higher number of communications by the Cabildo (see Table 2.5) and less communication between citizens (lack of participatory meetings) that denotes the great impact on the acceptability of the social innovation that these participatory meetings have.

Table 2.11. Mean percentage (and standard deviation, SD) of agents accepting, rejecting or undecided about the El Hierro project after running the model (average results of 100 runs).

Scenario	Accept(%)	SD (%)	Reject(%)	SD (%)	Undecided	SD (%)
Base	51.16	3.73	10.02	0.72	38.82	3.63
4	64.54	1.94	9.77	0.77	25.69	1.51

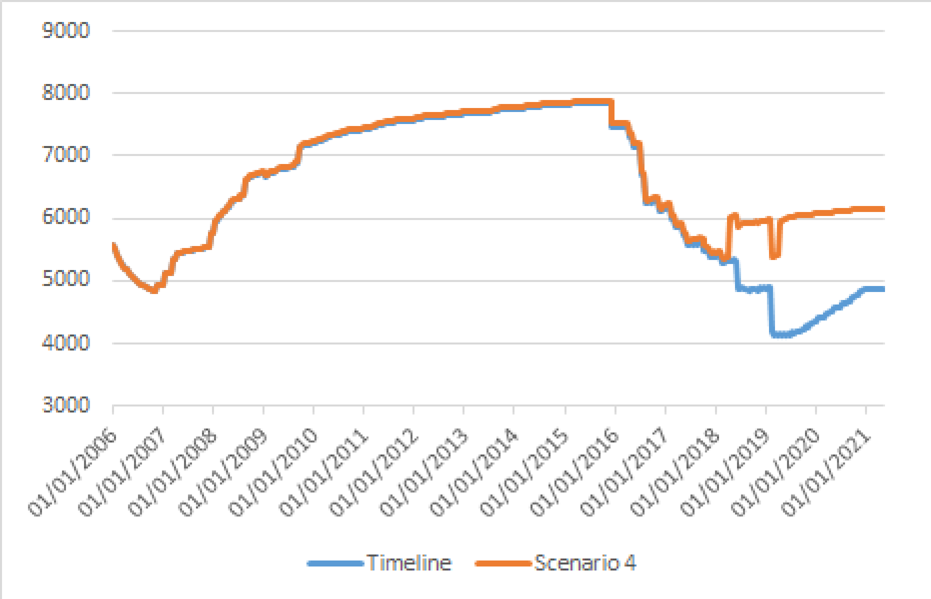


Figure 2.10. Evolution of the number of agents accepting the social innovation from 2006 to 2021. Comparison between the basic Timeline and scenario 4.

2.6 Conclusions and discussion for El Hierro case

The first general conclusion that can be drawn from the model concerns the factors that influence citizen acceptability towards the renewable energy project implemented in El Hierro. Public response towards the different alternative policies (in terms of acceptability of the social innovation) is determined by citizens' level of trust in different institutions and personal relationships, as well as by the importance they give to the satisfaction of social and psychological needs (e.g., prestige, energy independence, participation, economic sustainability, and environmental quality). The model recreates the communication processes in the baseline scenario at different stages in the development of the project, which result in current levels of public acceptability towards the expansion of the social innovation. As confirmed by the survey results, only 50% of respondents would vote in favour of expanding the social innovation, while 10% of respondents would vote against and 40% report being undecided. Consequently, the model simulates changes in citizens' support towards the social innovation as a result of the implementation of a series of alternative policy scenarios.

The first set of scenarios were implemented in the agent-based model as simulations of new communication strategies, launched by the promoters, addressing specific social and experiential needs. Thus, Scenario 1 consisted of a communication strategy developed in the period 2014-2020 (when a significant loss of citizen support for the project was identified). Two sub-scenarios were simulated: in Scenario 1A, the communication strategy targeted citizens´ concern for economic sustainability and Scenario 1B targeted the needs for economic sustainability, prestige and environmental quality together, the three most important needs for residents according to the research conducted in SMARTEES.

Scenario 2 consisted of testing the impact of a dissemination event (the "renewable energy fair") at the beginning of 2015, as a strategy to counteract the negative effect of a critical opinion piece published in the local newspaper, authored by two ex-engineers of Gorona del Viento in 2014, which was identified as a key moment in the development of the social innovation project. This scenario is implemented in the model through a communication campaign addressing the needs for prestige, economic sustainability, and environmental quality. Two sub-scenarios were developed: Scenario 2A implements the communication campaign only in 2015 while Scenario 2B tests the effect of maintaining the same policy for a duration of 3 years.

As the results of the model show in both scenarios 1 and 2, if a targeted communication strategy is launched addressing islanders' main social and experiential needs and concerns, citizens become more willing to endorse the project and vote for its expansion. If only the need for economic sustainability is addressed, the model shows that support towards the energy project rises to 64.6% (Scenario 1A), as compared to 51,1% in the baseline scenario. Moreover, when the alternative policy focuses on three different relevant needs together – economic sustainability, prestige and environmental quality (Scenario 1B), the rate of citizens voting in favour of the expansion of the energy project increases to 71.45% (↑21,3), as compared to the baseline scenario.

The results of Scenarios 1 and 2 point to that policy strategies that focus on the fulfilment of the different social, psychological and experiential needs are very promising, especially when they are maintained over long periods of time, helping people to realize the benefits of the project and to counteract negative or sceptical discourses from part of the population. For example, as can be observed when Scenario 2A and 2B are compared, if an event such as the "renewable energy fair" policy is organized just once, public support increases only by 3,3%. However, if the same policy is developed for 3 years, citizens' support for the social innovation increases up to 69% (↑18). These results confirm that discourses related to economic development strongly influence public acceptance but, interestingly, reputation and prestige appear to be key factors influencing citizens' acceptability of project expansion.

Scenarios 3 and 4 test the impact of enhanced participatory approaches, which stimulate citizens´ involvement across all stages of project development. Scenario 3 was implemented in the model through the simulation of a participatory strategy that consisted of face-to-face meetings organized by the local government with citizens. While Scenario 3A tests the effects of this policy in four specific stages (one meeting in each neighbourhood in 2007 projects' kick-off; in 2014, 2015 and 2018 – all identified as critical moments in case development), scenario

3B tests the effect of this strategy across the lifespan of the project (2006-2021) organized monthly during the most significant stages (2009, 2014 – all year; a three-month period in 2018 and 2019 when discussing the distribution of revenues) and every six months in the other, less critical stages. The results of scenario 3 confirm that participatory processes displayed for a long period of time, addressing the need for citizens to participate and feel they have the capacity to influence policies that affect them, are extremely effective. According to scenario 3A, support towards the energy project is raised to 62,4% (↑11,3). Furthermore, as scenario 3B shows, when participatory approaches are largely displayed, although the level of intensity varies in different stages as explained above, support rises up to 71.24% (↑21,1), compared to the baseline scenario.

Interestingly, scenario 4 shows that pilot participatory strategies, displayed during a shorter period of only two years, can also become effective in terms of social acceptability. Thus, Scenario 4 tests the effect of a pilot participatory budget experience launched by the island government for the period 2018-2019 aiming at involving the islanders in decision-making on the investment of the revenues from the exploitation of Gorona del Viento. This policy is implemented in the model by combining a communication campaign initiated by the island government, focused on the needs for economic sustainability and the opportunities for participation, and participatory events with citizens in all localities on the island. The results of Scenario 4 show that this policy is also highly successful as the rate of people voting in favour of the expansion of the social innovation increases up to 64,54% (↑13,3), compared to the baseline scenario. Consistent with all the alternative scenarios modelled in El Hierro, the role of media becomes relevant for the dissemination of the different campaigns, as it serves to reach wide audiences.

One alternative scenario to explore further would involve testing the impact of awareness-raising campaigns oriented to increase the importance citizens assign to issues of energy self-sufficiency and environmental quality, considering the ongoing achievements in terms of renewable energy production on the island and the future projects for increasing citizen's self-consumption capacity through solar panels in households and enterprises. Thus, it could also be interesting to explore the impact of these educational approaches if a variety of actors are involved as promoters or supporters.

2.7 'Follower' case: Western Isles of Scotland

The Western Isles is a 120-mile-long archipelago located 30 miles off the North West coast of Scotland with a population of about 29,000. Currently, the islands receive two independent electricity supplies (North Island Group/ South Island Group). Peak electricity demand across the Western Isles is circa 30MW but the existing supply is constrained to 22MW in its subsea sections. Top-up generation in times of peak demand is supplied by on-island diesel generation. Fuel Poverty rates are rampant in the Western Isles owing to a dependence on high-cost imported energy, low incomes and high levels of climatic exposure (which defy many conventional Energy Efficiency solutions for homes).

Following discussions with the contact in the Western Isles Council, we are proposing to use the follower case in this location to focus on the Isles of South Uist, North Uist and Benbecula, with a view to contributing insights towards their development of local energy plans. The modelling will be concentrated on questions of how incentives can be used to facilitate the transition to sustainable energy use. There are links with cluster five in that the models need to be able to show the alleviation of fuel poverty too. This leads to a further research question pertaining to the degree to which existing models can be adapted and repurposed to look at a new case study. With outcomes from assessing options for developing the policy sandbox tool beyond the end of the project suggesting clients are likely to prefer cheaper solutions, the repurposing question has ramifications for the project as a whole, and we propose, subject to the agreement of all parties, to explore and evaluate what can be achieved with a limited budget.

3. Case cluster 3: Sustainable district regeneration

3.1 Overview

The sustainable district regeneration case study cluster has Stockholm and Malmö as its focal points. These are historical case study clusters in the sense that, while there may be on-going social issues still to be explored, the specific social innovations studied pertain to activities that primarily occurred in the past. In Stockholm, the case study has focused on a project to upgrade housing in the Järva area, to the north of the city, and this has formed the prime focus of modelling. The Sustainable Järva project ran from 2010-2014, and entailed the retrofitting of seven residential buildings originally constructed between 1965 and 1975 as part of Sweden's 'million homes programme', with a view to achieving a 50% reduction in energy demand. Following this pilot, Svenska Bostäder has been commissioned to refurbish 5,200 apartments in the period to 2022 (Enarsson, n. d.). In Malmö, the Ekostaden Augustenborg programme,[2] which started in 1998, has the aim of making the Augustenborg region of the city more socially, economically and environmentally sustainable, enabling residents to take a leading role in designing and implementing the project. Figure 3.1 shows a screengrab of the model developed to explore the sustainable district regeneration case study cluster. The model is named 'wolverine' because, without the umlaut, 'jarva' is Swedish for wolverine.

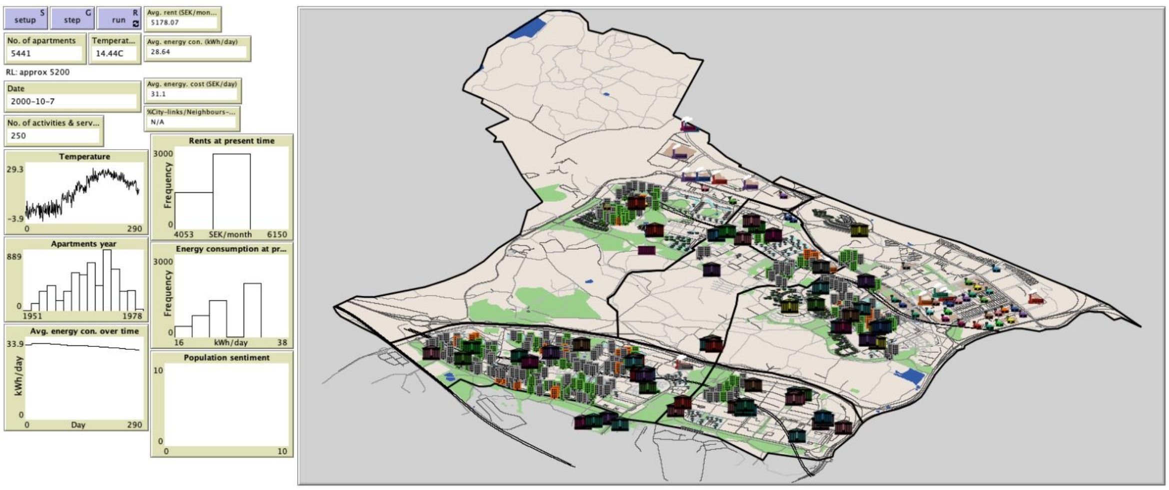


Figure 3.1: Screen grab of wolverine's user interface showing a map of the Järva area of Stockholm. Apartment buildings are coloured according to their renovation status (grey – not renovated; orange – renovation in progress; green – renovated), and though they are based on real location data, they do not reflect the living conditions or personal data of any living household.

[2] https://malmo.se/Sa-arbetar-vi-med.../Hallbar-utveckling/In-English---Sustainable-Malmo/Sustainable-Urban-Development/Augustenborg-Eco-City.html

3.2 Policy scenario development

As per the SMARTEES schedule, three policy workshops have been held, and these have been documented in detail in other project deliverables. There have also been protracted discussions between the various individuals with main responsibility for modelling the Stockholm case study in SMARTEES (at The James Hutton Institute), and the research team at NTNU and stakeholders in Stockholm, to discuss options. The representational structure of the interventions has been agreed with the stakeholders for preparing the simulations, the idea being to explore how different interventions lead to different outcomes. This synthetic approach is necessitated in part because the nature of these case studies is such that gathering further data for SMARTEES was precluded by the fact that they have been studied a lot already in earlier projects, while GDPR and ethical constraints mean those data cannot be reused here.

3.3 Experimentation with a policy scenario

In an initial experiment exploring policy, we examine the effect of increasing the probability that a building will be renovated on the distribution of energy consumption by apartments, under stylistic assumptions. Each day in the model, a probability p-renovate determines whether a building containing apartments that has not so far been renovated is selected for renovation. We then measure the mean and standard deviation energy consumption of the whole population of apartments in the model.

The results are shown in figure 3.2. These take the form of contour plots, with contours showing the mean (left) and standard deviation (right) in the energy consumption for different values of p-renovate (on the y-axis) at different time steps during the model (on the x-axis, which covers a period of approximately ten years with one day per step). As should be expected, the mean energy consumption clearly decreases with higher-probability of renovation. The mean energy consumption also increases over time, as decaying building infrastructure means poorer heating efficiency.

Standard deviation is a measure of social inequality, and from the right hand side of figure 3.2, we see higher levels of inequality emerging later in the model for lower renovation probabilities, especially around 0.1. Above p-renovate = 0.2, the inequality is consistently lower, especially later on in the run. These results suggest that building renovation can have knock-on effects on inequality. A slower renovation schedule will create a longer period of time in which there is disparity in the energy consumption in apartments. This could be indirectly discriminatory if people are allocated to apartments in ways that lead to disproportionately privileging people on the basis of protected characteristics. An example of how this could occur would be if households' ethnicities are not evenly spatially distributed among apartments scheduled for renovation.

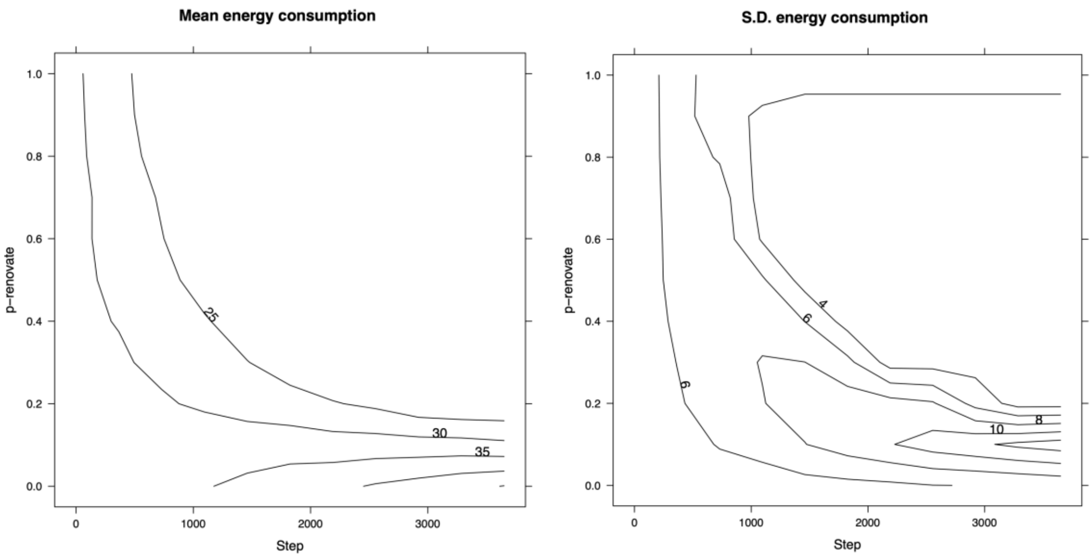


Figure 3.2: Contour plots showing the mean (left) and standard deviation (right) in energy consumptions by apartments in the wolverine model by time (x-axis) and renovation probability (y-axis).

3.4 Conclusions and discussion

There are various lessons to be learned for future attempts at empirical agent-based modelling of policy scenarios in a project such as this. First, empirical agent-based models are data-hungry, especially at the micro (individual/household) level. Though the experiment above did not require information about crime, it is a relevant piece of information: it affects people's perception of safety, the reputation of a neighbourhood, and has implications for how people will feel about disruption to their daily routine (e.g. if they have to move house while their apartment is being renovated). Crime is one example of relevant information that would be useful for building a model of the Järva case study, but which is not readily available. Specifically, for the closest empirical match, the crime rate is needed at the level of each borough, while the BRÅ website (https://www.bra.se/) where Swedish crime statistics are published only reports crime statistics at the whole of Sweden level. Expertise on the specific issue of crime (of the kind needed to know what data could be used instead) is not going to be available necessarily in a project in which the focal interest is the energy use of Europe's citizens, and matters such as the relevance of crime need not necessarily come to light until late on in the project. This highlights how agent-based modelling can be useful simply in making explicit how various seemingly unrelated issues (studied by completely different disciplines – energy conferences are not attended by criminologists) are interconnected through the lived experiences of the agents. Growing acceptance and adoption of FAIR principles when making data available will reduce the potential impact this issue has over time.

The second issue pertains to the lack of well-recognized established methodology in the area of empirical agent-based modelling. This has two effects. First, methodology is developed alongside model development, leaving non-modelling collaborators unsure of what their role is, and how they can best contribute to model development. Empirical agent-based modelling for policy is best done in a participatory way (Gilbert et al. 2018) because of the intersubjectivity of these models' predictions (Polhill et al. 2021). Though there is a long history of participatory agent-based model development (Ramanath and Gilbert 2004), attention to methods is still needed. The second effect is that agent-based modelling is rarely taught at undergraduate level in social science courses, meaning that the pool of potential recruits to take on modelling work is small. Besides knowledge and understanding of social science, agent-based social simulation requires interdisciplinary skills in a wide range of areas of computer science, potentially encompassing software engineering, knowledge engineering, knowledge acquisition, logics, data analytics, cloud computing, programming, and 'good old fashioned' (symbolic; Haugeland 1985) artificial intelligence. While this can be addressed in time with further applications of ABM, dedicated attention is needed to methodological development in ABM (Polhill et al. 2019).

4. Case cluster 4: Urban mobility with superblock

In this section, we describe the urban mobility with superblocks' case to which Vitoria-Gasteiz and Barcelona cities belong. First, we describe the model for Vitoria-Gasteiz which, given their similarity, was later adapted to Barcelona to hold the different data, such as the population profiles or the relevant entities that participated in the design and implementation of the social innovation, as well as the timeline in which it has been developed. An agent-based model has been developed that simulates how the citizens accept the social innovation project of superblocks and how this acceptance is influenced by the way the relevant entities (for example, City Council, the Press and some other associations) talk about the project.

4.1 Overview Vitoria case

4.1.1 Introduction Vitoria-Gasteiz case

Vitoria-Gasteiz is an ancient city in northern Spain with an area of 276 km^2 and a population close to 250,000 inhabitants. Some of its streets date from the 12th century and it preserves much of its medieval layout intact. Despite this, the orderly character of its streets, as well as its almond-shaped configuration, are remarkable.

Almost more than two decades ago, the city of Vitoria-Gasteiz proposed a Sustainable Mobility and Public Space Plan (see Muñoz, B. & Rondinella, G., 2016 or Vitoria-Gasteiz, 2007), partially based on a superblock model that reserves the space inside a part of the city (a block) for pedestrians and cyclists, with the final objective of recovering space for citizens use. A superblock is an area of the city free from passing traffic. It is surrounded by roads where perimeter traffic is allowed, while inside it is only allowed in the form of loops, so that the cars that enter are again expelled to the perimeter roads. They also have some other internal restrictions like the type of parking allowed or a low speed limit.

In the case of Vitoria-Gasteiz, the project gave place to the creation of the Superblock "Sancho El Sabio", a project that was developed in two phases: a Preliminary Phase (from October 2006 to April 2007), and the Implementation Phase (from 2007 to 2012). There have been controversies and debate among the population, certain associations, etc. about the project. The process modeled corresponds to the reactions of the population to the project together with the proposals and different measures taken by the City Council over the years. Despite the initial controversy, in a survey carried out in 2020 as part of the SMARTEES project, only about 15% of respondents of the questionnaires indicated to be against of the superblocks social innovation. To date, three superblocks (Central, Sancho el Sabio and Médico Tornay-Judimendi superblocks) have been completed and actions have been implemented in 20 of the 77 superblocks scheduled in the Plan. Five more interventions are planned to be implemented in the period 2021-2023. Our goal in modeling the development process of this first superblock over the years it lasted is to help determine which factors influence the population the most and thus be able to smooth the rejection curve in future similar projects.

4.1.2 Vitoria-Gasteiz model

The purpose of the model is to simulate the temporal evolution of citizens' opinions about the superblocks project and how it changes as policy actions take place in order to, finally, answer the question: which percentage of citizens will be both against and in favour of the superblock project based on different policy scenarios?

The HUMAT integrated framework was used to model the process of attitude formation among the residents of Vitoria-Gasteiz. As described in D7.3. (Antosz et al., 2020) Vitoria-Gasteiz agent-based model is very similar to the El Hierro agent-based model (see section 2) with respect to design and contents, with variations to account for differences in data sources, citizens' needs, entities and actors involved in the model and their policy strategies.

Again, the main entity (agent) of this model is the citizen, which has two behavioural alternatives: either accepts or rejects the superblocks innovation. In addition, four critical nodes known for their relevance were identified and included after an exhaustive documentary analysis of the case: the city council, merchants associations, other associations (neighbors, cyclists, pedestrians, etc.) and local media.

A survey was conducted in Vitoria-Gasteiz in November 2020 to collect data from citizens about their needs, trust and other socio-demographic aspects in order to feed the system with case-specific data. In this case, after the analysis of these data, we opted for the inclusion of 6 categories of needs:

- *Wellness* needs, which, among others, refer to health and security,
- *Environmental quality* needs, referring to air and noise pollution,
- *Comfort* which, among others, refers to parking availability and price,
- *City prestige*,
- *Participation* needs, referring to the possibility of participating in city decisions, and
- *Social* needs, referring to belongingness, social safety, social status, etc.

As already stated, the evolution of citizens is guided by how each behavioural alternative satisfied these needs. To parameterize the communication from the critical nodes to citizens the same schema already explained for El Hierro shown was used (see Table 2.1).

The interface of the model is presented in Figure 4.1. In the center the map of Vitoria-Gasteiz is shown with citizen agents placed in their corresponding census section, those in favor of the social innovation coloured in green and those against in red. As the model evolves, and citizen agents change their position towards the superblocks policy, their color is appropriately varied. On the left side, a text box is displayed showing information about the communication acts being launched by a critical node. On the right side, 8 graphics show a) the evolution of agents accepting (green)/rejecting (red) that are communicating and c) the evolution of the satisfaction/dissatisfaction of the six specific needs together with the importance of each (histogram in blue).

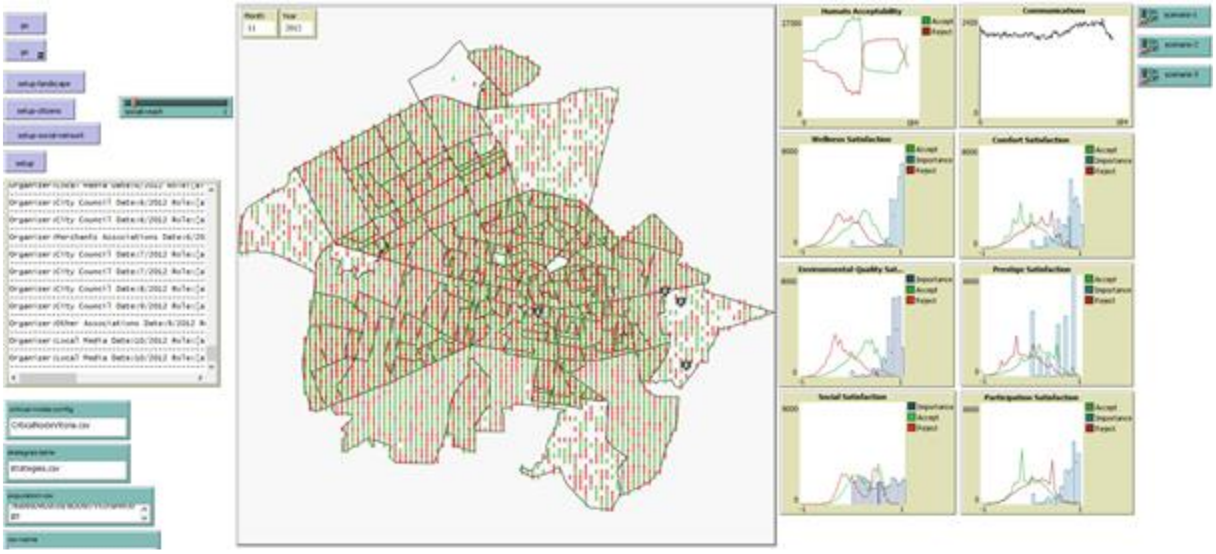


Figure 4.1. Interface of the model for the Vitoria-Gasteiz social innovation case.

This model has been designed to reproduce the basic timeline of several phases of the design and creation process of three different superblocks in the city (covering from the presentation of the Sustainable Mobility and Public Space Plan in 2006 to the implementation stage that lasted until 2012). In addition, the period from 2012 to the present (2021) has been added. To calibrate the model, field data from the case of Vitoria-Gasteiz has been used (surveys, in-depth interviews with key informants, press releases, local media analysis), but also the analysis carried out by the promoters and the stakeholders during the policy scenario workshops have been taken into account.

The procedure already described in Deliverable 7.3 (Antosz et al., 2020) and in (Alonso-Betanzos et al., 2021) was employed to reproduce the population of Vitoria in the model, using the profiles corresponding to data from the 865 questionnaires and according to census and the main population categories identified as relevant for acceptability by using Decision Trees (see Figure 4.2).

SMARTEES
local social innovation

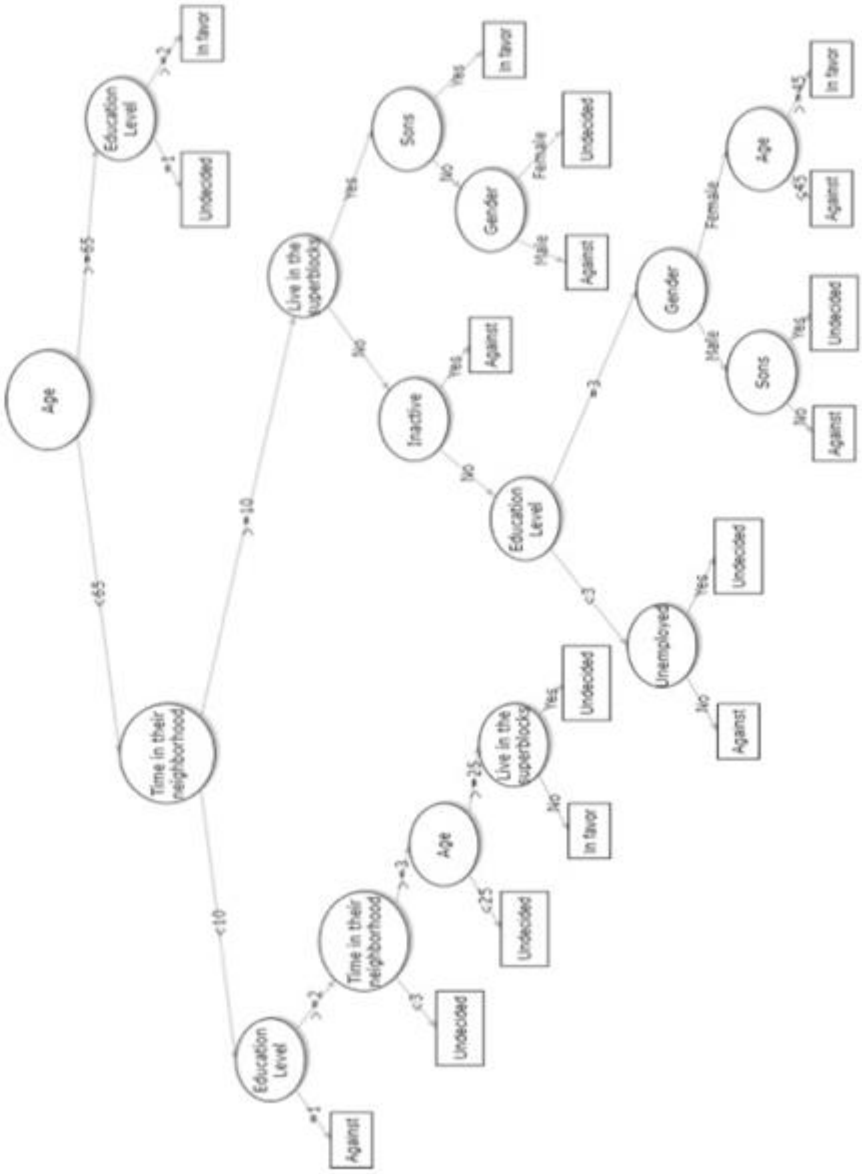


Figure 4.2. Population categories identified as relevant for the acceptance or rejection of the superblocks project

According to the responses to the survey carried out in Vitoria-Gasteiz in 2020, the majority of citizens report to have a favorable initial position concerning the superblocks project. As a consequence, the ABM reached high levels of acceptability of this social innovation in a very short period of time. This was consulted with the interested parties during the second policy scenario workshop, who identified memory and sample biases as factors to explain the high number of positive responses obtained from the survey since, after several years of successful implementation of the superblock, citizens would tend to raise their initial support for it. Besides, they confirmed the significant opposition around 2010 due to changes in parking regulation and car restrictions policies in the pilot and central superblock. Therefore, according to the suggestions of promoters and stakeholders, it was decided to raise the initial level of acceptance for the ABM considering more number of HUMATS who were against superblocks in order to fit the real starting point.

The communication strategies applied by the critical nodes are crucial to allow citizens to evolve and change their position. As mentioned, for the model to reflect reality, the communicative acts for the project's timeline were extracted from documentary analysis. Given their relevance, they were analysed in the workshop with stakeholders. A circumstance occurred was the low frequency of negative opponent messages (with a very reduced number of communicative acts), which again causes a fast acceptability of superblocks. According to one of the participants, since a certain consensus had been reached with the Citizen Pact for Sustainable Mobility, which obtained the support of political groups, relevant social groups and the local media, the opposite positions were little represented in the media discourse. In conclusion, the ABM accurately represents the communicative acts that took place in the modeled period.

Finally, the model was evaluated positively, as the stakeholders confirmed during the final workshop that it was able to correctly reproduce the pattern of acceptability under the scenario representing the history of the case.

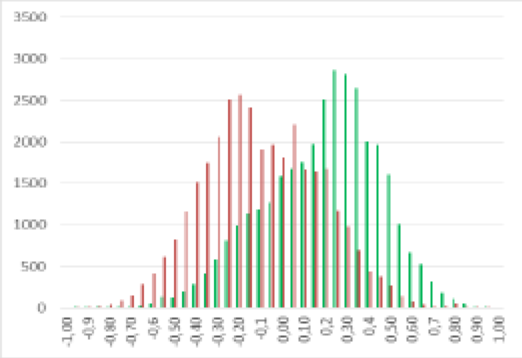
4.1.3 Vitoria-Gasteiz main model results and sensitivity analyses

In this section we will show the results of the model over the main timeline, taking into account that our desired outcome is to see how the number of agents who have accepted the superblocks social innovation is modified, although we will have a look also at the satisfaction achieved in the different groups of needs. We have run two different timelines for the model, the first one addresses the actual stages of the model (from 2006 to 2013, as described) while the other extends the run of the model to the present (2021). Regarding communicative acts, it must be taken into account that, 1) in the latter period, they are very scarce and mostly in favor of the social innovation, and 2) many citizens are in favor of the social innovation at the end of 2013. These conditions cause that, with the progress of time, almost the entire population is convinced of the superblocks' project as illustrated in Table 4.1. As it can be observed, the stability of the model is high, shown by its very low standard deviation. Besides that, its execution is very time consuming (around 50 minutes each run). Taking this into account, the number of runs is fixed to 10 for all simulations carried out, since due to the stability of the model a higher number of repetitions would not cause appreciable changes in the final results obtained.

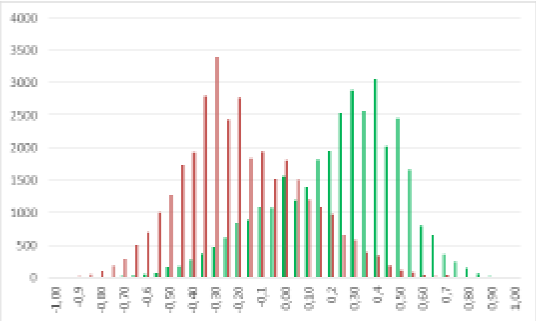
Table 4.1. Number of agents accepting the superblocks' social innovation after running the model (average results of 10 runs).

TimeLine	Average number of agents in favor (%)	Standard deviation (%)
2006-2013	66.3	0.32
2006-2021	85.3	0.26

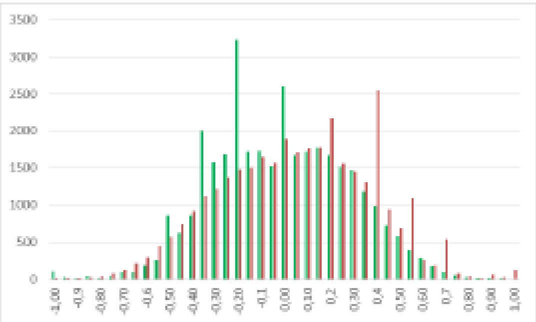
Figures 4.3 and 4.4 show, at the end of the two timelines and for every need, the level of satisfaction of the population of agents when accepting or rejecting the superblocks project. If we focus on the first timeline (ending 2013), from these figures it can be observed that for comfort and participation needs both accepting or rejecting the social innovation carries the same level of satisfaction. However, the rest of the needs are better satisfied when the superblocks' project is accepted. If we focus on the second timeline (ending 2021), it can be seen that prolonging the execution in time causes the differences between accepting or rejecting to be more pronounced. Moreover, in most cases, the levels of satisfaction when accepting the social innovation are increased which can be explained by more years of experimenting the benefits of superblocks.



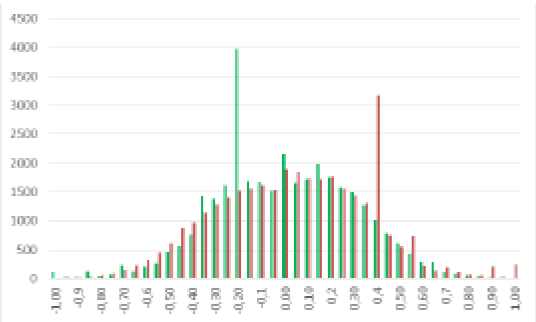
(a) Wellness – Timeline 2013



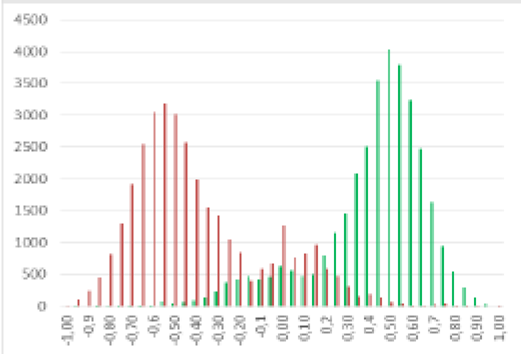
(b) Environmental Quality – Timeline 2013



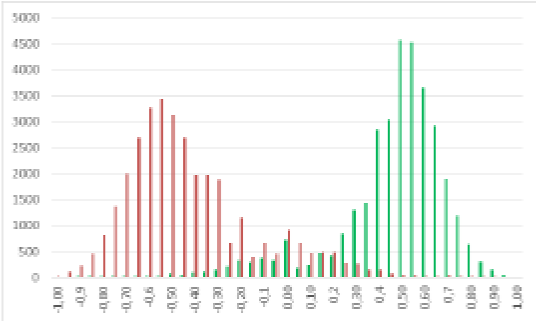
(c) Comfort- Timeline 2013



(d) Participation – Timeline 2013

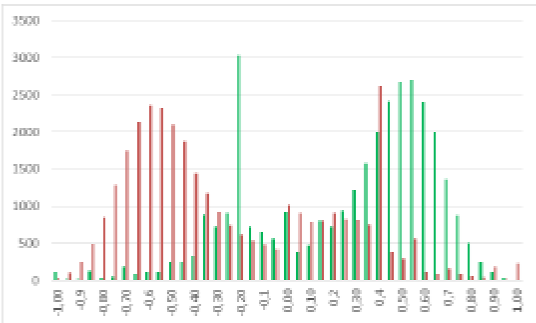


(e) Wellness – Time 2021



(f) Environmental Quality – Timeline 2021

(g) Comfort- Timeline 2021



(h) Participation – Timeline 2021

Figure 4.3. Mean satisfaction (from 10 different runs) of the different needs. The X axis represents the level of satisfaction (from -1 to 1), whereas the Y axis indicates the number of agents that accept (green) or reject (red) the superblock project.

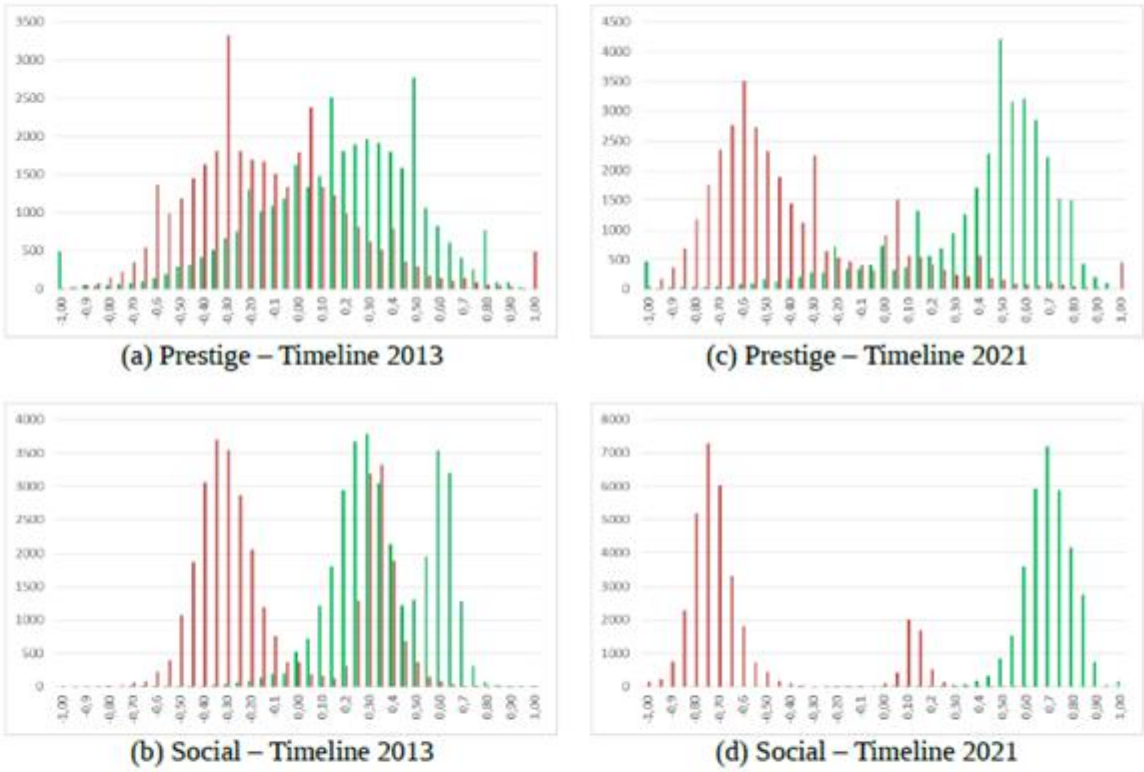


Figure 4.4. Mean satisfaction for Prestige and Social needs (from 10 different runs) . The X axis represents the level of satisfaction (from -1 to 1), whereas the Y axis indicates the number of agents that accept (green) or reject (red) the superblock project.

The model has several parameters (see Deliverable 7.3 in Antosz et al., 2019). As far as it was possible, the values of many of them were derived by applying theoretical knowledge. To study the impact of the model on these parameters, a sensitivity analysis has been carried out on one of the most determining ones: the maximum influence that a critical node can exert over a citizen. Note that very high values of this parameter are not possible because it would imply that the citizen is ignoring the opinion of the community or even its own position, so apart from the original value (0.2) three more values were considered: 0.1, 0.3 and 0.4. Table 4.2 shows the mean results achieved after 10 runs where it can be appreciated that best acceptability results are achieved when the influence is lower. Figure 4.5 explains this situation: changes for low influence are smoother than those for high influence. As a consequence, controversial policies have less impact when the influence of critical nodes is low (notice how the blue line in Figure 4.4. is clearly above in the conflict period between 2010 and 2012).

Table 4.2. Mean and Standard Deviation (over 10 different runs) of the number of agents that accept the superblocks' project after running the simulation.

	Timeline 2006-2013		Timeline 2006-2021	
Max influence	**Mean (%)**	**SD**	**Mean (%)**	**SD**
0,1	68.97	0.35	86.14	0.33
0,2	66.27	0.33	85.32	0.26
0,3	65.92	0.18	85.38	0.33
0,4	66.34	0.35	85.73	0.28

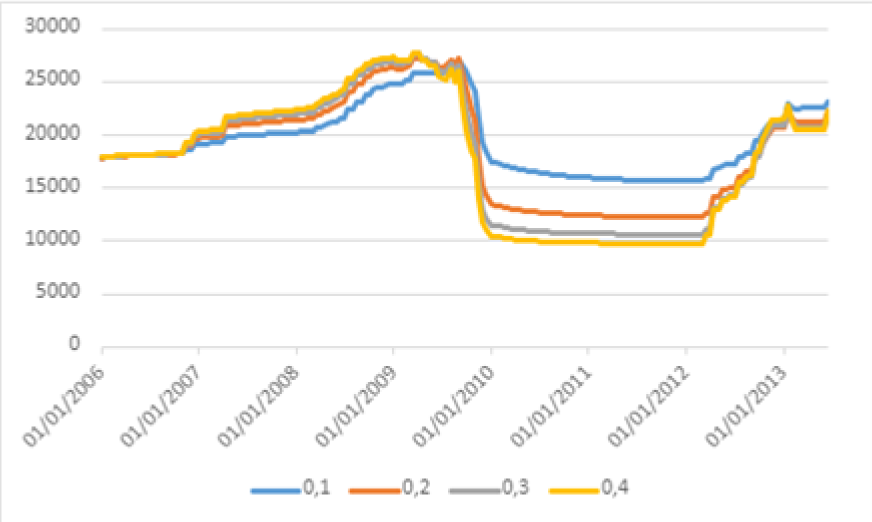


Figure 4.5. Number of agents accepting the social innovation from 2006 to 2013 varying the maximum influence that a critical node can exert.

Additionally, as it will be shown, other policy strategies were tested as the model is aimed at becoming a general simulation framework for usage in different urban scenarios.

4.2 Policy scenario development for the Vitoria-Gasteiz Case

4.2.1 Overview policy scenario workshops

The policy scenario workshops in the superblocks cluster focused on the design of innovative urban policies on sustainable mobility that serve as the basis for the replication of the superblocks model in Vitoria-Gasteiz, supported by the empirical data obtained in the SMARTEES project (further details in Dumitru et al, 2021a). The first round of policy scenarios aimed at promoting joint reflection, between promoters and political and social actors (stakeholders), about the best alternatives for the implementation of low-carbon mobility policies that will serve to support informed decision-making on social innovations. At the second round of policy scenarios, the main objective was to present the simulated timeline of the social innovation process and so refine the alternative policy scenarios that can be implemented in the model. Finally, the following alternative scenarios were considered.

SCENARIO 1: Intensification of the communication strategy focused on the need for comfort
A) Introducing new communications from the City Council to citizens to anticipate the discontent for uncomfort situations, like parking restrictions. B) Starting from 1A, this scenario increases the reach of the new communications made by the City Council. It also expands the communication period and the frequency of communications. C) Starting from 1B, this alternative scenario incorporates participatory meetings.
SCENARIO 2: Participatory approach to increase citizens' support towards superblocks
A) Encouraging social interaction to test the effect of the functioning of social networks when people discuss more about the project. B) Starting from 2A but communications from the local media (supporters) also occur. C) Starting from 2A but communications from ocal associations (supporters) also occur
SCENARIO 3: Environmental education combining awareness-raising strategy and participatory approach
A) Testing the effect of an environmental awareness campaign while encouraging social interaction between citizens. B) Same as Scenario 3A but adding communications involving also the press and local associations supporting the policy.

The results achieved by the model by the first two alternative scenarios were already presented during the second workshop. The first issues addressed, as mentioned above, were the low presence of opposition to the superblocks' project and the bias of the survey results towards acceptability that was slightly altered in the model. After that, other factors conditioning the social acceptability of superblocks, such as the international recognition of Vitoria-Gasteiz as European Green Capital, were also commented in the workshop, however, they are out of the scope of the ABM, so they cannot be considered as feasible scenarios.

Another alternative scenario formulated by the workshops' participants involves moving forward, beyond 2020, and testing what would happen if a communication strategy were implemented in a new superblock to be hypothetically defined in a new neighbourhood. However, the ABM uses numerous data acquired by employing various techniques, both qualitative and quantitative, in the SMARTEES project. As the model has real input data only until 2020, from then, we would need to figure them out. It would be an exercise of imagination, but the conclusions derived from the model would not have any validity. Finally, the last scenario proposed by the participants refers to a communication action that aims to launch a neighborhood association consisting of a recognition campaign for people who go to work in the nearby polygon by bicycle, giving them discount vouchers in shops from the neighborhood. In addition to the difficulty of representing this measure in the ABM as a communicative strategy, for which again no data is available, the relationship between this action and the acceptability of superblocks is not clear, so finally this scenario was not considered.

4.2.2 Description of experiments

All the simulated scenarios start from the original timeline of the project as presented in section 4.1.3 and include new communication strategies from different critical nodes aiming at overcoming the conflictive situations or increasing the acceptability of superblocks. As it was verified in Table 4.2, prolonging the model until 2021 achieves higher levels of acceptability, although not because of the actions carried out by stakeholders but just because of the natural evolution of the citizen agents as they experiment the superblock. For this reason, the scenarios will be extended until 2013 to see the effects of the new (alternative) policies implemented in these specific stages in the superblocks' timeline. Analogously to the initial situation 10 simulations have been carried out for all scenarios and the average results will be shown.

4.2.3 Scenario 1: Intensification of the communication strategy focused on the need for comfort

In November 2009, a new parking policy was introduced in the city centre to dissuade using private cars, increasing the regulated area and for on-street parking prices (multiplying by three the old prices). Residents should also pay for parking in the centre (while it was free before). This policy was accompanied by a communication strategy that aimed to increase citizen's environmental awareness, focusing on the benefits of the Sustainable Mobility Plan and the superblocks model. Due to the unpopularity of this measure, the City Council had to deal with the strong resistance of the city centre residents and the retail sector. The residents' associations gathered about 13,000 signatures against the measure. This conflictive situation can be clearly seen in the model (see years 2010 to 2012 in Figure 4.6) with the sharp decline in acceptability of superblocks in 2010. This scenario tries to overcome this situation by a more intense communication campaign, promoted mainly by the city council. The promoter's discourse will address the satisfaction of the need for comfort, in order to anticipate the discontent of the residents that, for example, perceive that the policy restricts their "right" to park in their street for free. To represent it, the communications made in the original timeline are maintained and new communications are added encouraging the benefits of superblocks for comfort (noise reduction, more free space for public use and so on). These communications can be seen in Table 4.3[3]. The communications column pinpoints how many communications are done and the direct/indirect term indicates if the communication is directly made by the sender or local media are used instead (indirect). This is relevant as the reach considered will be that of the final sender, that is, if the city council emits an indirect communication using local media, the reach will be the established percentage of the local media's social network. Note that all communications are equitably distributed in the indicated period.

Table 4.3. New communications in Scenario 1.

	Sender	Communications (direct /indirect)	Reach (% social network)	Period
SCENARIO 1A	City Council	18(12/6)	low(10)	Monthly from 01/2009 to 06/2010
	Associations	4(0/4)	high(30)	January, April, August and December 2009
	Local media	3(3/0)	high(30)	January, June and December 2009
SCENARIOS 1B AND 1C	City Council	36(24/12)	high (30)	Monthly from 01/2007 to 06/2009 and from 01/2009 to 06/2010
	Associations	8(0/8)	high(30)	Jan, Apr, Aug and Dec 2007 and 2009
	Local media	6(6/0)	high(30)	Jan, Jun and Dec 2007 and 2009

[3] Note that the description of the scenario 1 slightly differs from those discussed in the Deliverable 5.2

In addition, trust in the local media and associations is modified with the aim of enhancing the orientation of communication towards comfort (provoking different reactions depending on the importance a citizen gives to that need). It is held during a year and a half (from the beginning of 2009 to mid-2010) and trust is increased or decreased depending on the importance of the need for comfort to HUMATS. This trust modification tries to reflect the situation of discomfort generated by superblocks due to, for example, the reduction of parking spaces that prevents parking near home. Faced with this situation, the main opponents criticize the superblocks project, then citizens may ignore or follow this criticism. According to the main sociologist researchers of this case, citizen agents vary their behaviour. Then, citizen agents with high values in their comfort need to trust these opponents more, those with intermediate comfort values maintain their position in favour of the city council and ignore the critical voices, and those with low values remain the same. In fact, if the importance level of this need is between 0.4-0.6, trust is reduced by 20%, however if importance for comfort is over 0.8, trust in local media and associations is augmented by 20%.

This scenario was approached in different ways trying to achieve a greater impact on reducing the decrease in acceptability along years 2010 to 2012. To do so, the communications will be centered in emphasizing the benefits of superblocks and the following approaches were considered:

- Scenario 1A. Orientation of new communications towards only comfort needs.
- Scenario 1B. Similar to Scenario 1A but increasing the reach of the campaign made by the city council, going from a low (10) to a high reach (30) in both direct and indirect communication types. Moreover, it expands the communication period and the frequency of communications. Communications started earlier (in 2007) trying to prevent rejection to superblocks and the number of communications of scenario 1A doubles, with the City Council being active throughout the period while associations and local media carry out communications only during the years 2007 and 2009. Note that the trust modification is held in the same period.
- Scenario 1C. This scenario tests the impact of participatory meetings among citizens (see sections 2.5.3 and 2.5.4 for the description of these meetings). This scenario reproduces the communication strategy described in the previous scenario (1B) and introduces additional communications between residents simulating citizen discussions about the policy. These meetings happen in three specific time periods:
    - July 2006 (starting out of the project): Meetings in all census sections of the city
    - June 2009 (new parking policy in central superblocks): Meetings in specific census sections (46 of 188) that are affected by the increase in the price of outdoor parking
    - January 2012: Meetings in all census sections of the city.

Table 4.4 illustrates the number of agents accepting the superblocks innovation once the model is run under the different approaches of this scenario. For the sake of comparison, the first row shows the base result. Similarly, Figure 4.6 displays agents accepting the social innovation in the execution of these scenarios from 2006 to 2013. Both table and figure reveal the same conclusion, scenario 1C clearly leads to more agents accepting the project, denoting the importance of participatory meetings apart from prolonging the campaign. Focusing on the satisfaction of needs, we show in Figure 4.7 the results of the most moderate approach (1A), where only comfort-oriented communications are increased, and in Figure 4.8 the results of the approach 1B in which the campaign is intensified. It can be appreciated that, in the scenario 1B, there are more agents with a higher satisfaction value (above 0.3) in comfort needs.

Table 4.4. Number of agents accepting the superblocks' social innovation after running the model under different approaches of Scenario 1 (average results of 10 runs).

Scenario	Mean number of agents in favor (%)	Standard deviation (%)
Timeline 2006-2013	66.30	0.32
Scenario 1A	66.86	0.32
Scenario 1B	70.59	0.33
Scenario 1C	72.03	0.37

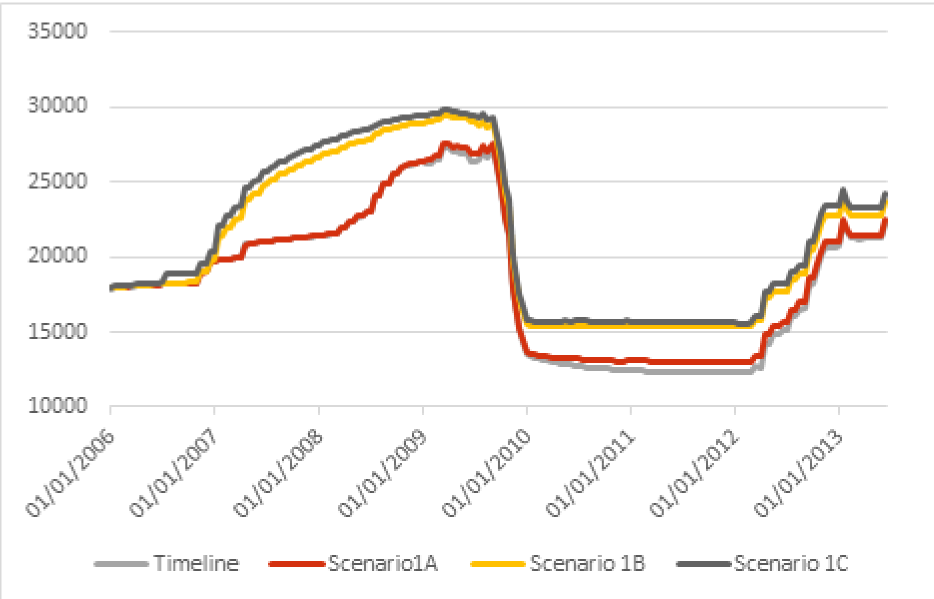


Figure 4.6. Number of agents accepting the social innovation from 2006 to 2013 in three different approaches of Scenario 1 (1A, 1B and 1C).

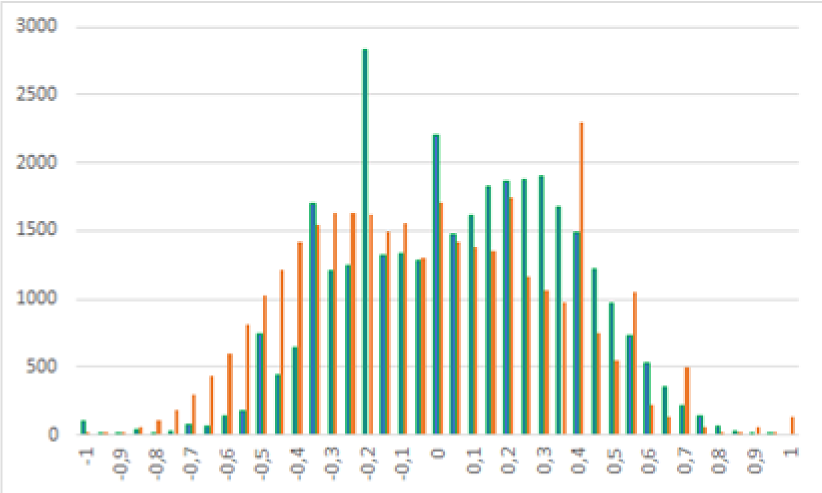


Figure 4.7. Scenario 1A. Mean satisfaction for Comfort needs (from 10 different runs) . The X axis represents the level of satisfaction (from -1 to 1), whereas the Y axis indicates the number of agents that accept (green) or reject (red) the superblock project.

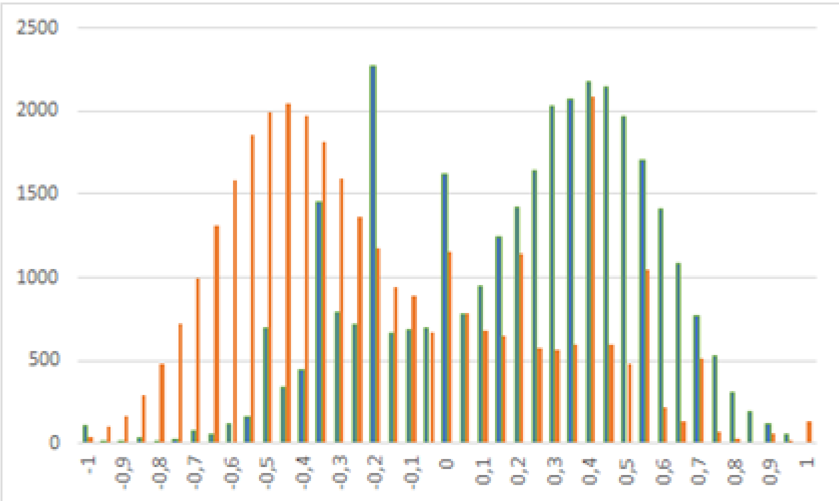


Figure 4.8. Scenario 1B. Mean satisfaction for Comfort needs (from 10 different runs). The X axis represents the level of satisfaction (from -1 to 1), whereas the Y axis indicates the number of agents that accept (green) or reject (red) the superblock project.

4.2.4. Scenario 2: Participatory approach to increase citizens' support towards superblock

This alternative policy scenario consists of "rethinking the participatory model", trying to answer the question: If people have spaces to communicate among them and discuss the new policy, would the acceptability of the superblocks project improve?

In addition to the possibility of communicating with their social networks to solve HUMATS dissonances, the model includes the possibility of having random conversations between citizen agents of the same census section (see section 4.1.3 in Antosz et col., 2019). The idea of this scenario is to increase these random conversations, but three alternatives have been designed:

- Scenario 2A dramatically increases these random and spontaneous conversations in controversial stages of social innovation by adding participatory meetings (see section 2.5.4 for the description of these meetings). The conflictive stages taken into account are:
    - July 2006. Meetings in all census sections when the Sustainable Mobility Plan is proposed.
    - September 2009. Meetings in the census sections (46 of 188) affected by the increase in the price of outdoor parking .
    - January 2012. Meetings in all census sections once the discrepancies regarding the outdoor parking issue have subsided.
- Scenario 2B reproduces meetings among residents as in scenario 2A. Besides, this scenario adds 6 new communications from the local media (supporting the policy) at the same period of time that conversations among citizens occur. The specific details are indicated in Table 4.5.
- Scenario 2C reproduces meetings among residents as in scenario 2A. Besides, it adds 6 new communications from the local associations (supporting the policy) at the same period of time that conversations among citizens occur (see Table 4.5).

Table 4.5. New communications in Scenario 2.

Scenario	Sender	Communications (direct /indirect)	Reach (% social network)	Period
2B	Local media	6(6/0)	high(0.3)	Two at each period (Jul 2006, Sept 2009 and Jan 2012)
2C	Associations	6(0/6)	high(0.3)	Two at each period (Jul 2006, Sept 2009 and Jan 2012)

Figure 4.9 shows the large increase in citizen agents communicating (both in favor and against the social innovation) at the specified times (note that in a normal situation there are around 2000 agents communicating). However, this communicative overload barely affects acceptability, as it can be seen in Table 4.6 and Figure 4.10. The differences with the original situation slightly exceed 1%, which considering the current population of the city, would be an increase of around 2,500 inhabitants more in favor of the social innovation. However, considering these meetings together with communications from critical nodes, more from local associations (2C) than from the press (2B), a higher impact on acceptability is obtained, increasing more than 5%. Notice the relevant increase on acceptability in the year 2006, for scenarios 2B and 2C, due to the first meeting combined with the communication of critical nodes.

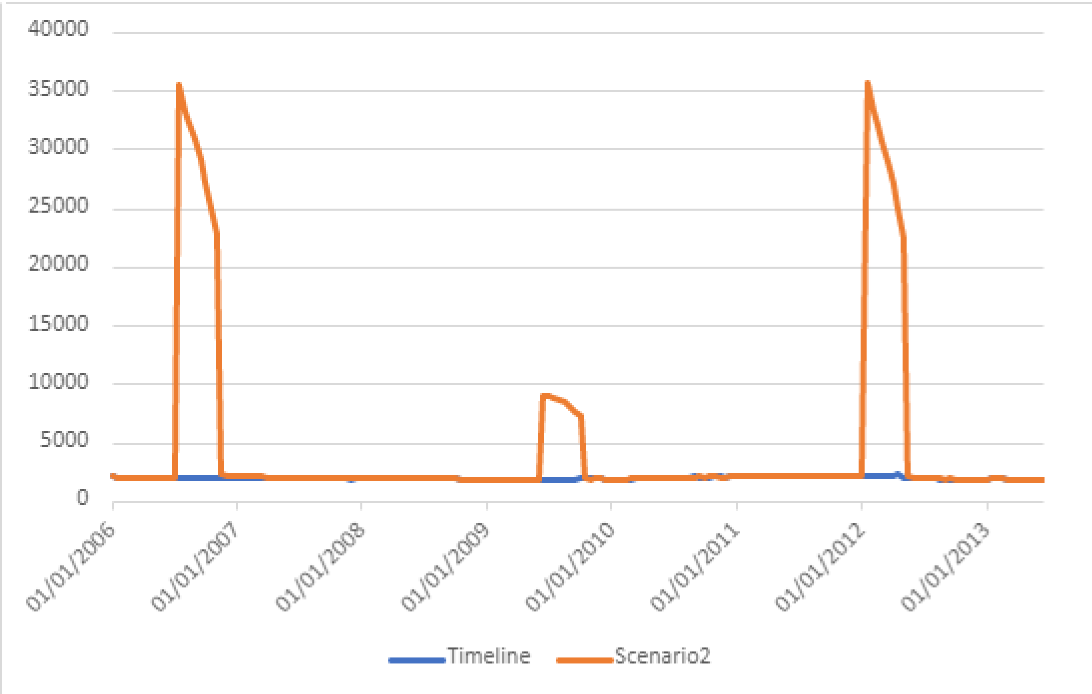


Figure 4.9. Scenario 2A: Mean number of citizen agents communicating (average of 10 runs). X axis represents the temporal line, whereas Y axis indicates the number of agents.

Table 4.6. Mean number of citizen agents communicating after running the model for Scenario 2 (average results of 10 runs).

Scenario	Mean number of agents in favor (%)	Standard deviation (%)
Timeline 2006-2013	66.30	0.32
Scenario 2A	67.40	0.36
Scenario 2B	70.45	0.24
Scenario 2C	71.52	0.21

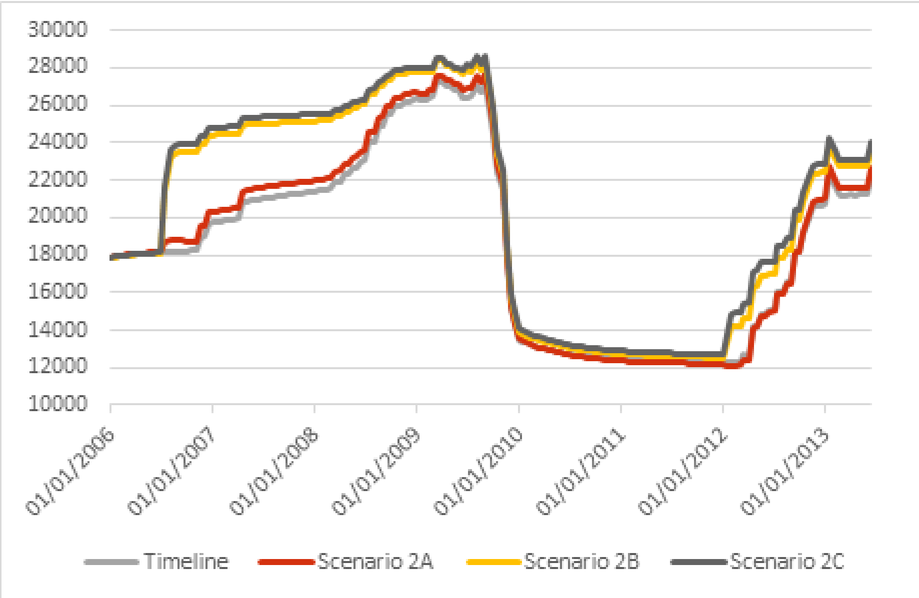


Figure 4.10. Number of agents accepting the social innovation from 2006 to 2013 in three different approaches of Scenario 2 (2A, 2B and 2C).

4.2.5. Scenario 3: Environmental education combining awareness-raising strategy and a participatory approach

Citizen meetings and campaign for increase citizens' environmental awareness

The goal of this scenario is to change the orientation of the new communications to increase the importance of environmental quality and wellbeing, so that the global satisfaction of the agents is also increased if they give more importance to those needs. Although initially the implementation of an environmental awareness campaign for citizens was treated separately, the results that were achieved were better results by also incorporating the strategy of the previous scenario (including meetings between citizens). Thus, and starting from scenario 2A (i.e., considering participatory meetings), this 3rd scenario incorporates an environmental awareness campaign for citizens. Similarly to previous scenarios, different alternatives were considered:

- Scenario 3A. A environmental awareness campaign for citizens lasting from 2007 until 2010.
- Scenario 3B involves also the press and local associations supporting the policy. It reproduces the previous one but adds new communications from local actors supporting the environmental education campaign.

The number of communications from the city council to simulate the campaign and those of local supporters (for scenario 3B) can be consulted in Table 4.7.

Table 4.7. New communications in Scenario 3

Scenario	Sender	Communications (direct /indirect)	Reach (% social network)	Period
3A	City council	42(0/42)	high(30)	01/2007-06/2010 (monthly)
3B	City council	42(0/42)	high(30)	01/2007-06/2010 (monthly)
	Association	6(0/6)	high(30)	Two at each period (July 2006, June 2009, January 2012)
	Local Media	6(6/0)	high(30)	Two at each period (July 2006, June 2009, January 2012)

It is important to note that this scenario is aimed at modifying the importance of the needs (not the satisfaction of those needs). This means that the original algorithm that defined the strategy of the critical node described in section 4.3 in deliverable 7.3 (Antosz et al. 2019):

```
ask strategy secondary critical node
    selected-citizens = choose randomly citizens in social network according to strategy reach
    ask selected-citizens
      persuasion = trust in primary-critical-node * 0.2
      foreach need of both behaviours
        satisfaction = (1-persuasion) * satisfaction + persuasion * satisfaction-critical-node
      experience effects
```

is modified to:

```
ask strategy secondary critical node
          selected-citizens = choose randomly citizens in social network according to comm reach
    ask selected-citizens
      persuasion = trust in primary-critical-node * 0.2
      foreach need of both behaviours  ;in this scenario only enviro-quality  and wellness
        importance = (1-persuasion) * importance + persuasion * importance-critical-node
      experience effects
```

where the importance is taken under consideration instead of satisfaction.

Analogously to the previous scenario, in the initial situation there are hardly any differences between the original situation and the scenario 3A for which Table 4.8 reports a 1.58% increase in acceptability at the end of the model execution. Figure 4.11 shows the evolution of this model, scenarios covering only the campaign (3A) clearly overlap with the base timeline, however, the incorporation of the press and local associations (3B) makes the increase in acceptability remarkable (up to 9%). It is also worth highlighting the notable increase at the beginning of the project (early 2007 when the communications started).

Table 4.8. Number of agents accepting the superblocks' social innovation after running the model for Scenario 3 (average results of 10 runs).

Scenario	Mean number of agents in favor (%)	Standard deviation (%)
Timeline 2006-2013	66.30	0.32
Scenario 3A	67.88	0.16
Scenario 3B	75.71	0.18

Figure 4.11. Number of agents accepting the social innovation from 2006 to 2013 for Scenario 3 (3A and 3B).

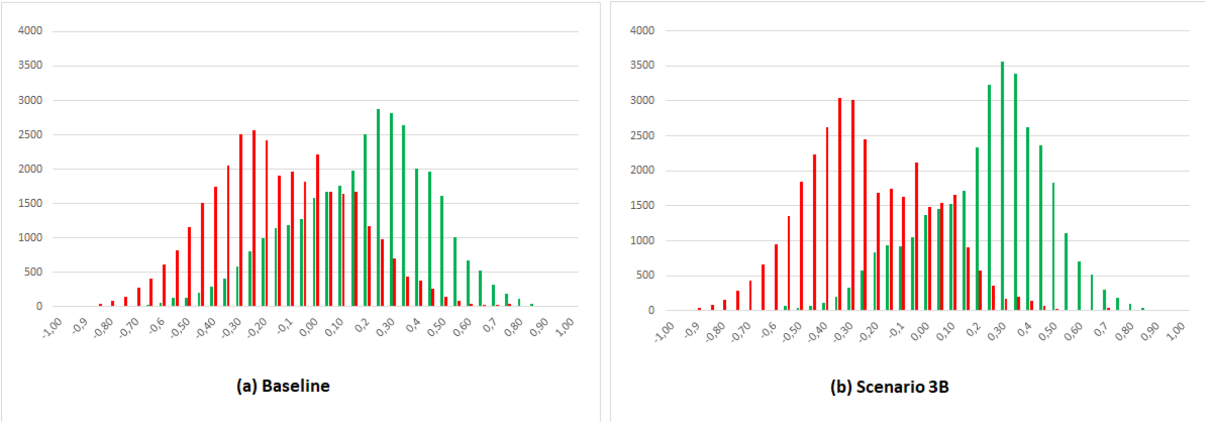


Figure 4.12. Scenario 3B. Mean satisfaction for Wellness needs (from 10 different runs). The X axis represents the level of satisfaction (from -1 to 1), whereas the Y axis indicates the number of agents that accept (green) or reject (red) the superblock project.

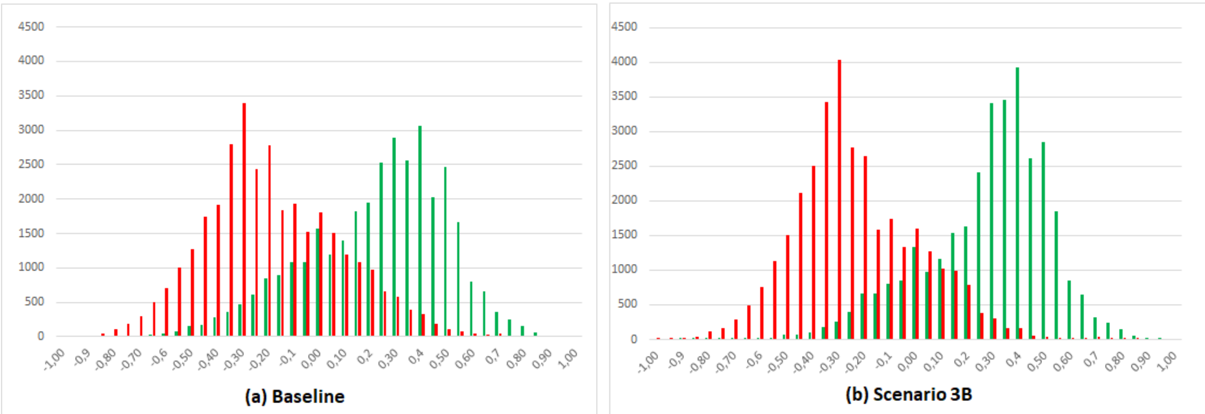


Figure 4.13. Scenario 3B. Mean satisfaction for Environmental Quality needs (from 10 different runs). The X axis represents the level of satisfaction (from -1 to 1), whereas the Y axis indicates the number of agents that accept (green) or reject (red) the superblock project.

Figures 4.12 and 4.13 display the final satisfaction in Wellness and Environmental Quality needs in the original timeline versus scenario 3B. Although the difference is not very relevant, if we focus on the peak of the curves where the density of agents is higher, we can observe a slight increase in the number of agents who experience an acceptable level of satisfaction supporting the project when communication is focused on emphasizing the importance of these aspects. Reciprocally, the number of agents who experience a level of dissatisfaction when rejecting the project also increases.

4.3. Conclusions and discussion of alternative scenarios for Vitoria-Gasteiz

The agent-based model for the case of Vitoria-Gasteiz recreates the communication strategies developed by the municipality (and other key actors supporting the social innovation) aiming at increasing social acceptability towards the Sustainable Mobility and Public Space Plan and superblocks measures. Thus, the baseline scenario simulates citizens´ support towards the social innovation in the different phases of the social innovation (between the period 2006-2012), involving only 66,3% of the population in favour of the social innovation at the beginning of the project.

Scenario 1 consists of the implementation of a targeted communication strategy since the early stages of the project (January 2007), for citizens to become familiar with superblocks and anticipate residents' contestation. This scenario is implemented in the model by introducing new communications from the promoters and supporters to citizens addressing the satisfaction of the need for comfort, in order to anticipate the discontent of the residents towards parking restrictions in the period 2009-2010. The results of the model show that communication strategies merely addressing the satisfaction of the need for comfort are not successful, as Scenario 1B only raises the level of public acceptability to 70,6% (↑4,3) as compared to 66.3% of the population who voted in favour of the social innovation in the baseline scenario. Scenario 1C tests the effect of the combination of this targeted communication strategy with spontaneous meetings among citizens discussing the policy. The results of scenario 1C show that when citizens engage in conversations about the policy, the social support towards the policy reaches up to 72% (increasing 5,73% compared to the baseline scenario). Scenario 1C also highlights the importance of supporting participatory processes that create the conditions for the positive effects of the campaign to reach more citizens and, consequently, increase the acceptability of the project.

As the comparative analysis between sub-scenarios 1A, 1B, 1C shows, a relevant number of citizens is susceptible to be influenced by the policy and become more convinced that superblocks can support their need for comfort, despite the ongoing parking restrictions, when these policies are supported by local associations (e.g., cyclists’ association, resident’s associations) and the media, and reinforce the key message of the city council. Further, the results also stress the importance of increasing the impact of the campaigns in terms of the rate of population addressed and reached. A third relevant lesson relates to the importance of anticipating contestation and negative reactions towards potentially unpopular policies. Thus, this first alternative scenario shows it is more effective to start a year earlier, in 2007, and sustain a coherent message for four years, addressing specific needs, by using several information channels and with different actors leading the communication, especially in alliance with local media who endorse the policy and contribute to create a climate of acceptance towards the measure.

Scenario 2 consists of the implementation of new participatory approaches, promoting citizen meetings at the neighbourhood scale where the project can be discussed and co-defined, across the different stages of the project. This scenario tested the effect of creating arenas for citizens to discuss superblocks and the results of the model that Vitoria-Gasteiz inhabitants are more willing to vote in favour of the superblocks' policy if they have been involved somehow in discussions about the policy. This policy strategy has a higher impact if local associations endorse the participatory process as sub-scenario 2C shows, increasing public support towards superblocks up to 71.52% (↑5,22), which becomes a significant difference compared to the baseline scenario. It can be argued, however, that organizing only one meeting at three specific periods is not meaningful for citizens. On the contrary, implementing a participatory approach would involve frequent communication actions (e.g., participatory meetings) sustained overtime for the need for participation (and the desire of being involved in relevant decisions) to be fulfilled and citizens to be keener to support socially innovative policies. In line with this, one alternative scenario to explore further would test the effect of fostering citizen's engagement in the definition of the superblocks programme, simulating a more citizen locally-embedded participatory strategy that involves participatory events displayed, for example, every month during 2-3 years, in a specific city district in which a superblock is being implemented.

Scenario 3 represents the effect of an environmental awareness campaign, aiming at increasing residents' concern towards wellbeing and environmental quality, in combination with citizen participatory actions. Differently from the previous scenarios, the communication strategy from the city council addresses the importance of achieving a clean and healthy environment. The combination of both strategies increases the level of social acceptability up to 1.6%. However, involving different voices leading the communications become crucial for gaining public acceptability. As scenario 3B shows, if local associations and local press endorse the city council's discourse, citizens' support to the policy rises dramatically (up to 9.3%). These results are consistent with the two previous scenarios, which means that people apparently need an arena for discussing, validating, and consolidating the "new normal" triggered by the innovative policy.

After presenting the results of the different scenarios, it is observed that scenario 3B is the most promising since it achieves the most significant difference in acceptability (9% more), as it is shown in Figure 4.14 .

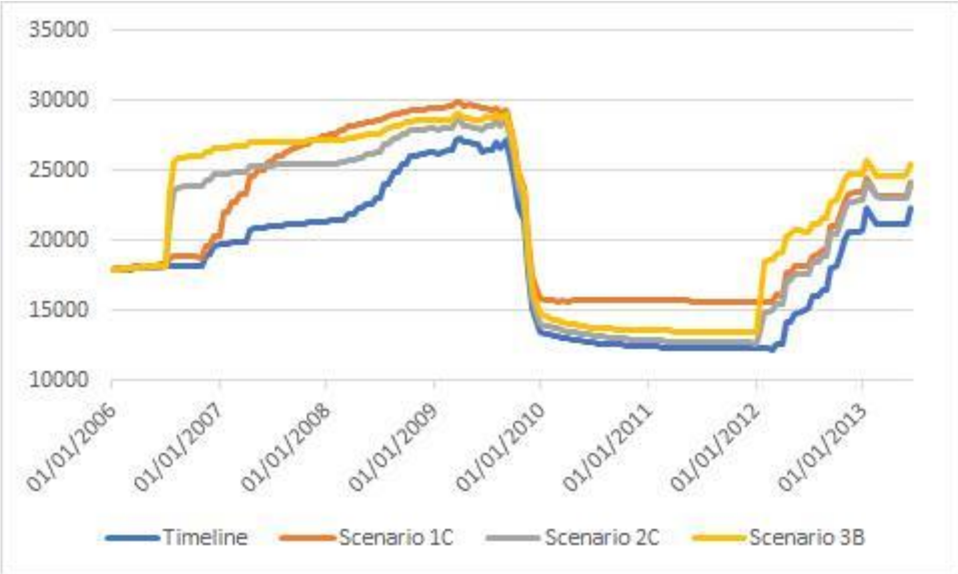


Figure 4.14. Number of agents accepting the social innovation from 2006 to 2013 for the most promising alternatives of each scenario (1C, 2C and 3B)

Interestingly, if the outcomes of the three scenarios are compared, it could be concluded that awareness-rising campaigns appear to be more effective (in terms of increasing public support) than single targeted communication or participatory strategies. Therefore, citizens can be influenced to support the social innovation when communication strategies address their specific concerns and needs (e.g., need for comfort, need for security, need for health, etc.). Furthermore, employing several strategies of communication and gaining alliances with other social actors and media who endorse the policy appear to be key factors to gain social acceptability towards the policy. However, for these strategies being successful, several features should be considered: First, the scope of the policy. The results from the ABM stress the importance of increasing the impact of the campaigns in terms of the rate of population addressed. Many inhabitants should be reached by these campaigns, and several formats should be used (e.g., by employing several sources of information, social media, etc.). Second, (expected) contestation and negative reaction towards the unpopular measure should be anticipated. Vitoria-Gasteiz´s model shows that the most effective policy (scenario 3B) is the one that started two years in advance and sustains a coherent message strategy for three years and a half. Finally, another alternative scenario to explore forward would involve testing the impact of involving other stakeholders in these alternative policy scenarios campaigning against the superblock model, which becomes interesting considering the actual low level of social contestation in the baseline.

4.4 Overview Barcelona case

4.4.1 Introduction Barcelona case

Barcelona is a pioneer city in establishing superblocks areas, with the first superblocks created in the Born and Gràcia districts in 1993 and 2006 respectively. Inspired by these positive experiences, in September 2016 the City Council extended the superblock management model throughout the city, aiming at responding to the city's scarcity of green spaces, its high levels of pollution, environmental noise, accident rates, and unhealthy lifestyles. Superblocks are implemented pursuing the objectives of enhancing habitability of public spaces, increasing urban greenery and biodiversity, and promoting low carbon mobility.

Through the Urban Mobility Plan, Barcelona city is planned to be organized into 503 superblocks, as approved in the 'Let's fill the streets with life' superblock program (Municipality of Barcelona, 2016). The plan is being implemented by the Municipality of Barcelona receiving also technical support from other municipal areas. Superblocks in Barcelona have received social support and social acceptance in certain areas (e.g. Sant Antoni, Horta) but also high levels of protests and contestation in others (e.g. pilot superblock in Poblenou) that have been reduced overtime. Social contestation was motivated by the lack of information and lack of social participation before starting the urban interventions. Changes in the pilot project were made after, following the suggestions of residents and the citizens ́ associations in the area. In the following superblocks, public participatory processes have been launched. The outcomes of the superblocks program have been assessed in three pilot interventions, measuring positive outcomes in the following dimensions: improvement of environmental and public space conditions, increase in green areas, enhancement of social activity and social interaction in the neighborhood. El Poblenou's Superblock received a "special mention" at the 2018 European Prize for Urban Public Space.

4.4.2 Barcelona model

In this case, the model is aimed to simulate the temporal evolution of citizens' opinions about the project to answer the following question: which percentage of citizens will be both against and in favour of the superblock project based on different policy scenarios?

For this case, and taking into account that Barcelona is a city with more than a million and a half inhabitants, data acquisition (from surveys to documentary analysis) was centered in two superblocks areas: Sant Antoni and Poblenou. As previously commented, there was hardly any public opposition at Sant Antoni and the superblocks project was usually accepted. However, the case of Poblenou was the opposite and there was a strong social protest, so this latter will be the case to be modeled and hopefully allow us to be able to simulate alternative policy scenarios that try to minimize social opposition.

The HUMAT integrated framework was used to model the process of attitude formation among the residents of Poblenou (Barcelona). As described in D7.3 (Antosz et al., 2020), the Poblenou agent-based model is very similar to the Vitoria Gasteiz agent-based model with respect to design and contents, with variations to account for differences in data sources, citizens' needs, entities and actors involved in the model and their policy strategies.

The main entity (agent) of this model is the citizen, which has two behavioural alternatives: either to accept or to reject the expansion of the project. As the agents tend to prioritize communication with other agents who are in their same state, this state influences their behavior when interacting in their social network: both in the inquiring process, to know the opinion of others, and in the signaling process, for the agents to disseminate their opinion (see Antosz et al., 2020, for details of these processes) .

The model also deals with several critical nodes that played a relevant role during the implementation of the project: the city council, the opposition political parties, local media, and other associations. In this model, associations play an important role and will be very active in their communicative acts. In addition, there are associations both in favor of the social innovation (for example CSP9, collective Poblenou superblock) and against (PASP, acronym in Catalan for platform of those affected by the Poblenou Superblock).

Different quantitative and qualitative procedures were used to collect relevant information in order to feed the system with case-specific data: analysis of the newspaper library, interviews with the promoters of the project, etc. Furthermore, a survey was conducted in 2020 to collect data directly from citizens. After the analysis of these data, 6 categories of citizens needs (and the relative importance they give to each one) were identified and included in the model with respect to:

- *Wellness* needs, which, among others, refer to health and security,
- *Environmental quality* needs, referring to air and noise pollution,
- *Comfort* which, among others, refer to parking availability and price,
- *City prestige*,
- *Participation* needs, referring to the possibility of participating in city decisions, and
- *Social* needs, referring to belongingness, social safety, social status, etc.

The main timeline implemented was:

1. May - September 2016, this period is considered the start-up of the pilot superblock.
2. September 2016. A period of citizen information and participation is launched.
3. October 2016- January 2017, period in which the promoters maintain meetings with the associations of residents and those affected by the final design of the superblock.
4. March - September 2017, period in which the final design of the superblock is implemented.

Along this timeline, critical nodes exerted their influence on citizens for and against the project through various communicative acts that were extracted from the documentary analysis. Table 4.9 contains an example showing how this communication has been parameterized to be injected into the model: supporter or opponent indicates being for or against the project, respectively; reach is the percentage of agents of the social network affected by the communication act; finally, some communications are made indirectly through other critical nodes and this is indicated in the column Secondary Critical Node.

Table 4.9 Example of communication acts of critical nodes (Freq. stands for Frequency).

Primary Critical Node	Behaviour	Starting Month	Starting Year	Ending Month	Ending Year	Freq.	Reach	Secondary Critical Node
City council	Supporter	8	2016	8	2016	1	0.1	City council
Local media	Supporter	8	2016	8	2016	1	0.1	Local media
City council	Opponent	9	2016	9	2016	1	0.1	City council
Political opposition	Opponent	9	2016	9	2016	1	0.1	Local media
Other Associations	Opponent	9	2016	11	2016	1	0.3	Local Media
Other Associations	Supporter	9	2016	9	2016	1	0.3	Local Media
Local Media	Opponent	9	2016	9	2016	1	0.1	Local Media
Other Associations	Supporter	9	2016	9	2016	2	0.1	Other associations

As already mentioned, in this model the communication strategies applied by the critical nodes are crucial to allow citizens to evolve and change their position. For the model to reflect reality, the communicative acts and their orientation in the four phases of the project were analyzed and the following conclusions have been drawn:

1. The first phase of the project (May-September 2016) is just an experimentation period, with the start-up of the Poblenou superblock pilot. In this period, it is mainly the city council which sends communications to the citizens and the local media publishes some news about it.
2. The second phase of the project (during September 2016) is an information and public participation phase with debates in the street, sector meetings, information points and an open day to assess the superblock proposal. The local government, as promoter, carries out many communicative acts, although so do associations both in favor (CSP9) and against (PASP) the social innovation.
3. During the third phase of the project (October 2016-January 2017) starts the final design of the superblock area, so the local authorities have meetings with the associations of residents and those affected for discussing this final design. At this

period, there is a strong mobilization of both supporters and opponents associations and the local media take a relevant role.

4. The last phase of the project (March-September 2017) corresponds to the implementation of the final design of the superblock. Again, the city council, as main promoter, takes an active communication role and there are some protests from associations against the project (PASP), also supported by the political opposition, although other associations continue to express their support to the superblocks project (CSP9).

The interface of the model is presented in Figure 4.15. In the center section the map of the area of Poblenou is shown with citizen agents placed in their corresponding census section, those in favor of the superblocks project coloured in green and those against in red. As the model evolves, the color of citizens changes accordingly.

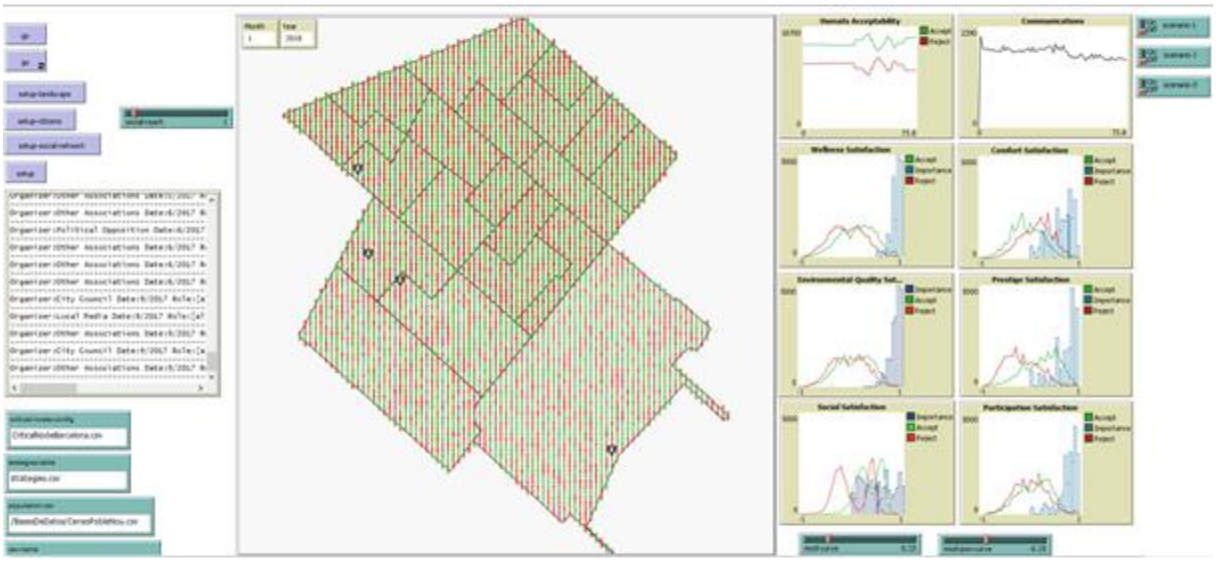


Figure 4.15. Interface of the model for Poblenou social innovation case.

On the left side, a text box is displayed showing information about the communication acts being launched by a critical node. On the right side, 8 graphics show a) the evolution of agents accepting (green)/rejecting (red) the social innovation, b) the number of agents being communicating and c) the evolution of the satisfaction/dissatisfaction on the six specific needs together with the importance of each (histogram in blue).

This model has been designed to reproduce the basic timeline of the several phases of the design and creation process, as previously described. To calibrate the model, field data from the case of Poblenou has been used (surveys, in-depth interviews with key informants, press releases, local media analysis) but also some relevant items that emerged in discussion with promoters and stakeholders during the policy scenario workshops.

As stated in Deliverable 7.3 (Antosz et al., 2020) the data for the agents were feed directly from the questionnaires, that were replicated proportionally to census and according to the main population categories identified by using Decision Trees (see Figure 4.16) and following the procedure described in (Alonso-Betanzos et al., 2021).

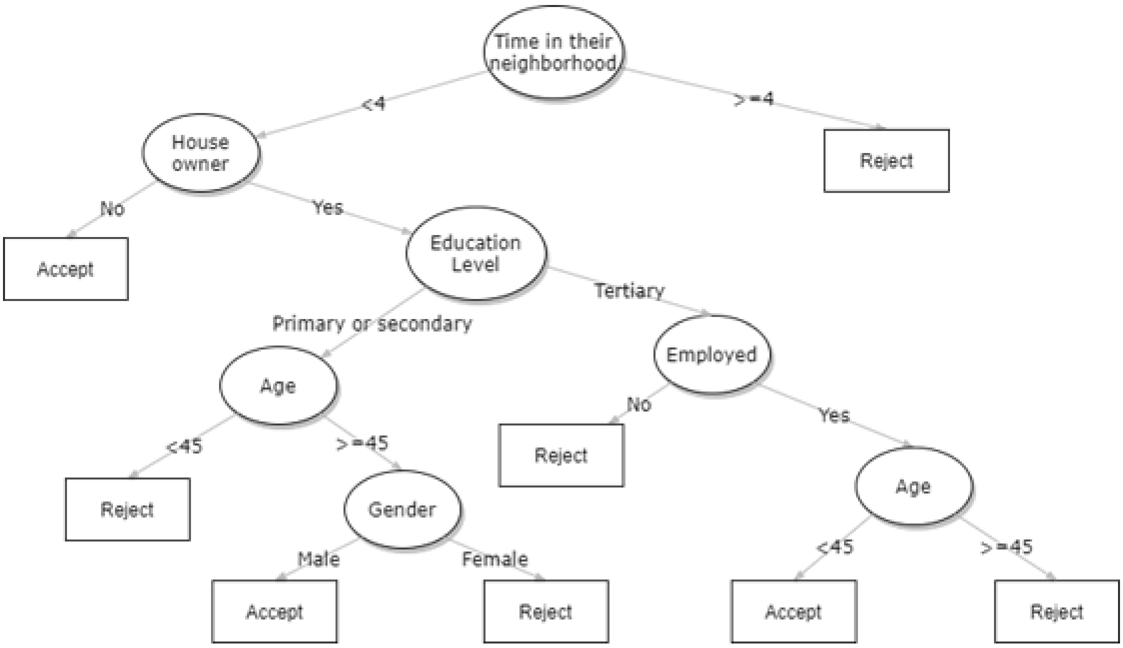


Figure 4.16. Population categories identified as relevant to the acceptance or rejection of the project

The model has several parameters as listed in Deliverable 7.3 (Antosz et al., 2020). In the interest of model simplicity and to make it easier to use, the values of many of them have been derived by applying theoretical knowledge.

4.4.3 Barcelona main model results and sensitivity analyses

The model underwent a sensitivity analysis and calibration of the parameters in order to faithfully reproduce the basic timeline. In this section we will show the results over this main timeline, taking into account that our desired outcome is to see the evolution of the number of agents accepting the superblocks project of Poblenou.

As in some of the alternative scenarios that will be described later we wish to include more communicative acts before the start of the project, the basic model starts in 2015 even though the first phase of the project starts in september 2016, so that the comparison between the real timeline and the alternative scenarios is clearer.

Table 4.10 shows the results at the end of the timeline where it can be observed that the model ends in 2018 with almost 61% of the population in favour of the project, which is coherent with the data obtained with the surveys. Also, Figure 4.17 shows the evolution of the number of agents accepting the project from 2015 to 2018. As can be observed, a decrease in the acceptability begins around October 2016 that corresponds to the third phase (with social mobilization), and starts to increase again once the final project starts its implementation (march 2017) although it slightly decreases during this last phase.

Table 4.10. Percentage of agents accepting or rejecting Barcelona project after running the model (average results of 10 runs). Mean percentage of agents and standard deviation (SD).

Accept(%)	SD (%)	Reject(%)	SD (%)
60.9	0.31	39.1	0.31

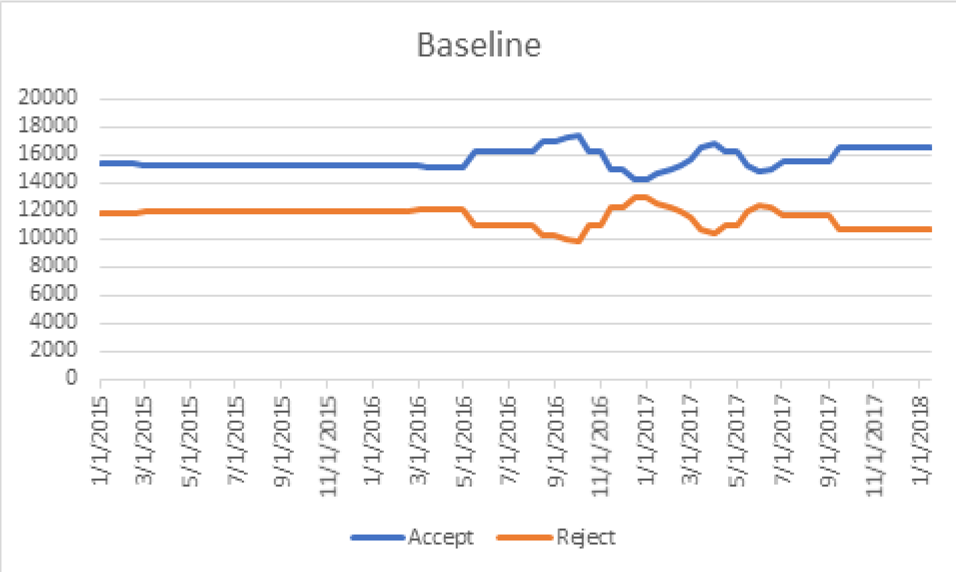


Figure 4.17. Evolution of the number of agents accepting the social innovation in Barcelona Poblenou superblock from 2015 to 2018.

Similarly to the Vitoria-Gasteiz model (section 4.1.3), a sensitivity analysis was carried out for the maximum influence that a critical node can exert over a citizen. Again, apart from the original value (0.2), three more values were considered: 0.1, 0.3 and 0.4. Table 4.11 shows the mean results achieved after 10 runs where it can be appreciated that best acceptability results are achieved when the influence parameter is higher. Figure 4.18 shows that, in periods where the city council is the main promoter of communicative acts (sometimes supported and / or criticized by local associations), the acceptability increases or decreases the most in direct relation with the value of the parameter. However, when the opponents intervene (mid-2017) this tendency reverses and the higher the parameter, the lower descent happens.

Table 4.11 Mean and Standard Deviation (over 10 different runs) of the number of agents that accept the superblocks' project after running the simulation.

	Timeline	
Max influence	**Mean (%)**	**SD**
0.1	59.15	0.39
0.2	60.90	0.31
0.3	62.75	0.29
0.4	64.03	0.30

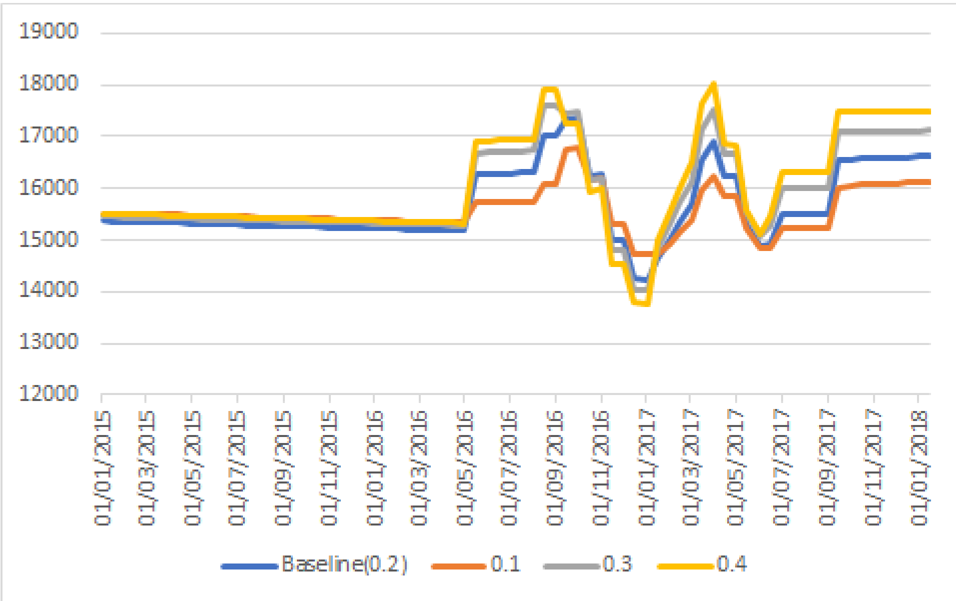


Figure 4.18. Number of agents accepting the social innovation from 2015 to 2018 varying the maximum influence that a critical node can exert.

4.5 Policy scenario development for the Barcelona Case

4.5.1 Overview policy scenario workshops

The urban mobility case considers two different cities in Spain: Vitoria-Gasteiz and Barcelona. A first round of policy scenario workshops was organized in both cities in two different sessions. The first session was conducted separately in Vitoria-Gasteiz and Barcelona. The second session was conducted simultaneously to facilitate the participants in both cities to engage in joint discussions and interchange experiences and lessons about the implementation of superblocks in their respective contexts. Following a participatory and interactive methodology, a diversity of participants reflected jointly on the experiences and lessons learned during the implementation of the superblocks program in the city, discussed the most relevant dimensions (barriers and facilitators) as well as suggested alternatives measures and communication strategies to increase citizens' acceptability of the superblocks model and so the following alternative scenarios were considered:

SCENARIO 1: Enhancing citizenry participation in the co-designing of social innovation
A) Organize guided **meetings** among **local government** and **citizens** B) Organize guided **meetings** over a **longer period**
SCENARIO 2: Campaign launched by the City Council addressing specific social and experiential needs
A) Focus on **comfort** and **participation** B) Focus on **wellness**, **comfort** and city **prestige** C) Focus on **different needs** but **directed to families with children** D) Focus on **wellness, comfort, participation** and city **prestige** E) Focus on **comfort**
SCENARIO 3: Environmental education combining awareness-raising strategy and participatory approach
A) Run an awareness campaign aimed at increasing the concern of Poblenou residents for well-being and environmental quality B) Similar to scenario 3A, but incorporating participatory meetings between neighbors C) Similar to scenario 3B, but adding new communications from local media and associations supporting the social innovation project D) Similar to scenario 3B, but adding new communications from local media supporting the social innovation project E) Similar to scenario 3C, but the duration of the campaign is extended a few months after the implementation of the superblock

4.5.2 Description of experiments

All the simulated scenarios start from the original timeline of the project as presented in section 4.4.3 and include new communication strategies from different critical nodes aiming at overcoming the conflictive situations. Analogously to the analysis of the basic timeline, 10 simulations have been carried out for all scenarios and the average results will be shown.

4.5.3 Scenario 1: Enhancing citizenry participation in the co-designing of social innovation

This scenario tries to reflect the development of a neighborhood participation strategy prior to the execution of the Poblenou pilot superblock, involving citizens in the development of the Superblock Action Plan.

Two different situations (1A and 1B) were tested in this scenario. The first situation (scenario 1A) consists of the organization of guided meetings (see section 2.5.3 for the description of these meetings) between the local government and citizens in the census sections affected by the Poblenou superblock a year before the start-up of the pilot superblock. Therefore, these meetings begin in September 2015 and are held during a year on a monthly basis, in all census sections affected. The second situation (scenario 1B) reinforces scenario 1A by increasing and prolonging the number of meetings. To do this, apart from the monthly meetings of scenario 1A, quarterly follow-up meetings are held during the year 2017 (see details at Table 4.12). Note that both alternatives increase notoriously the number of communications between citizens, in fact they clearly overlap when guided meetings take place (as can be seen in Figure 4.19), however the follow-up meetings increase communication in specific moments of the following months. Also bear in mind that in the baseline situation there are around 1700 agents communicating.

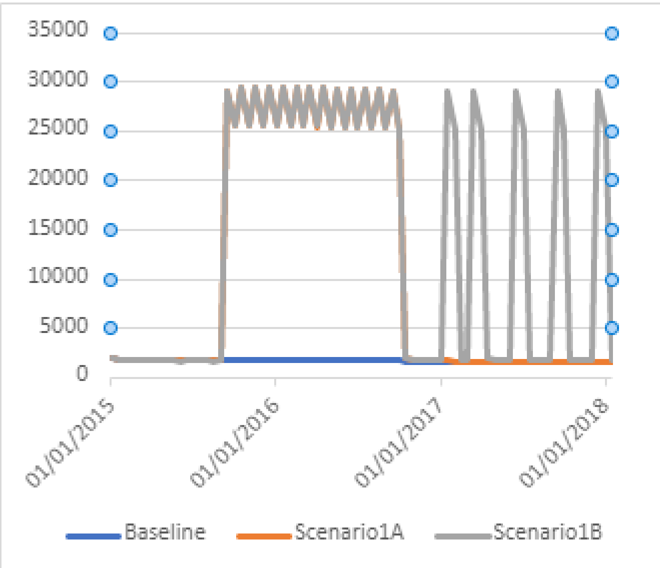


Figure 4.19. Scenario 1: Mean number of citizen agents communicating (average of 10 runs). X axis represents the temporal line, whereas Y axis indicates the number of agents

Table 4.12. New communications in Scenarios 1A and 1B.

	Sender	Communications (direct /indirect)	Reach (% social network)	Period
SCENARIO 1A	City Council	12 (12/0)	medium(20)	Sep 2015- Sep 2016
SCENARIO 1B	City Council	12 (12/0)	medium(20)	Sep 2015-Sep 2016
	City Council	4(4/0)	medium(20)	January 2017, March 2017, September 2017, December 2017

Table 4.13 illustrates the results of this Scenario. For the sake of comparison, the first row shows the base result obtained with the original timeline. Both scenarios increase acceptance compared to the base situation, although scenario 1B does so to a greater extent (almost 10% more of acceptability), which indicates the convenience of maintaining and reinforcing the meetings for a longer period. It is also important to note that in September 2016, when the start-up pilot was launched, the acceptability is very high (see Figure 4.20).

Table 4.13. Number of agents accepting or rejecting the Barcelona social innovation after running the model for Scenario 1 (average results of 10 runs). Mean percentage of agents and standard deviation (SD).

Scenario	Accept(%)	SD (%)	Reject(%)	SD (%)
Base	60.9	0.31	39.1	0.31
1A	66.54	0.32	33.46	0.32
1B	70.35	0.36	29.65	0.36

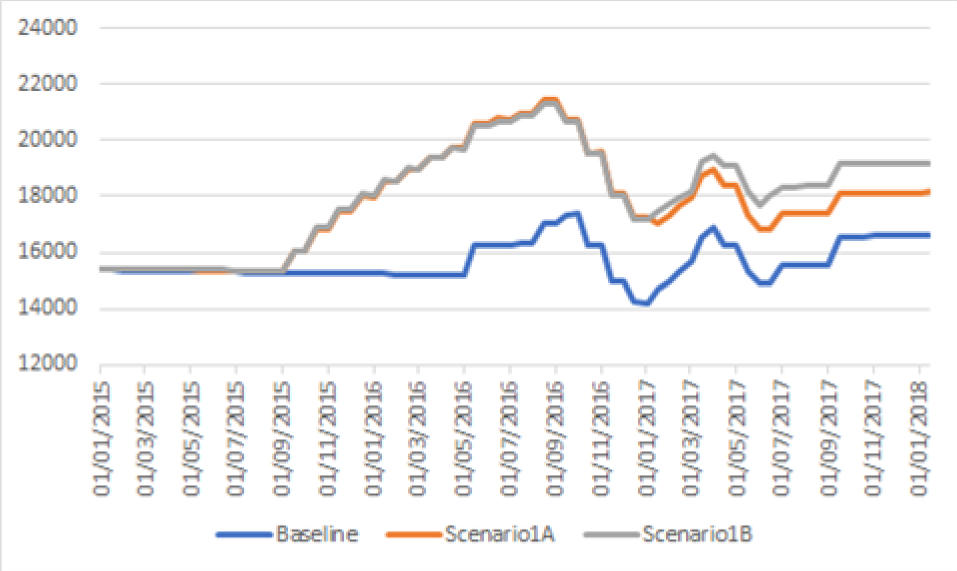


Figure 4.20. Evolution of the number of agents accepting the social innovation from 2015 to 2018. Comparison between the basic Timeline and scenarios 1A and 1B

4.5.4 Scenario 2: Campaign launched by the City Council addressing specific social and experiential needs

During the policy scenario workshop, stakeholders indicated the importance of identifying the needs of the different groups of population living and/or working in the neighbourhood, so it would be recommended to align the superblock preparatory activities (information, communication) with the satisfaction of these social needs. Then, this second alternative scenario consists of a new communication strategy for the promoters addressing the satisfaction of the specific needs of the residents.

Different situations were considered varying the addressed need (or needs) of the campaign and the targeted audience, note that all scenarios are aimed at the entire population except alternative C, which is aimed at families with children. The alternatives considered are:

- Scenario 2A represents a communication campaign of the Barcelona City Council, addressing the dimension of comfort and participation. This campaign consists of 12 communications made for 2 years (bi-monthly communication): September 2015 to September 2017. Furthermore, local media support this campaign and publish a news item for each communicative act (see details of the communications at table 4.14).
- Scenario 2B reproduces the same strategy as scenario 2A but addressing the needs of well-being (health, safety), comfort and prestige (recognition as an innovative city). Again, local media supports this campaign.
- Scenario 2C. In this scenario the campaign is aimed at families with children, intensifying the communication generated to this sector that is most concerned about the health of minors. Different campaigns were considered varying the needs addressed:

- o Scenario 2C.1. Focus on wellbeing
- o Scenario 2C.2. Focus on wellbeing and environmental quality.
- o Scenario 2C.3. Focus on wellbeing, participation, comfort and prestige.

- Scenario 2D. Communication campaign focused on the needs of well-being, participation, comfort and prestige.
- Scenario 2E. Communication campaign focused on the need for comfort. Although the scenarios are not strictly the same, this alternative is contemplated to allow a comparative analysis between the two models included in this research case, i.e., Barcelona and Vitoria-Gasteiz.

Table 4.14. New communications in the different alternatives of Scenario 2.

	Sender	Communications (direct /indirect)	Reach (% social network)	Period
SCENARIOS 2A, 2B, 2C, 2D, 2E	City Council	12 (12/0)	medium(20)	Sep 2015-Sep 2017 (bi-monthly)
	Local media	12(12/0)	medium(20)	Sep 2015-Sep 2017 (bi-monthly)

It is important to highlight that the population was replicated proportionally to census data and using decision trees as explained at the end of section 4.4.2, however this tree (see Figure 4.16) has no decision node based on “family with children”, so, during the process of generating the population, a new procedure was created that determines whether a new citizen belongs to a "family with children" or not. This procedure consists of the following steps:

1. First, the decision tree was analyzed, based on the available questionnaires, to determine how many agents (citizens) were in each leaf belonging to a "family with children" or not. It is supposed that citizens with children behave differently, if the same distribution prevails, the scenario 2C would behave exactly the same to the equivalent scenario aimed to the whole population. As expected, some differences were observed, for instance, those who have been a long period in the neighborhood and reject the social innovation (first upper leaf on the right at Figure 4.16) have no children (93,33%), however those who have not been in the neighborhood for too long, own a home, have higher education, work and are young (<45) have mostly young children (71,43%) and accept the social innovation (third leaf at the bottom at Figure 4.16).

2. Second, once a citizen is assigned to one of these profiles (see Alonso-Betanzos et col., 2021), it is established, if the citizen has children or not, keeping the proportions calculated in the previous step.

Table 4.15 shows the results obtained in this case. Similar to the previous scenario, this scenario also increases the acceptability significantly in the social innovation project (near 19%) when compared to the original situation, reaching much higher levels than Scenario 1.

It is observed that focusing on families is not the most effective solution, since, in the best of cases (scenario 2C.3), addressing the same needs as the scenario 2D, the results are clearly inferior (up to 8%). Focusing only in the need of comfort, it seems to have the least impact on acceptability (scenario 2E), and similar values to the Vitoria-Gasteiz case are reported (scenario 1 at section 4.2.3). However, covering different needs in the campaign results in a considerable increment in acceptability (scenario 2D).

Table 4.15. Number of agents accepting or rejecting Barcelona social innovation after running the model for Scenario 2 (average results of 10 runs). Mean percentage of agents and standard deviation (SD).

Scenario	Accept(%)	SD (%)	Reject(%)	SD (%)
Base	60.90	0.31	39.10	0.31
2A	70.86	0.33	29.19	0.33
2B	76.59	0.30	23.41	0.30
2C.1	67.20	0.29	32.80	0.29
2C.2	70.06	0.37	29.94	0.37
2C.3	71.50	0.32	28.50	0.32
2D	79.48	0.29	20.52	0.29
2E	65.94	0.39	34.06	0.39

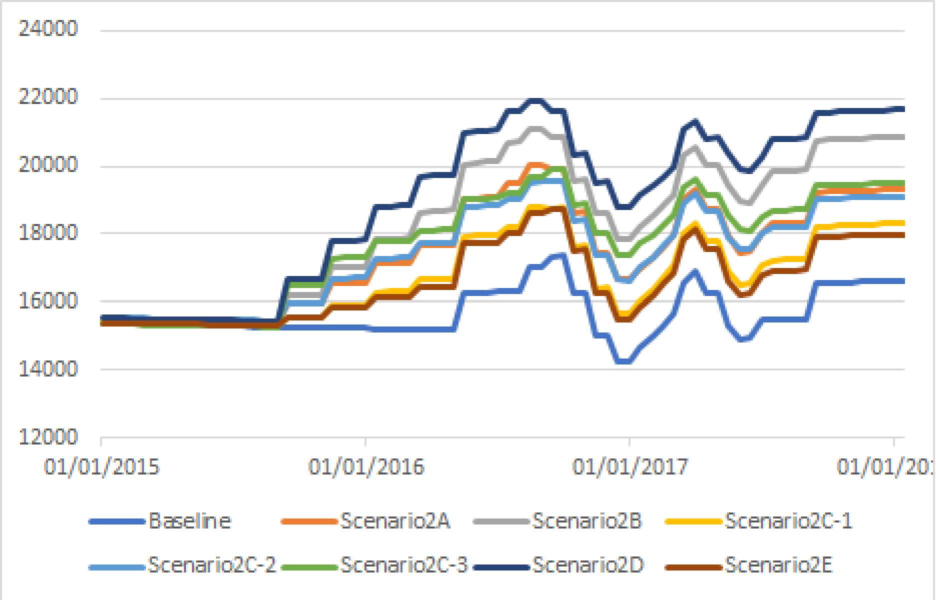


Figure 4.21. Evolution of the number of agents accepting the social innovation from 2015 to 2018. Comparison between the basic Timeline and scenarios 2A, 2B, 2C, 2D and 2E.

4.5.5 Scenario 3: Environmental education combining awareness-raising strategy and participatory approach

This scenario tries to represent an environmental awareness campaign with the aim of increasing the concern of the residents of Poblenou for the well-being and environmental quality, focusing the discourse on the relationship between environmental quality, health and safety. As in the previous scenarios, several situations were contemplated:

- Scenario 3A consists of an environmental awareness campaign promoted by the Barcelona City Council (see details at table 4.16). The communication strategy focuses on increasing the importance of citizens on environmental quality and well-being (health, safety).
- Scenario 3B combines the previous campaign of scenario 3A with participatory meetings between residents of the same census sections (neighbors), fostering citizen debate about superblocks. These communications between citizens will occur in 3 periods: September 2015, March 2016 and September 2016.
- Scenario 3C reproduces the previous one (scenario 3B) but adds new communications from local actors that support the campaign: media and associations. Thus, we added new communications from the local media (in favor of social innovation) and other communications from local associations, again details of these communications can be consulted in table 4.16.
- Scenario 3D reproduces 3B but only adds new communications from the local media supporting the campaign and ignores the communication of the local associations considered in scenario 3C.

- Scenario 3E reproduces 3C but extends the duration of the campaign until January 2018 and adds new communications between citizens in: March 2017 and September 2017.

Table 4.16. New communications in the different alternatives of Scenario 3.

	Sender	Communications (direct /indirect)	Reach (% social network)	Period
SCENARIOS 3A AND 3B	City Council	12 (12/0)	High (30)	Sep 2015-Sep 2016 (monthly)
SCENARIO 3C	City Council	12 (12/0)	High (30)	Sep 2015-Sep 2016 (monthly)
	Local media	3(3/0)	Medium (20)	Sep 2015, Mar 2016, Sep 2016
	Associations	3(3/0)	Medium(20)	Sep 2015, Mar 2016, Sep 2016
SCENARIO 3D	City Council	12 (12/0)	High (30)	Sep 2015-Sep 2016 (monthly)
	Local media	3(3/0)	Medium(20)	Sep 2015, Mar 2016, September 2016
SCENARIO 3E	City Council	28(28/0)	High(30)	Sep 2015-January 2018 (monthly)
	Local Media	5(5/0)	Medium (20)	Sep 2015, Mar 2016, Sep 2016, Mar 2017, Sep 2017
	Associations	5(5/0)	Medium (20)	Sep 2015, Mar 2016, Sep 2016, Mar 2017, Sep 2017

Table 4.17 shows the number of agents accepting the superblocks innovation once the model is run under the different approaches of scenario 3. Similarly, Figure 4.22 displays agents accepting the project in the execution of these scenarios from the period of the basic timeline. Both table 4.17 and figure 4.22 show that scenario 3 slightly overcomes the base timeline (in some cases), being the scenario with the least promising results. As can be seen, scenario 3B produces worse results than 3A. The reason is that, on the one hand, the city council's communication campaign was not yet focused on showing the advantages of superblocks but on raising awareness about the environment as a more general concept. On the other hand, meetings between neighbors take place at a time when they have very little information about superblocks and the main promoters do not participate in them. This means that the neighbors against the project reaffirm even more and convince some of those who were in favor or undecided. Scenario 3E turns out to be the best of this series denoting the importance of prolonging the campaign and the support of all local supporters.

Table 4.17. Number of agents accepting or rejecting Barcelona social innovation after running the model for Scenario 3 (average results of 10 runs). Mean percentage of agents and standard deviation (SD).

Scenario	Accept(%)	SD (%)	Reject(%)	SD (%)
Base	60.90	0.31	39.10	0.31
3A	60.92	0.29	39.08	0.29
3B	59.57	0.29	40.43	0.29
3C	61.44	0.42	38.56	0.42
3D	61.27	0.33	38.75	0.33
3E	64.27	0.70	35.70	0.70

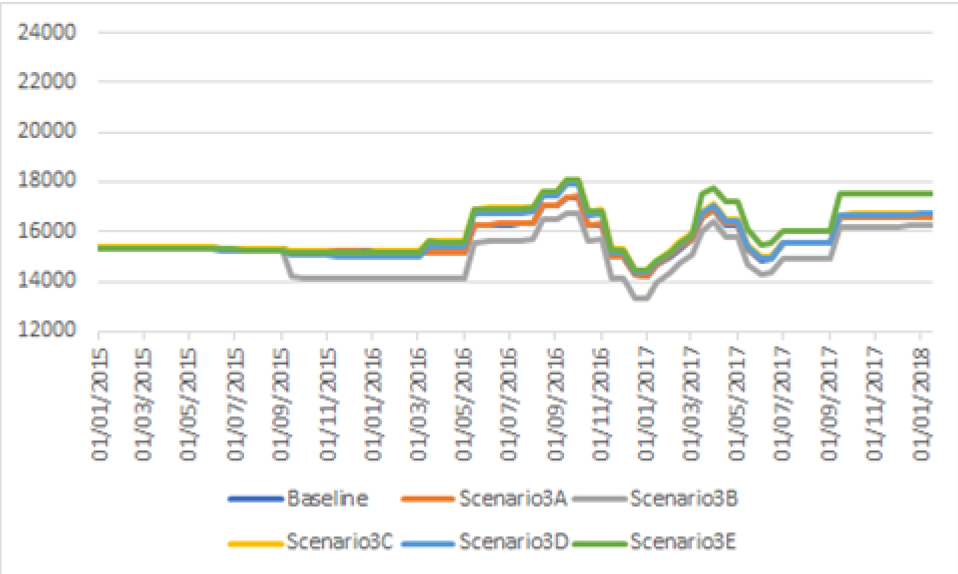


Figure 4.22. Evolution of the number of agents accepting the social innovation from 2015 to 2018. Comparison between the basic Timeline and scenarios 3A, 3B, 3C, 3D and 3E.

4.6 Conclusions and discussion of alternative scenarios for Barcelona

The model for Barcelona recreates the process of implementation of the pilot superblock of Poblenou. The model represents the main communication strategies developed by the promoters, the supporters and the opponents, since the starting of the project (summer 2016) to the execution of different structural and tactical interventions in the area of Poblenou (January 2018). Consistent with the results of the survey conducted in Barcelona, the baseline scenario shows that 60,9% of the population supports the expansion of the social innovation. Consequently, the model simulates changes in citizens' support towards the social innovation as a result of the implementation of a set of participatory and communication strategies promoted by the city council in the area of Poblenou.

Scenario 1 tested the impact of developing a participatory process engaging citizens and local actors in a co-designing exercise of the superblock, a participatory approach which was used by the promoters in other neighbourhoods in Barcelona, but not in Poblenou. This is implemented in the model as participatory meetings that start one year in advance of the implementation of the pilot superblock in Poblenou and are organized monthly. Moreover, the model simulates the impact of this policy in terms of the resulting spontaneous conversations among citizens within their social networks. The model shows that this policy strategy has a significant impact on the rate of citizen support towards superblocks. Scenario 1B, in particular, shows an increase of an additional **9.45%** of the population that would support the policy. In this variant, the results of the model point to the importance of implementing a participatory approach that involve frequent and regular communication actions (e.g., participatory meetings) sustained during and after the implementation of the social innovation (September 2015 – December 2016 – monthly; and 2017 – 4 meetings a year) (e.g., evaluation and follow-up meetings). Citizens are keener to support socially innovative policies when they experience that they have the chance to voice their opinion during the entire process of design and implementation of the policy and feel that their participation is meaningful.

Scenario 2 simulates the effect of targeted communication strategies addressing social and experiential needs that, according to the results of the SMARTEES survey, appear to be significant for the population of Barcelona city. Through several sub-scenarios, the needs for comfort, participation, wellbeing, and prestige have been targeted. Addressing the need for comfort raises the level of social acceptability of the superblock by **5.53%**. However, as scenarios 2B, and 2D show, if the communication strategy succeeds in addressing all the needs that are important for citizens, e.g. comfort, participation, wellbeing and prestige, the level of citizen's support increases by **18.58%**, which is significant in a case plagued with from high rates of social contestation. Even if the communication strategy targets only specific groups of the population, like families with children, the level of support towards the superblock rises significantly as sub-scenario 2C shows. Furthermore, the results also stress the importance of increasing the impact of the campaigns in terms of the rate of population addressed by involving local media supporting the campaign. Similar to the results of the Vitoria-Gasteiz's model, the case of Barcelona highlights the importance of anticipating negative reactions towards the unpopular measure by starting the campaign one year earlier, in September 2015, and maintaining the strategy for two years (until September 2017), thus reinforcing the positive outcomes of the superblock intervention with an intense and meaningful participatory process.

Scenario 3 represents the effect of an environmental awareness campaign in combination with citizen participation strategy during the implementation of the pilot superblock, which targets an increase in residents' concern regarding the relationship between wellbeing (in relation to health and safety in particular) and environmental quality. Different from the Vitoria-Gasteiz's model, this scenario seems to be the least promising, as the combination of awareness strategies involving both City Council and local associations increases the level of social acceptability only by 0.54% if the policy is displayed for a year (2015-2016). However, if the campaign is sustained for three years (January 2015-January 2018), as Scenario 3E tests, the percentage of population that would vote in favour of the superblock model rises by a slightly higher margin of 3.37%. Several reasons would explain that this policy has not achieved better results. One possible reason for this lack of impact might be that there were a series of studies conducted by a relevant research health institute in Barcelona which alarmed the population concerning the negative impact of traffic-related emissions on health, especially on the elderly and the young population. Thus, families in Poblenou might already have a high level of concern and this new campaign might not have a relevant impact on their level of health awareness and their attitudes towards superblocks.

5. Case cluster 5: Fuel Poverty

5.1 Overview

The fuel poverty case studies pertain to Aberdeen and Timişoara. This section primarily discusses the former, as the latter case study is sufficiently similar that the same model will be used. Fuel poverty has been a significant issue in Europe, the UK, and Scotland generally, as well as in Aberdeen, where the presence of the oil industry since the 1970s tends to mask awareness of the issues with poverty that persist in the city to this day. Indeed it is notable that the City has 21 of its 283 data zones in the most deprived 20% of the Scottish Index of Multiple Deprivation, accounting for approximately 8% of the City's population (Aberdeen City Council 2018, p. 98).

Fuel poverty has complex, multidimensional causes, including poor condition of buildings, long term physical and mental ill-health, precarious and low-paid employment, and rising energy prices. In 2018, fuel poverty (defined as the need to spend more than 10% of household income to maintain a satisfactory heating condition) affected 29,400 households in Aberdeen (28%), including 9,000 households in extreme fuel poverty (where the proportion of income is more than 20%) (Aberdeen City Council, 2018). This situation persists despite a Scottish Government commitment in 2002 to eradicate fuel poverty in Scotland by the end of 2016 (ibid., p. 92). With the vast majority of social housing meeting the Scottish Government's minimum energy efficiency standards for social housing, but fuel poverty still being a greater issue in that sector than in private-rented or owner-occupied accommodation, the Council observe (Aberdeen City Council 2018, p. 96) that energy price rises and household income are key drivers of fuel poverty.

In this context, Aberdeen City is interested in expanding its District Heating network, which has been run by a non-for-profit organization called 'Aberdeen Heat and Power' since 2002. Running the organization as a not-for-profit means Aberdeen Heat and Power can provide heating to households most in need with a considerably lower return-on-investment than is typically sought by a standard for-profit private company. This, along with the creation of an independent advice-giving body (SCARF: Save Costs And Reduce Fuel) in the mid-1980s, forms the basis of Aberdeen's social innovation, in the sense of "new ways of doing [and] organizing" espoused by Avelino et al. (2019).

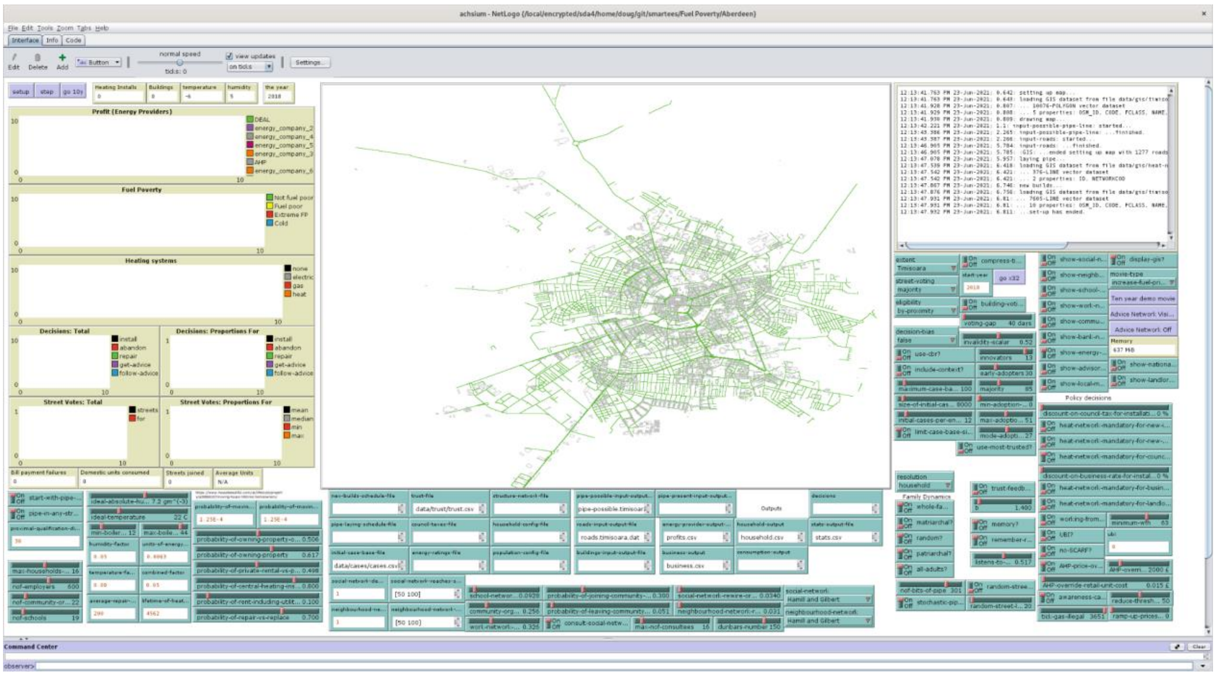


Figure 5.1. The ACHSIUM model featuring the Timişoara case study.

5.2 Policy scenario development

Over the course of the policy workshops in Aberdeen, policy scenarios were developed along four themes, detailed in other SMARTEES deliverables:

- Technological innovation: in particular, the introduction of hydrogen-based central heating boilers, which have been speculated as being a suitable alternative to natural gas since they can make use of the same infrastructure (Dodds and Demoullin 2013), albeit that electrification may be a cheaper decarbonization option (Quarton and Samsatli 2020). Equally, Aberdeen Heat and Power could replace their gas boilers with hydrogen boilers to reduce their energy costs.
- Legislative: for example, phasing out the installation of new natural gas boiler installations, as recommended by IEA in 2025 as a key milestone in the pathway to net zero by 2050 (IEA 2021, p. 20). More locally to Aberdeen, planning legislation could be used to mandate new developments use the heat network.
- Financial: currently, Aberdeen's district heating networks are focused on social housing in various multistorey apartment buildings dispersed throughout Aberdeen. The cost per dwelling for heat network installation is considerably lower for such buildings than it is for tenements (3-4 storey terraces with two apartments per floor) and other dwellings (terraced, semidetached and detached houses), because of the high costs of pipelaying (approximately £1,000±£500 per metre; DECC 2015, p. 12)), which leads to a wide range in costs of installation per MWh (£25-£624; DECC 2015, p. 12).
- Social: we can simulate awareness-raising campaigns as part of the district heating roll-out, so that agents know that the heat network is an option that will work for them when deciding whether to use it.

5.3 Experimentation with policy scenarios

5.3.1 Sensitivity analysis

Though not a policy scenario as such, it is informative to modellers, and potentially to stakeholders, to explore the sensitivities of the model's parameters, and their impacts on outcome variables of interest. The method used for this study entails making as many runs as time and space will allow (here 2,353) from uniformly distributed samples of parameter space, and then examining the distribution of those parameters matching specified criteria (in the case of the results presented here, runs entailing at least 1,500 adoptions of the heat network by time step 1,095 in the model – after three years). Here, we examine the output by visual inspection, and by conducting a Kruskal test on the distribution to see if there is any functional relationship between the parameter and the number of connected households (the null hypothesis being that this relationship is random). The parameters varied, and the p-values of those Kruskal tests conducted, are shown in Table 5.1.

Parameters can be divided into three categories:

- 'Traditional': the parameter acts in much the same way as the factors on a polynomial. This is the traditional sense in which parameters are understood by mathematicians, and they *only* act to change the shape of a fitting function. They have no real-world meaning, and can only be measured by calibrating them to minimize fitting error of the function as a whole to a set of observed data.
- 'Ontological': these kinds of parameter are contrasted with traditional in that they could theoretically be measured (though they can also be calibrated by exploring values' fit-to-data), and do have some level of real-world meaning. They are subdivided into two types that are relevant for policy scenarios:
    - 'Controllable': it is possible for a governing organization to make adjustments that control the values of these parameters. Examples include pricing, or thresholds for categorization.
    - 'Noncontrollable': a governing organization would not usually expect to be in a position to control these values. Examples could include demographics of residents, or perceptions of thermal comfort.

Table 5.1: Parameters varied in the sensitivity study of the model of Aberdeen, and the p-value of a Kruskal test on the histogram of matching parameter distributions (0 indicates a value less than 1e-15).

parameter	type	min.	max.	p-value
all-adults?	boolean	TRUE	FALSE	0.166
b	numeric	1	2	0.05875
combined-factor	numeric	0.001	0.02	0.8573
early-adopters	numeric	30	60	0
humidity-factor	numeric	0.001	0.02	0.9909
ideal-absolute-humidity	numeric	5	10	0.03167
ideal-temperature	numeric	15	25	0.9869
innovators	numeric	1	15	0
majority	numeric	76	100	0
probability-of-moving-in	numeric	1.20E-04	1.30E-04	0.4039
probability-of-moving-out	numeric	1.20E-04	1.30E-04	0.6957
probability-of-owning-property	numeric	0.2	0.6	0.0003207
probability-of-owning-property-outright	numeric	0	1	0.9852
probability-of-private-rental-vs-public	numeric	0	1	0
temperature-factor	numeric	0.001	0.03	0.6308
units-of-energy-per-degree	numeric	0.001	0.02	0.8631

In terms of usefulness of knowledge, it is clear that ‘traditional’ parameters, which have no real-world meaning, are not useful to stakeholders: there is no easy way for them to understand how they can affect the system such that a new set of observed data would require different parameter values to effect an optimum fit. Ideally, therefore, from a pragmatic perspective, we would try and avoid situations whereby traditional parameters affected model outcomes. Ontological parameters are useful whether controllable or not: they can give guidance on where matters within stakeholders’ control can be adjusted towards more robustly favourable outcomes; they can also highlight their limits on their ability to control things.

In table 5.1, the p-values of the Kruskal tests suggests significant results for the innovators, early-adopters, and majority parameters. These parameters determine psychodemographic profiles of the agents with respect to Rogers (2003) theory of innovation diffusion, as characterised by Moore (2014). Innovators are drawn to new technology (in Aberdeen, district heating) simply because it is new, while early adopters need to know that the technology will work for them. In the model, we simplified the early and late majority (which are separated by ease of use in Moore (2014)); such agents adopting if most of those they know have. Rather than using the specific values for these parameters suggested by the theory, we explored other cumulative percentage points in the population at which the boundaries between innovators and early adopters, early adopters and majority, and majority and laggards occur. These are theoretically measurable parameters, and given the dynamics implemented in the model, it is unsurprising that their values should have a significant influence on heat network adoption, albeit that they are not in the control of the Council. However, figure 5.2 shows that lower values of innovators are typically associated with higher proportions of runs meeting the adoption criterion, which is counterintuitive given their automatic adoption – even if the higher values are associated with roughly the expected proportion of the population as per innovation theory (2.5%). With laggards adopting only if they have to, we would also expect higher, rather than lower values of majority to be associated with runs meeting the adoption criterion. The early-adopters parameter behaves much as expected.

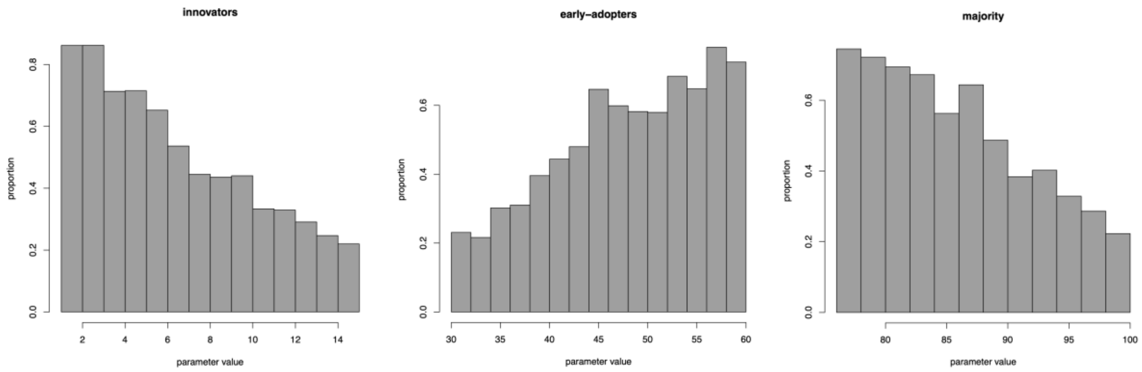


Figure 5.2: Posterior distributions of psychodemographic parameters leading to at least 1,500 adoptions of the heat network by time step 1,095 in the sensitivity runs.

The other parameter with a significant effect is probability-of-private-rental-vs-public. To some extent this parameter is in control of the Council, through limiting or prohibiting sale of the roughly 20,000 properties they own in the City to provide social housing. In the model, the fact that the Council owns the properties mean they decide in favour of adopting district heating on behalf of the tenant. Given these dynamics, it is again unsurprising that this parameter would prove significant. As figure 5.3 confirms, lower values of the parameter have greater association with runs entailing at least 1,500 adoptions of the heat network in step 1,095.

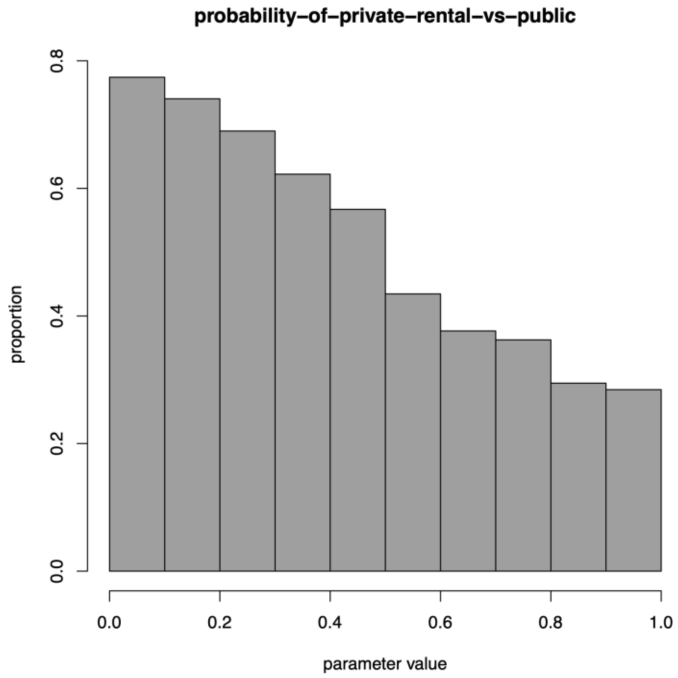


Figure 5.3: Histogram of probability-of-private-rental-vs-public posterior distribution as selected from runs entailing at least 1,500 adoptions in step 1,095.

5.3.2 Policy scenarios

This section briefly covers work done to simulate some of the policy scenarios discussed with stakeholders and detailed in D5.2. Using selected values of the parameters, we simulated the policy scenarios as follows:

- New technology: introduce a new technology into the system as a tariff with a high connection cost (to represent the installation of new equipment) and lower ongoing costs (to represent more favourable conditions for the technology).
- Ban gas: implement a prohibition on new gas installations, with gas prices rising in tariffs thereafter.
- Awareness raising: implement more favourable conditions for adoption by simulating awareness campaigns running concurrently with street votes. These affect early adopters by giving them the information that the heat network will keep them warm (rather than them asking people they know for this information), and majority by reducing the proportion of their social network who needs to have adopted for them to have adopted (essentially, representing the idea that they are told lots of people like them use the heat network).

For each of these scenarios, we ran the model 100 times to gauge the level of uncertainty in the outcomes. We measure the results by comparing the amount of pipe rolled out, numbers of households in fuel poverty and extreme fuel poverty, and number of households using district heating – all at time step 2190 of the model (i.e. six years). These outcome variables are shown using boxplots in figures 5.4, 5.5 and 5.6. The results suggest that the new technology and ban gas scenarios are similar in their influence on the amount of pipe laid and number of households in fuel poverty, while new technology has proven better than banning gas at reducing the number of households in extreme fuel poverty, albeit with fewer households joining the heat network. While there is variability in the results, they do also show that awareness-raising generally has better outcomes for all the outcome variables: more pipe laid, fewer people in fuel poverty and extreme fuel poverty, and more households using the heat network.

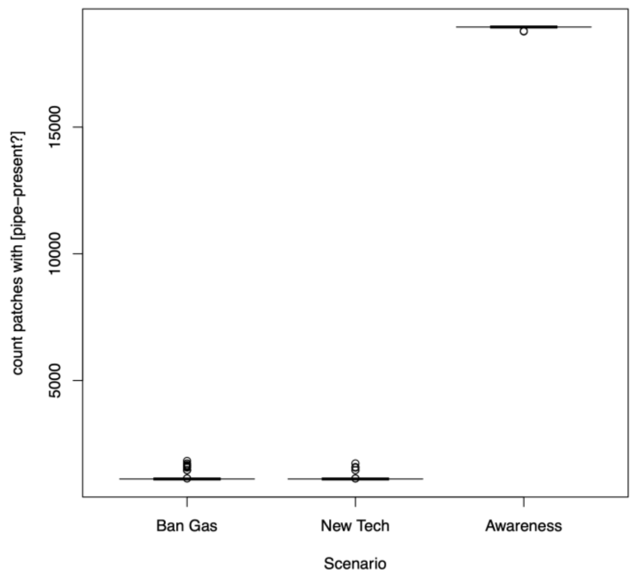


Figure 5.4: Rollout of the heat pipe network in the streets of Torry compared.

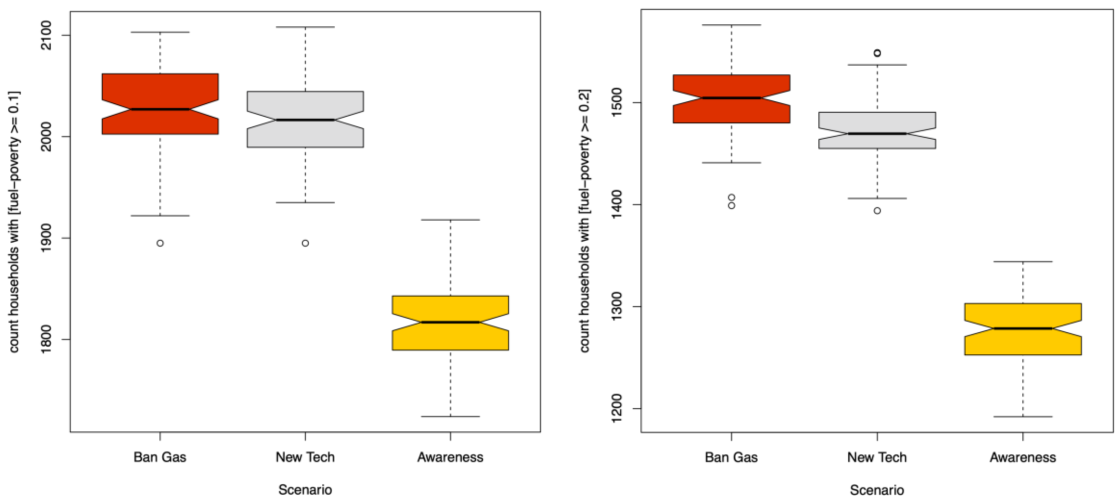


Figure 5.5: Households in fuel poverty (left) and extreme fuel poverty (right). 'Notches' in the boxplots allow estimation by eye of the significance of any difference in the distributions – if the notches do not overlap, the two distributions are likely significantly different.

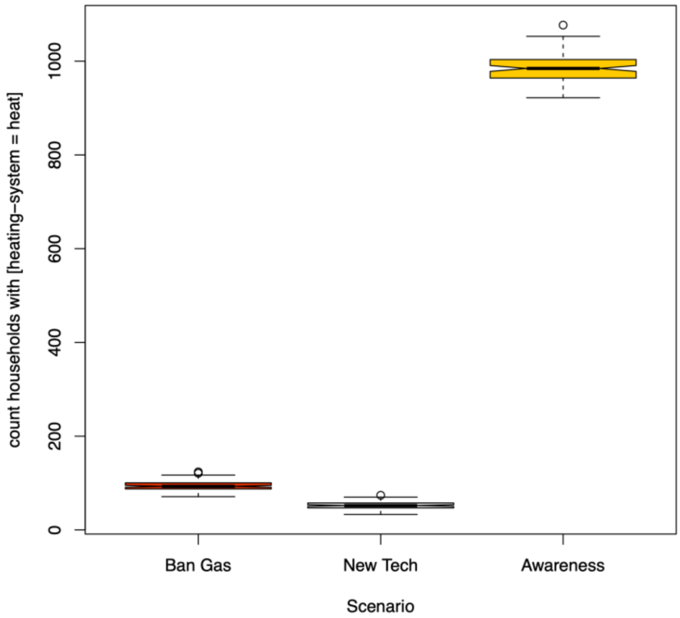


Figure 5.5: Number of households using the heat network in each of the three scenarios.

5.4 Conclusions and discussion

The significance of the probability-of-private-rental-vs-public parameter in the model, though unsurprising, does have important implications both for the model and for the long-term ambition of the Council to join up their currently separated district heating schemes to improve resilience and take best advantage of the opportunities offered by the Council's energy from waste scheme. This mainly pertains to strategies for identifying favourable (cost-effective) routes to use to connect the disjoint networks, which should be biased towards those entailing larger numbers of council-owned properties. Given the earlier reported observation that council tenants are more likely to be in fuel poverty than private tenants or owner-occupiers, such a strategy would also be best for addressing the Scottish Government's priority of eliminating fuel poverty. For the model, exploring specific scenarios of heat pipe roll-out will require access to data on the locations of council-owned properties -- as the spatial distributions of these can be anticipated to be significant in determining routes taken. In the absence of such data (e.g. where GDPR, licensing or other constraints prohibit it being shared), the model could still be useful in exploring the sensitivity of the outcomes to the spatial distribution.

Turning to the scenarios, the results have suggested that awareness-raising is on-the-whole more effective than banning new gas installations or introducing new (low carbon) heating technology in addressing fuel poverty, and in achieving the Council's aim of wider use of the heat network with a view to making good use of the opportunities provided by its new energy-from-waste plant. This is not to say that technological and legislative measures are ineffective. It is important to note that this result is specific to the algorithms used in the model to implement awareness-raising; without further investigation exploring alternative algorithms, it is difficult to justify making the general claim that in the real world awareness-raising will necessarily be more effective. However, with an eye on the innovation diffusion theory rather than the model, we might well expect that new technology would lead to lower adoption of the heat network than banning gas because the innovators would be drawn to the new technology just as much as the heat network – effectively reducing the opportunity to expand the adoption of the heat network. As for banning gas, the timing will be important – if the heat network is not sufficiently rolled out at the time gas is banned, households have little choice but to adopt electric heating as the alternative. They are then that much less likely to adopt the heat network should it later become an option because of the relatively recent commitment to electric heating and any associated financial outlay. Though this reasoning is based on understanding of the case study rather than processes in the model, it does highlight that social as well as technological measures have their role to play in achieving low-carbon energy transitions, and that the model can provoke thinking that might not otherwise have occurred.

6. Conclusion Chapter

This report presents the first policy scenario experiments conducted with the agent based simulation models of local social innovation processes. In the previously produced report (D7.3) we demonstrated that it is possible to use agent based models to simulate the local social innovative processes for different empirical cases. Here we demonstrate that these models can actually be used to simulate how different policies and events could have influenced the social dynamics and resulting success of policy plans. This is an important step in developing a better understanding of how processes of social innovation can be supported.

Whereas in the social sciences much research is available on the effects of certain policies on individual perceptions, preferences and behaviour, less is known about how sensitive social dynamics can be when plans are being discussed and criticized in local communities. Here we deal with social dynamics that sometimes can display unexpected turbulences, tipping points and inertia. The simulation models that we have developed are capable of generating such social dynamics on a representative network of artificial citizens that are interacting about innovative plans. This allows exploring how local communities discuss plans like closing a park for traffic, collective investment in home improvement, joining a heat network or developing a city block with a higher quality-of-life. The models can reveal interesting and relevant social dynamics related to energy savings, as for example the model results of Järva, Stockholm suggest that a more rapid renovation of buildings can reduce inequality in a neighborhood. This indicates that the models can contribute to a more integrated perspective on quality-of-life when exploring the potential effects of energy related social innovation projects

The simulation models that we developed allow us to replicate historical cases in a convincing way, balancing the realism of socio-cognitive dynamics with the level of empirical detail. As such, the models allow us to “regrow” the historic case. But because it is a computer simulation, we can rerun the past as often as we like, and conduct what-if experiments with these models in a systematic manner. In this report we demonstrate a number of such policy scenario experiments for the different cases. For example, does an informational campaign have an impact on the opinions concerning the opening or closing of a park (Groningen case)? Does more discussion have an impact on the enthusiasm about implementing a low-car-intens superblock, and how do media support such a policy (Vitoria Gasteiz case)? How important is trust in developing support for a plan (El Hierro case). Does an increased awareness result in a higher interest in joining a heat network (Aberdeen case)?

A relevant contribution of the simulation models is their capability of simulating second order effects of network dynamics. Where classical social scientific studies are capable of identifying the (first order) effect of e.g. an informational campaign, in agent based models it is possible to simulate how these effects transpire through a community.

For example, the impact of an informational campaign has a first order effect on the opinions of individuals, and second order effects if these individuals subsequently influence others in their networks. As a result we observe that in some cases the simulations display bimodal distributions of outcomes, which indicate the existence of so-called points of attraction in the solution space. In deliverable 7.2, section 2 (Antosz et al, 2019) a theoretical basis for the existence of such complex dynamics is provided. For policy development the identification of such dynamics is important as it indicates that a point prediction of the impact of a policy is not possible because small differences in initial conditions may result in different outcomes. As a consequence, simulation models can identify the existence of such fundamental uncertainties that force policy makers to adopt a more adaptive perspective on policy. If a simulation model signals the possibility of different outcomes of an intervention, policy makers should be more closely monitoring the impact of policies, and adapt policies to steer away from unwanted outcomes. Simulation models help here to anticipate different outcomes and to prepare for additional policies helping to steer developments in the desired direction.

Whereas the agent based models are opening new possibilities to test second order social effects, also policies that are - deliberately or not - addressing such second order effects can be studied. For example, in the Groningen case study we explored the effect of organising group meetings attended by a selected number of interested agents. In real cases, the attendance of group meetings depends on the location where they are organised and the time. A town hall meeting may be perceived to be more of a high-brow setting, which can be experienced as intimidating by e.g. less educated people. As a result, the people attending such a meeting will have different characteristics than organising a meeting in the afternoon or evening in a local neighborhood setting, such as a popular café. In the simulation we can replicate this by taking out a selected group of agents with specific characteristics, and let them change their opinions as a result of the group meeting. Afterwards these agents return to their neighborhood/networks and share their opinions in their networks, thus generating second order effects. In principle it is even possible to simulate the social dynamics of the group meetings themselves, and explore what different outcomes such meetings can have depending on the initial beliefs and importances of the different simulated participants.

Conducting policy scenario experiments on a simulated population is thus helpful in anticipating barriers in a local social innovation process, and in exploring what policies support avoiding negative developments in the community. For example, when a proposed plan bears a risk of polarisations in a community, or if a small group of citizens will suffer from implementing a plan, a simulation model can explore ways to avoid (parts of) a community ending up in negative scenarios.

After developing models for the main cases we also implemented the follower cases. The implementation of follower cases was done in a more crude way, adapting a main case to the basic characteristics of a follower case (e.g. Budapest). The key lesson here is that implementing a follower case model is a much easier and faster process than developing the initial main case model. This is a relevant finding, as it indicates that other cases that in some way reflect some of the key characteristics of the main cases are relatively easy to implement as well, especially when good data are available. This means that other cities that want to develop simulation models for specific social innovation projects may be capable - with support - of developing a case model within a matter of weeks. The sandbox tool here serves as an initial support in identifying which type of case-model fits best to the social innovation at hand. Hence there is a great potential for the practical use of simulation models of social innovations to explore the dynamics associated with different policy strategies.

A key warning here is that using such models themselves can have an impact on the social dynamics. If for example models are being used without informing the citizens, and are being used to optimize the conditions to get a certain plan accepted, without the citizens having an opportunity to discuss the plan, a model would be used unethically as a manipulative instrument. This would strongly contrast with the advocated co-creative use of these models. When it is getting known in the community that they are being modelled without consent, it seems obvious that the trust of the community in collaborating in a project will be low.

Instead, we advocate that the use of such models for future projects should include the local community being modelled. Not only because letting people discuss the way in which they are being represented in the model will result in more accurate models of the situation, but also because the modelling process itself serves as a tool to support local social innovation. Having people with different perspectives and interests together discussing model outcomes that describe their own behaviour and future quality-of-life provides a helicopter-view on the plan. This would support developing a better perspective on the outcomes of other people, and thus hopefully foster the dialogue that is so important in keeping a good spirited local community

Considering that local social innovation plays an important part in the EU “green deal” plans, focusing on the social dynamics and community wellbeing are important topics where the type of models we developed in SMARTEES can contribute to. The models that we developed as a proof-of-concept here took quite some time to develop. First of all, the architecture of the models had to be developed, as existing integrative models that are capable of simulating the dynamics of social innovation were not available. Second, implementing historic cases was important to demonstrate the capacity of the models to replicate the empirical reality, but was also challenging because of the incomplete data. However, for future practical use the modelling will be much easier because (1) the modelling architecture is available, so less time will be needed for the implementation, and (2) data will be more accessible, and additional data can be collected using e.g., interviews and surveys, so the morel parameterization will also be easier.

The current report presents - as a proof of concept - the first examples of simulated policy scenarios, but we realise too well that many more policy experiments can be envisaged. During the workshops interesting discussions took place with respect to what types of policies can be envisaged. One interesting policy that we did not implement (yet) due to the additional layer of network complexity it would require is the organization of informational/discussion meetings on the plans. This policy scenario type relates to the organisation of meetings to discuss a plan. Here for example a distinction can be made between town hall meetings versus neighbourhood meetings. These meetings can attract different people with different perspectives and interests, depending on where they are organised and at what time. For example, meetings scheduled during the day will result in an underrepresentation of working people, whereas meetings in the afternoon may result in an underrepresentation of (young) parents. A relevant policy question here is how such meetings may impact the people that did not attend the meeting themselves? Will information obtained by attending people diffuse through the community, or will subgroups in the community feel excluded and rebel against the plans? Experiments revealing such social dynamics are envisaged in the future.

Reflecting on the scientific progress being made in the project, we demonstrate the possibility of conducting experiments on a simulated population that would be impossible - and often unethical - when conducted on a real population. Simulations make it possible to conduct many runs, explore the landscape of possible outcomes, and identify if certain tipping points exist in the community dynamics. Concerning the experimentation, it is possible to test how a wide variety of policies and events may affect the community dynamics. This possibility opens up experimental possibilities for an old ambition in the social sciences: understanding the dynamics of group processes. Being capable of growing these dynamics under experimental control contributes to the development of a "generative social science" (Epstein, 2006). We hope that this generative social science will also contribute to a more inclusive policy process, resulting in strengthening local democratic processes in the context of local social innovation. In the course of this modelling work package we made significant progress in our capacity to model the social dynamics in social innovation. We also experienced that the models provided many interesting dynamics and possibilities for deeper analysis of the processes taking place, e.g. trace following of social influences in complex networks. Many new questions emerged during the project, and increasingly we realised the possibility to do much deeper experiments with our case models. For example, the role of opinion leaders, internet channels, citizen panels and many more options for social exchange could be tested, and a very detailed analysis of how influence propagates and transforms in a social system becomes possible. For example, one person being convinced by information may successively exert a normative influence on other people. Hence we can imagine that a complete research project could be devoted to the further analysis of each of the single cases we presented in this report. However, for the time being we have demonstrated the value and potential of agent based models in getting a grip on the social dynamics that are critical in making social innovations a success.

References

Aberdeen City Council (2018) *Local Housing Strategy 2018-2023* https://www.aberdeencity.gov.uk/sites/default/files/2018-09/Local%20Housing%20Strategy%202018-2023.pdf

Alonso-Betanzos, A., Guijarro-Berdiñas, B., Rodríguez-Arias, A., Sánchez-Maroño, N. (2021) Generating a synthetic population of agents through decision trees and socio demographic data. 16th International Work-Conference on Artificial Neural Networks (IWANN).

Antosz, P., Jager, W., Polhill, G., Salt, D., Alonso-Betanzos, A., Sanchez-Marono, N., Guijarro-Berdinas, B., Rodríguez, A. (2019). D7.2 Simulation model implementing different relevant layers of social innovation, human choice behaviour and habitual structures Report describing the theoretical principles of the model and justification and clarification of assumptions used. SMARTEES Deliverable 7.2; August 2019 > Download

Antosz, A., Jager, W., Polhill, J.G., Salt, D., Scalco, A., Alonso-Betanzos, A., Sánchez-Maroño, N., Guijarro-Berdiñas, B., Rodríguez, A., (2020). *SMARTEES simulation implementations*. Deliverable 7.3; December 2020 > Download

Avelino, F., Wittmayer, J.M., Pel, B., Weaver, P., Dumitru, A., Haxeltine, A., Kemp, R., Jørgensen, M.S., Bauler, T., Ruijsink, S., O'Riordan, T., (2019) Transformative social innovation and (dis)empowerment. *Technological Forecasting and Social Change* **145**, 195-206. https://doi.org/10.1016/j.techfore.2017.05.002

Department of Energy and Climate Change (2015) Assessment of the Costs, Performance, and Characteristics of UK Heat Networks. https://www.gov.uk/government/publications/assessment-of-the-costs-performance-and-characteristics-of-uk-heat-networks

Dodds, P. E. & Demoullin, S. (2013) Conversion of the UK gas system to transport hydrogen. *International Journal of Hydrogen Energy* **38** (18), 7189-7200.

Dumitru, A. Lema Blanco, I., Albulescu, P., Antosz, P., Bouman, L., Colley, K., Craig, T., Jager, W., Macsinga, I., Meskovic, E., Mischkowski, N., Pellegrini Masini, G., Polhill, G., Quinti, G., Salt, D., Somervail, P., Wilson, R. (2021a). *Policy Recommendations for each cluster of case-studies. Insights from policy scenario workshops.* Deliverable 5.2, August 2021. SMARTEES project. Grant agreement No 763912.

Dumitru, A., & Wendling, L., (2021b). *Evaluating the impact of nature-based solutions. Appendix of methods.* Directorate-General for Research and Innovation (European Commission). ISBN 978-92-76-22960-5, DOI 10.2777/11361, Catalogue number KI-02-20-861-EN-N

Enarsson, L., (no date). Sustainable Järva -- Rebuilding the suburbs. https://international.stockholm.se/globalassets/listor/sustainable-jarva-a4-info.pdf

Epstein, J.M. (2006). Generative Social Science. Princeton University Press.

Gilbert, N., Ahrweiler, P., Barbrook-Johnson, P., Narasimhan, K. P., Wilkinson, H. (2018) Computational modelling of public policy: reflections on practice. *Journal of Artificial Societies and Social Simulation* **21** (4), 14. http://jasss.soc.surrey.ac.uk/21/1/14.html

Haugeland, J. (1985) *Artificial Intelligence: The Very Idea*. MIT Press.

International Energy Agency (2021) Net Zero by 2050: A Roadmap for the Global Energy Sector. https://www.iea.org/reports/net-zero-by-2050

Jager, W. (2021). Using Agent Based Modelling to Explore Behavioural Dynamics Affecting our Climate. *Current Opinion in Psychology*. , 42, 133-139. ISSN 2352-250X, https://doi.org/10.1016/j.copsyc.2021.06.024. (https://www.sciencedirect.com/science/article/pii/S2352250X21000968)

Municipality of Groningen (1994). Gemeente Groningen's report from the referendum: Uitslag en Achtergrond van het Referendum Noorderplantsoen. October 1994. https://os-groningen.nl/wp-content/uploads/2018/11/referendum-noorderplantsoen-1994.pdf

Municipality of Groningen (1999). Statistical yearbook Groningen 1999

Municipality of Barcelona (2016). Let's fill streets with life. https://ajuntament.barcelona.cat/ecologiaurbana/sites/default/files/en_gb_MESURA %20GOVERN%20SUPERILLES.pdf

Muñoz, B. & Rondinella, G. (2016) - *2006-2016 A decade of changes in the mobility of Vitoria-Gasteiz - Evaluation report of the Sustainable Mobility and Public Space Plan and the Master Plan for Cyclist Mobility of Vitoria-Gasteiz*. https://www.vitoria-gasteiz.org/wb021/http/contenidosEstaticos/adjuntos/en/57/32/75732.pdf

Polhill, J. G., Hare, M., Bauermann, T., Anzola, D., Palmer, E., Salt, D., Antosz, P. (2021) Using agent-based models for prediction in complex and wicked systems. *Journal of Artificial Societies and Social Simulation* **24** (3), 2. http://jasss.soc.surrey.ac.uk/24/3/2.html

Polhill, J. G., Ge, J., Hare, M. P., Matthews, K. B., Gimona, A., Salt, D. and Yeluripati, J. (2019) Crossing the chasm: a 'tube-map' for agent-based social simulation of policy scenarios in spatially distributed systems. *GeoInformatica* **23**, 169-199.

Quarton, C. J. & Samsatli, S. (2020) Should we inject hydrogen into gas grids? Practicalities and whole-system value chain optimisation. *Applied Energy* **275**, article no. 115172.

Ramanath, A. M. & Gilbert, N. (2004) The design of participatory agent-based social simulation. *Journal of Artificial Societies and Social Simulation* **7** (4), 1. http://jasss.soc.surrey.ac.uk/7/4/1.html

Vitoria-Gasteiz (2007). *Plan de Movilidad y Espacio Públic*o. https://www.vitoria-gasteiz.org/wb021/was/contenidoAction.do?idioma=es&uid=_5e2b2877_120d224e518__7fe7

Wilenski, U. NetLogo. Evanston, IL: Center for Connected Learning and Computer-Based Modeling. Northwestern University; 1997