When your goals do not address your concerns: Lessons learned from a mediated model to support regional planning in Wellington, New Zealand

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Abstract

Regional planning processes are often based on inconsistent views among involved stakeholders on (1) what the problems or concerns are for the region, (2) what the visions or goals are for the region, and (3) what the scope for a regional plan should be. Such plans will lack commitment when implemented and might fail to address the "real" concerns of the region. In addition, when implementation takes place new problems may be created. To avoid such undesired outcomes, this paper illustrates how mediated modeling, and more specifically a model emerging from such a process, can contribute consistency to the views, goals and scope of regional planning. Based on a case study in the Wellington region, this paper illustrates how a mediated model helps to identify and assist with the revision of inconsistent goals among stakeholders and how it can be used to build consistency in a future plan.

Key words: Mediated Modeling, Visioning, Adaptive Management, Shared Mental Models, Learning, Scenarios, Wellington Region, New Zealand.

Introduction

When developing regional plans one embarks on a strategic exercise, ideally as part of an adaptively managed process (van den Belt, 2009). Agreeing on a regional plan is often difficult as this inherently implies solving what Vennix (1996) refers to as "messy problems". Problems are messy when people that need to deal with the problem hold (entirely) different views on (1) whether a problem exists, and if they agree (2) what the actual problem is. As a result, it is not surprising that regional planning processes often result in uncertainty on (1) what the problems or concerns are for the region, (2) what the targets or goals are for the region, and (3) what the scope for the plan should be. Lack of consensus leads to a lack of commitment to the plan (Vennix, 1996; van den Belt, 2004) and when such plans are implemented unintended consequences and policy resistance (i.e., "the tendency for interventions to be delayed, diluted, or defeated by the response of the system to the intervention itself" (Sterman, 2000)) may occur. A regional plan may fail to address the "real" concerns of the region because it simply did not discover what the "real" concerns actually are in the first place. Hence, the problems facing the region may increase given that (1) the "real" concerns are left unaddressed and (2) actions may cause new problems to arise. This clearly illustrates the importance of building a critical

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level of consensus and commitment to regional planning through an adaptive management process. This paper illustrates how mediated modeling (i.e., the process of building system dynamics models with stakeholders), and more specifically the model emerging from such a process, can aid with planning as it can be used as a tool to increase shared understanding and build consensus among stakeholders (van den Belt, 2004). Its objective is to illustrate that such a model can be used to (1) help identify inconsistent visions and goals, and (2) assist with the revision of such visions and goals (in an attempt to build consensus and a more anchored vision). The case study in which mediated modeling is used is the Wellington region, New Zealand. As part of a 6-year action research program, "Sustainable Pathways 2"[6], fifteen interested stakeholders were invited to participate in a series of three mediated modeling workshops aimed at integrating the four well-beings (i.e., economic, environmental, social and cultural) and determining the underlying system which defines the dynamics of the Wellington region. Results from the mediated modeling will provide input to a data intense spatially explicit model being constructed also as part of the Sustainable Pathways 2 project.

This article contains five sections. Section 2 starts with a brief description of the context of the case study being the Wellington region. Subsequently, mediated modeling and its process to support regional planning in Wellington are discussed, followed by the identification of two scenarios related to the concerns and goals participants of the mediated modeling had for the Wellington region. This section ends with a description of the model that has emerged from the mediated modeling process. Section 3 contains results on how the model helped identify the inconsistent visions, concerns and goals of participants and how they can be revised. Firstly, it illustrates that data-gathering to develop a model can be a first step in discovering discrepancies between what participants believe the situation to be and existing time series data. Secondly, runs of the simulation model for two scenarios illustrate that (1) the concerns participants expressed for the Wellington region might not be major concerns, and (2) reaching the goals the participants had in mind for the Wellington region would not necessarily address these concerns. Section 4 discusses these results in light of learning, systems theory and adaptive management. Section 5 presents the conclusions.

Material and methods

The Wellington region and regional planning

The Wellington region is one of 16 regions in New Zealand covering the conurbation and rural hinterlands around New Zealand's capital city, Wellington (see Figure 1). The Wellington region in 2010 was home to 483,300 people (i.e., 11% of the national population) and is the country's second largest regional economy (i.e., 13% of the nation's GDP in 2007), in part because it benefits from a large public sector; Wellington being the seat of government. The region has a median income well above the average in New Zealand (10% higher in 2007) and a much higher proportion of people with tertiary qualifications than the national average. Wellington's urban form is one of a strong and compact Central Business District, supported by regional centres (i.e., suburban towns). This urban form emerged from geographic restraints as it is squeezed between the coastline and surrounding hills. The hills also limit access to the capital with transport networks restricted to two corridors.

Figure 1: The geographical location of the Wellington region within New Zealand

[6] For more information on this project see: www.sp2.nz.org

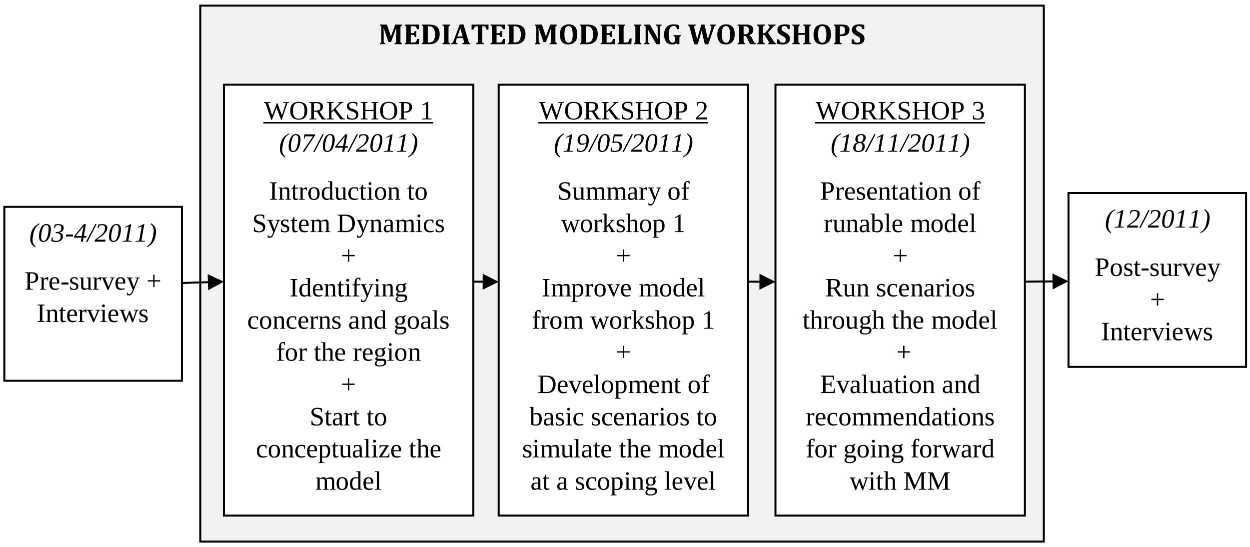
Source: Wikipedia

The Wellington region comprises eight territorial authorities (TAs) and the Greater Wellington Regional Council. Until 2004, councils worked in relative isolation regarding planning and development activities across the region. In 2004-2005, projections for the Wellington region revealed that certain factors relating to the ongoing prosperity and development of the region out to 2025 were not looking as positive as in other regions. Traditional manufacturing was being replaced by smaller more specialised manufacturing businesses resulting in unemployment for unskilled labor. Many industrial manufacturers were moving north due to agglomeration benefits in Auckland. Increasing income gaps with international competitors was providing strong incentives for the region's talent to move offshore (Greater Wellington Regional Council, 2007). These, plus other concerns, led to the nine local authorities, central government, the regions business, education, research and voluntary interests coming together to develop the Wellington Regional Strategy (WRS). This strategy identifies that sustainable economic growth is not about growth for growth's sake. It is about growth that enables the region to enjoy a sound economic base as well as a high quality of life for its citizens (Greater Wellington Regional Council, 2007). In this light, prosperity in the Wellington region means more than monetary wealth. To reflect this the region has also developed a Genuine Progress Index (GPI) which integrates economic, environmental, cultural and social data to monitor and report more holistically on well-being in the region (Durling, 2011). This new emerging context allowed for the initiation of the project "Sustainable Pathways 2" and the mediated modeling process discussed in this paper. A more detailed contextual description for this case study is provided in van den Belt et al, (2011) and van den Belt et al (2012).

The mediated modeling process in the Wellington region

The foundations of mediated modeling (MM) are grounded in group model building (Antunes, Santos, & Videira, 2006). Group model building refers to those interventions in which a client group is deeply involved in the process of model construction (Vennix, 1996). Mediated modeling differs from group model building as it is a process where stakeholders, not only clients, collaborate together in the development of a simulation model about a specific problem, usually in a series of modeling workshops supported by a facilitator (Antunes et al., 2006; van den Belt, 2004). Hence, the advantages of modeling and systems thinking, being the improved understanding of the dynamics of a complex problem, are combined with the gains of collaborative practices to create a shared vision of a problem (Antunes et al., 2006). Mediated modeling is an iterative process involving stakeholder feedback between distinct stages of problem scoping, model quantification, and testing of alternative scenarios (Thompson, Forster, Werner, & Peterson, 2010). In this process, a computer-based mathematical model serves to encourage and focus stakeholder group dialogue (Metcalf, Wheeler, BenDor, Lubinski, & Hannon, 2010). MM is time consuming, as capacity building among stakeholders to allow involvement in, and interact with, the evolving model is an important goal. When the required time is not available, the MM process becomes what is often referred to as 'participatory modeling'. Figure 2 visualizes the mediated modeling process applied in the Wellington region to support regional planning. A full description of the process is available in van den Belt et al (2012).

Figure 2: The applied mediated modeling process in the Wellington region, New Zealand



During the MM process the Wellington region was undertaking a review of its long-term strategy. In addition governance issues were under consideration in response to amalgamation of councils in the Auckland region and a central government initiative to overhaul the existing local government structure and resource management legislation.

The Wellington Region MM goal was to provide an opportunity for representative stakeholders to come together over a period of three workshops to interactively build a scoping model to link social, cultural, economic and environmental issues in a framework that could be used to look at key planning issues from a whole-of-system perspective.

Prior to the first workshop stakeholders completed survey forms and interviews were held with each person to canvas their views on what the major issues for the region were. The workshops were then held to: (i) allow stakeholders see the integrated 'big picture' and gain a greater understanding of the other stakeholder positions, (ii) construct a system dynamics scoping model for stakeholders to use to explain possible outcomes from proposed actions, and (iii) inform the development of the more data intensive Spatially Dynamic Support System being constructed for Wellington. The process was designed to allow stakeholders to identify and build their understanding and mutual appreciation of the key stocks and flows in the Wellington region (such as population density, land use, infrastructure, employment) and model the dynamic interaction between these variables.

After workshop 3 a post-survey and interview was carried out to provide feed-back on how stakeholders found the MM process and the extent to which their views had changed.

The scenarios: concerns and goals for the Wellington region

During the pre-surveys, pre-interviews and first two workshops, it became clear that the Wellington region was concerned about a decrease in their well-being due to population decline. An identified concern was that population decline would lead to job losses and increase inequality resulting which would result in a loss of attractiveness for the region. Many participants believed that increasing or at least maintaining their population base is an absolute requirement in order to increase or maintain the level of well-being. Most participants believed inequality was increasing, hence, the first question for the model to address was: What if population changes by 10% (up or down) by 2020 then what happens to "inequality"? The 10%-decline in population would illustrate what happens to the Wellington region if their concern becomes reality. A 10%-increase in population would illustrate what happens to inequality if population growth is set as a goal.

A second concern the participants had was related to the increasing income gap between Wellington (New Zealand) and its international competitors (especially Australia). Participants believe this generates strong incentives for the region's talent to move offshore (and it is also perceived as the reason why it is so difficult to attract overseas talent). The assumption was that such a "brain drain" negatively affects the attractiveness of the Wellington region which would be problematic given Wellington's large governmental sector. Therefore, a second question for the model was: What if the relative income per person in the Wellington region changes by 10% (up or down)? How does this impact on the relative attractiveness of the Wellington region? A 10% decrease in income would illustrate if the brain drain was indeed a major concern for the attractiveness of the Wellington region. A 10% increase in income would gain insights into whether the goal of increasing income levels for the Wellington region would increase the region's attractiveness and limit emigration.

The Wellington regional model

To test these scenarios a conceptual model was developed during the mediated modeling workshops using STELLA. The model development required 8 months of a full-time modeler's time. Figure 3 gives a sector-representation of the model that emerged after the three mediated modeling workshops. The model runs from 1990 to 2050 (i.e., time horizon of 60 years with a yearly time step, operational base: STELLA). It contains the following five sectors (i.e., sub models): (1) Population and Households, (2) Economics, (3) Natural Environment, (4) Government, and (5) External Factors (influencing the Wellington Region). These five sectors are interconnected through the following feedback loops: (1) "Population and Households" affect "Economics" and vice versa, (2) "Economics" and "Government" are interconnected, (3) "Economics" affect the "Natural Environment" and vice versa, and lastly (4) "Population and Households" affect the "Natural Environment" which in turn affects "Economics" and therefore ultimately again the "Population and Households". In addition to these four feedback loops, the potential impacts external factors (such as earthquakes) would have on the regional economy, natural environment and population, are taken into account. Appendix A discusses the fit of the overall model and a more detailed model description can be found in van den Belt et al (2012)[7].

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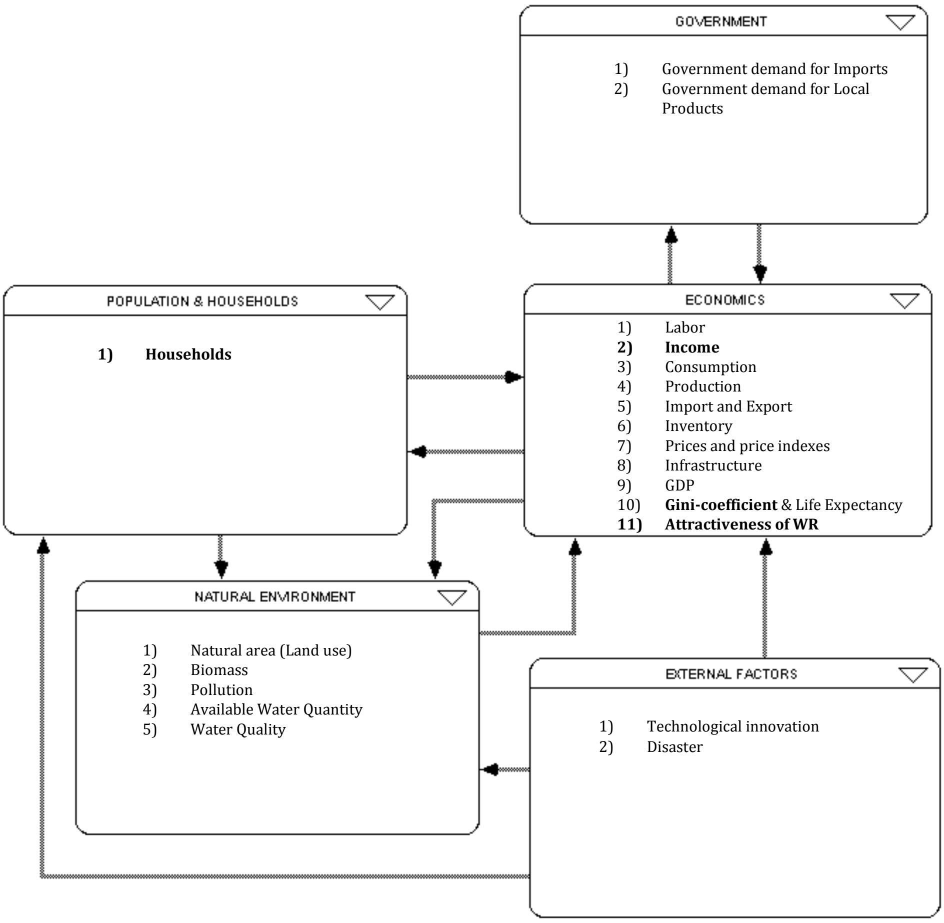
[7] The model can also be accessed at: http://forio.com/simulate/m.vandenbelt/wellington-regional-model

Figure 3: The sectors of the Wellington Regional Model and how they are interconnected



Data to run the simulation model was collected for the years between 1990 and 2010 for each of the five sectors. Data was obtained from Market Economics and Statistic New Zealand. When data was unavailable, some "guestimates" were made by the modeling team. The capability within STELLA to provide sliders to vary these estimates was used by stakeholders during the mediated modeling workshops.[8]

Results

Data gathering to align perceptions with facts

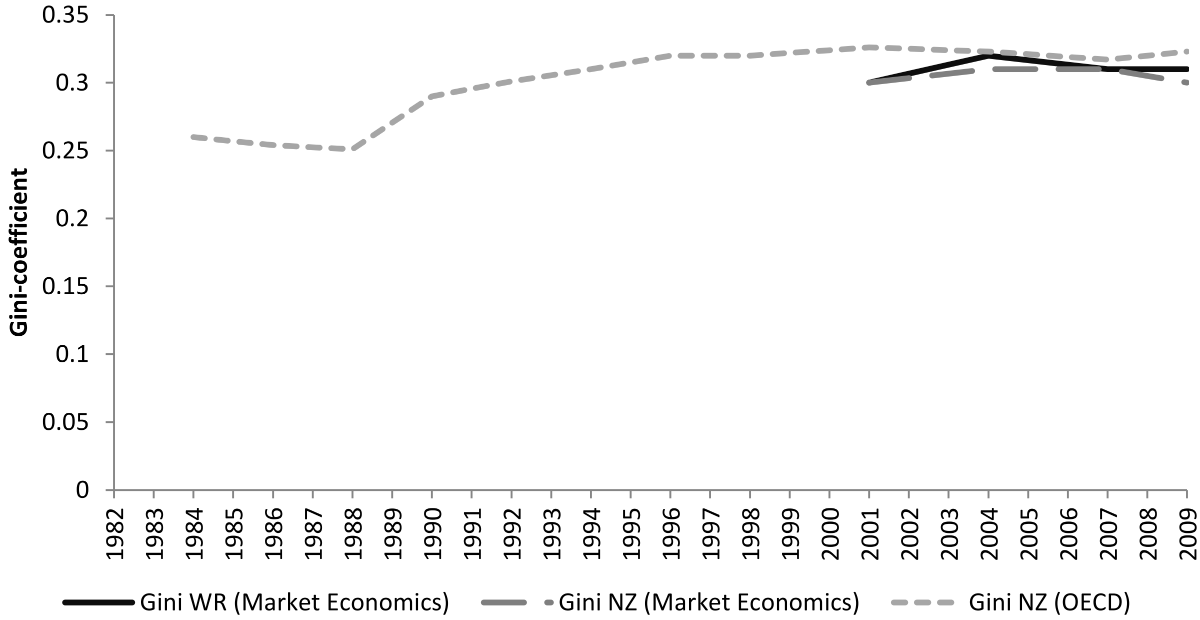
A first indication of the possible prematurity of the concerns and goals the participants brought to the table was discovered through the data gathering required to run the model. For instance, participants believed that inequality was continuing on a growth trend in the Wellington region. However, reports on inequality (e.g., Market Economics, 2011; OECD, 2011) with time series data trends for the gini-coefficient[9] for both the Wellington region and New Zealand as a whole

[8] For a fully documented description and discussion on the data and data collection for the model, see: van den Belt, M., V. Forgie, H. Stouten, M. Thornton, G. McDonald, 2012. Wellington Region Mediated Modelling - Post-report supporting Action Research and Integrated Assessment. Ecological Economics Research New Zealand, Palmerston North, New Zealand.

[9] A gini-coefficient measures the extent to which the distribution of income among individuals or households within an economy deviates from a perfect equal distribution. It is the area between the Lorenz curve and the hypothetical line of absolute equality, expressed as a fraction or percentage of the maximum area under the line. A gini-

did not confirm this. While a dramatic growth in inequality in New Zealand took place between 1988 and 1996 the gini-coefficient remained relatively stable over the last decade as is shown in Figure 4. This disconnect between participant's belief of increasing inequality and what the data shows can be a first indication of possible intuitive rather than fact based goal setting.

Figure 4: Historical data on the gini-coefficient for the Wellington region (WR) and New Zealand (NZ)



Source: Market Economics (2011) & OECD (2011)

Scenario 1: What if population changes by 10% (up or down) by 2020 then what happens to "inequality"?

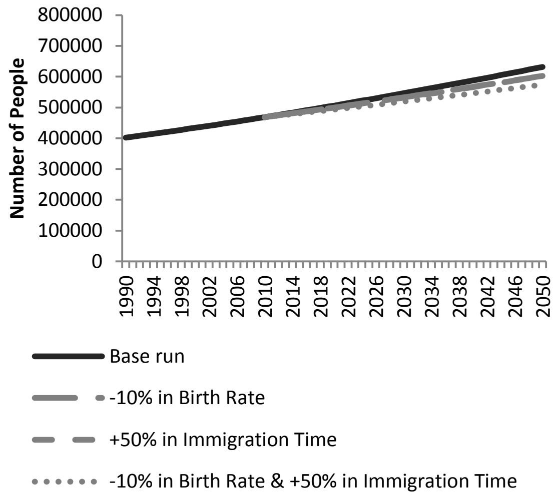
To address this "what-if"-question, the model was run to see what happens to inequality if the participants concern regarding population decline takes place after the year 2010. Four runs were performed and the results are given in Figure 5. The first run was a base run which let the model run without parameter adjustments ("full black line" in Figure 5a+b). In a second run, the birth rate was decreased by 10% in year 2010 which resulted in a population trajectory only slightly below the base run (population is only 4.56% lower compared to the base run in 2050). This was not expected as it was thought a 10%-change in birth rate would have had at least the expected result of a 10%-change in population by 2020. In addition, the gini-coefficient did not differ significantly when compared to the base run (only 1.46% lower in 2050). In a third run, population decrease was achieved by discouraging immigration by increasing the time it takes for immigrants to move to the Wellington region by 50% from 2010 onwards. Interestingly, this generates almost an identical trajectory for population as a 10% decrease in birth rate (there are only 400 people less by 2050), but now inequality is much lower (over 20% when compared to both the "-10% in birth rate"-run and the base run). The reason for this lower inequality is not related to changes in the total population or an increase in unemployment as unemployment rates are even slightly higher (+4.25%) when compared to the "-10% in birth rate"-run. The explanation is found in changes within the total population (i.e., the distribution

coefficient ranges between 0 and 1 (or 100 if expressed as a percentage). A coefficient of zero represents perfect equality, and a coefficient of 1 (or 100) represents perfect inequality.

of the different labor types). Indeed, the lower inequality (i.e., the gini-coefficient) is a result of having less primary industry workers (-11.26%) and unemployed primary industry workers (-12.15%) living in the Wellington region when compared to the "-10% in birth rate"-run. Although primary industry workers are still immigrating to the Wellington region, they do so at a lower rate (-26.85%) due to the increased time delay for immigration. In addition, this causes a scarcity of primary industry workers which increases their income (+9.39% compared to the "-10% in birth rate"-run) and thereby lowers inequality. When both policies (a 10% decrease in birth rate and a 50% increase in immigration time) are combined the increase in immigration time has the most positive impact on inequality. While population is lower compared to the "+50% in immigration time"-run, the impact on inequality this is insignificant.

Figure 5: Simulation results for (a) population and (b) inequality of the Wellington region for four runs related to Wellington's concern of population decline, being: (1) a base run, (2) a 10% decrease in birth rate, (3) a 50% increase in time it takes for immigrants to enter Wellington, and (4) both a 10% decrease in birth rate and a 50% increase in immigration time.

(a) Population in the Wellington region



(b) Inequality in the Wellington region

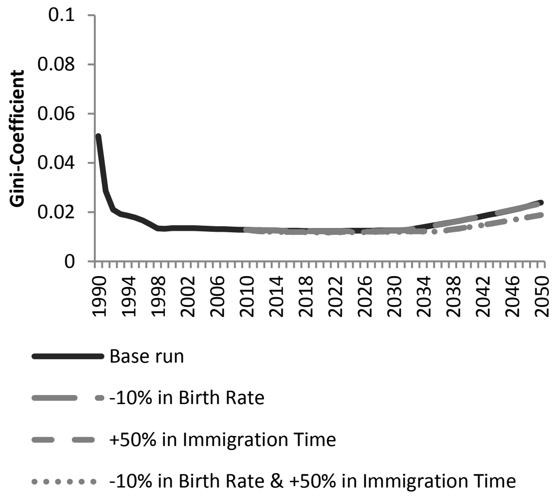
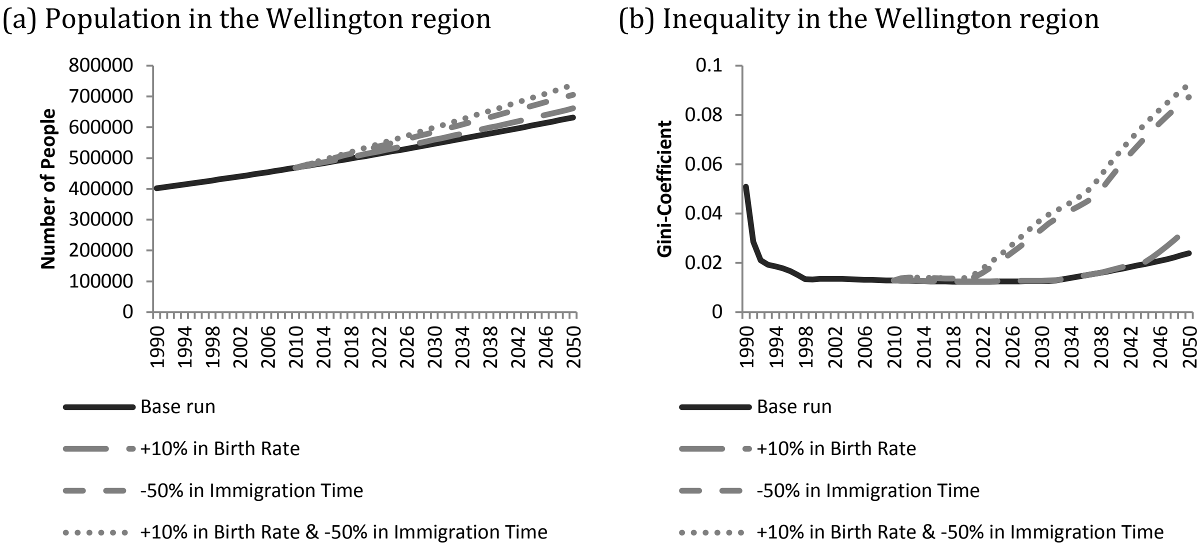


Figure 6 illustrates what happens to inequality if the goal of population growth is achieved after 2010. Again four runs were performed starting with the base run which is depicted in Figure 6a+b (full black line). The second model run, for 2010 onwards, has a birth rate of 10% higher than the base run. This results in only a small increase in population (+4.69% in year 2050 compared to the base run) which was not expected. But, its effect on inequality came as an even bigger surprise for the participants as it had almost no effect at all, except for the last years (from 2045 onwards) where inequality increased instead of decreasing as participants believed it would. This delay in effect is caused by the time it takes for newborns to grow up and become householders (i.e., approximately 20 years). The reason for the increase instead of anticipated decrease in inequality after year 2045 is due to a more than doubling of the unemployment rate. This doubling of the unemployment rate is the result of having more householders competing for the same number of jobs. Job opportunities have not yet increased because the Wellington economy has not yet expanded in response to increased demand from consumers. It takes time for an economy to adjust its production capacity. A third run tests what happens if immigration is encouraged through cutting the time it takes to immigrate to the Wellington region by half. Doing so is seemingly more effective at increasing the population since its trajectory lies well above the base run (+11.71% in 2050) and also well above the "+10% in birth rate" run (+6.70% in 2050). In addition, inequality increases dramatically after approximately 2020. In fact, in 2050, it is almost a fourfold of the base run and it is more than twice as high as in the

"+10% in birth rate" run. This increase in inequality can be mainly explained by the vast increase in unemployment rate (from approximately 2% in 2010 to almost 17% in 2050), which is due to the inability of the economy to grow at a similar rate to population growth and demand for jobs. In a final run, the 10% increase in birth rate is combined with the halving of the immigration time. This results in the highest trajectories for both the population and inequality.

Figure 6: Simulation results for (a) population and (b) inequality of the Wellington region for four runs related to Wellington's goals of population increase, being: (1) a base run, (2) a 10% increase in birth rate, (3) a 50% decrease in time it takes for immigrants to enter Wellington, and (4) both a 10% increase in birth rate and a 50% decrease in immigration time.



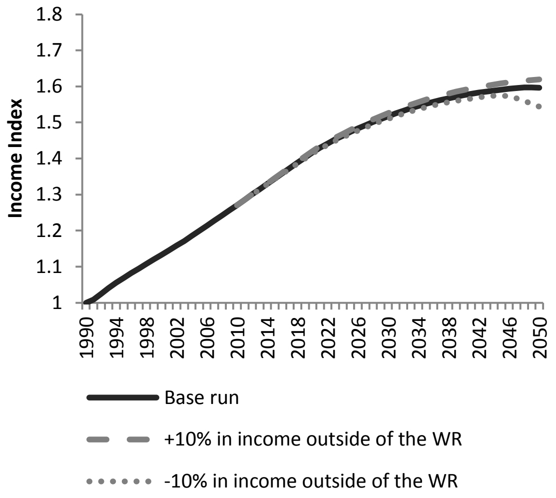
Scenario 2: What if the relative income per person in Wellington region changes by 10% (up or down)? How does this impact on the relative attractiveness of the WR?

The participant's concern that talent moves offshore due to lower wages in the region is tested through a 10% decrease in income to see how this impacts the attractiveness of the region. The current version of the model allows changing the income per person in various ways. However, the simplest and most straight forward way for testing this scenario is to change the income that people earn outside the Wellington region because the income in the Wellington region is relative. Three runs were performed to see what would happen to income and the attractiveness of the Wellington region if relative income per person outside the Wellington region changed (see Figure 7). The first run was a base run and is indicated in Figure 7a+b as a full black line. In a second run, the income outside the Wellington region is increased by 10% from 2010 onwards. This 10%-increase has an effect on average income in the Wellington region as income in the last simulated years is slightly higher (+1.45%) than the base run. This is explained by an increase in wages (especially in agriculture) as there is less labor available due to the decreased attractiveness causing people to leave the Wellington region. With less people competing for the same number of jobs lower unemployment pushes up wages. In addition, the region still produces the same amount of food, goods and services which increases the productivity of labor which also leads to higher average wages. The '10%-increase in income outside the Wellington region' reduces the (perceived) relative attractiveness of the Wellington region, however, the effect is small with relative attractiveness in 2050 only 4.63% lower than the base run. The converging behavior of the trajectory towards the base run was not anticipated by stakeholders at the workshop. There are a number of reasons for this converging behavior, the first is the relative attractiveness of a region is determined by more than just income. This model also includes the effect of (1) job opportunities, (2) housing affordability, (3) culture, and (4) waste and pollution, and therefore the relative attractiveness of the Wellington region is a weighted average of the relative attractiveness for each of these components. The second explanation for why the effect is small is the choice of weights for each of these components, which was estimated by the modeler. These settings could be further explored in stakeholder discussion as they can be changed on the user-interface. Income as a component contributing to attractiveness of the WR was assigned a weight of 15 out of 100. These weights, and weights used in the sensitivity analysis are set out in Table 1. A third reason is the decision to calculate the weighted average for relative attractiveness for each component as a harmonic mean instead of an arithmetic or geometric mean. This decision is based on the assumption that attractiveness of a region is mainly determined by all components being in "harmony". For instance, if the region performs well for all components except one, the harmonic weighted average of those components will be well below the arithmetic and geometric mean. Finally, the last but probably most important reason for the lack of a significant decrease in attractiveness is the region's ability to adjusts (in various ways) for this (sudden) increase in income outside the Wellington region. An example is the increase in wages due to a shortfall in labor when labor moves from the Wellington region to obtain higher wages. This last reason of system adjustment is also the reason behind the convergence of the trajectories between the "+10% in income outside the WR"-run and the base run.

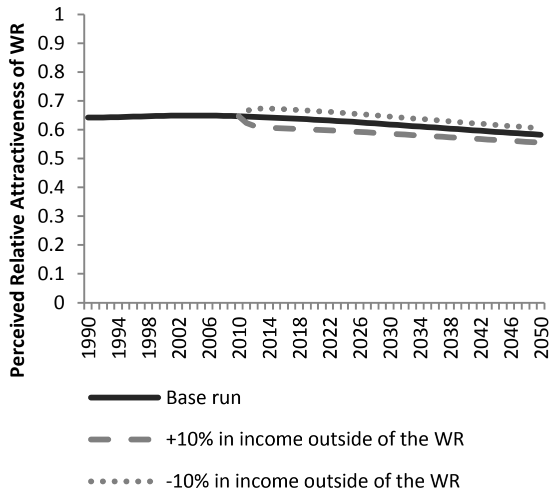
The third run investigates what would happen to income and attractiveness in the Wellington region if income outside the Wellington region decreased (instead of increased) by 10% from 2010 onwards resulting in higher income levels within the region. The result is an income trajectory below that of the base run especially after the year 2045. This was unexpected as it was assumed that higher relative incomes would attract more people to the region catalyzing economic growth which would create even higher incomes. The reason income is lower is explained by the lag time between population change and the follow-on effect on the economy. When for example, the population grows, demand for goods and services grow. However, it takes time to expand the capacity of the economy to cope with these demands. Due to this delay, population growth initially results in unemployment because the economy does not immediately adjust. With labor less scarce, wages are lower (assuming a free labor market) and additional labor is hired to expand the economy. This causes a (at least temporal) drop in labor productivity which reduces economic efficiency. The relative attractiveness of the Wellington region lies slightly above the base run but it was expected to deviate more. And again, it seems like the trajectory is converging towards the base run. Similar explanations as for the "+10% in income outside of the WR" count for this lack of effect and converging behavior.

Figure 7: Simulation results for (a) average income per person (expressed as an index in relation to initial income in 1990) and (b) perceived relative attractiveness of the Wellington region for three runs related to Wellington's concern on income changes, being: (1) a base run, (2) a 10% increase in income outside the WR, and (3) a 10% decrease in income outside the WR.

(a) Average income per person in the Wellington region



(b) Attractiveness of the Wellington region



The sensitivity of these results to changes in the weights used to calculate the harmonic weighted average of relative attractiveness was investigated for the change in income scenario runs. All three scenarios were performed again for two different weight distributions. One distribution doubled the weighting for income and the other reduced it by a third in determining its effect on the attractiveness of the Wellington region (see Table 1 for the exact weights). The effect of these adjustments was that changes in the income outside the Wellington region had a larger effect when more weight was giving to income and vice versa. However, the deviation was not spectacular given the maximum deviation from the base run for these trajectories was approximately 14% and the "normal weights" scenarios deviated around 4% from the base run. In addition, the converging behavior of the trajectories towards the base run was still observed for all sensitivity results. In conclusion, it is fair to state that varying the weights within reasonable limits has only limited effects on the behavior of the overall relative attractiveness of the Wellington region.

Table 1: Sensitivity analysis for the weights used in the calculation of the harmonic mean for the relative attractiveness of the Wellington region

	"Normal" weight to income	"More" weight to income	"Less" weight to income
Weight for income in attractiveness of WR	**15**	**30**	**10**
Weight for job opportunities in attractiveness of WR	25	22	25
Weight for housing affordability in attractiveness of WR	15	11	16
Weight for culture in attractiveness of WR	20	15	21
Weight for pollution concentration in attractiveness of WR	15	12	15
Weight for waste concentration in attractiveness of WR	10	10	13
Total	100	100	100

Discussion

The objective of this study was to illustrate how a model emerging from a mediated modeling process can support regional planning processes and provide an opportunity to assess whether goals address the concerns and regional plans represent a high level of 'systemic' consistency. This study illustrated that data gathering (to develop the model) can in itself be a first step in unveiling intuitive rather than "real" concerns. It became clear that the participants in our mediated modeling workshops were convinced that inequality was continuing to increase in the Wellington region. This was, however, not backed by time series data on the gini-coefficient as this coefficient remained relatively constant for the last ten years for the Wellington region. Although there may be many reasons for such discrepancies between what people identify as a concern and what time series data tell us, one of them might be that people accept as valid a story that is easy to recall and is not presented with contradictions or competing scenarios (Kahneman, 2011).

Running scenarios through the developed (mediated) model can further assist with unveiling inconsistent goals. Such scenarios can unveil (additional) discrepancies between what people think are concerns for the region and what the model results tell us. In our study it became clear that the model results indicated that inequality is not a big issue for the future of the Wellington region. Furthermore, Wellington's fear of population decline did not necessary result in more inequality as a decline in birth rate did not significantly affect the gini-coefficient. Inequality only worsened when population declined through making it more difficult for immigrants to enter the region. However, inequality increased not because of population decline, but because changing the time lag for immigration altered the population distribution. Next, the concern of loss of regional attractiveness and therefore talent moving offshore due to lower income in the Wellington region was not confirmed by running scenarios through the model. In fact, when relative income in the Wellington region decreased, the (modeled) Wellington region reacted to adjust for this loss.

Running scenarios through the model also helped with illustrating that the goals the participants had in mind for the Wellington region did not always addressed their concerns effectively. The model for instance clearly illustrated that population growth did not decrease inequality at all. On the contrary, inequality eventually increased after a time lag of approximately 20 years when birth rates were increased or when immigration time was decreased. The goal of increased relative income for the Wellington region also turned out not to have the desired effect on attractiveness of the region. Although the attractiveness indeed increased, this increase was not as spectacular as was expected by the participants of the mediated modeling process. Increased attractiveness came at a high cost as unemployment increased and income within the Wellington region decreased in absolute terms. Hence, the model was able to illustrate current goals for the Wellington region might not be the right ones to achieve long term objectives.

The reasons for the discrepancies between what the participants believe to be the goals for the Wellington region and what the model results tell us can be due to either the inaccuracy of goal setting or the inaccuracy of the model. The model was tested and perceived to be internally valid so it is assumed this is not the cause. Goal setting is often inconsistent because humans can only deal with a limited amount of information and complexity (e.g., bounded rationality and misperception of feedback loops). This is especially the case when humans deal with dynamically complex feedback systems. The inaccuracy of goal setting is then an artifact of (1) not taking the most important feedback loops of the system into account (e.g., loops related to policy resistance) or (2) misperceiving the dynamic behavior emerging from the interaction between multiple feedback loops. Implementing inconsistent goals, based on the identification of intuitive concerns and the setting of premature goals for a region, can worsen rather than benefit the region as (1) the "real" concerns are left unaddressed and (2) actions that are taken may cause new problems to arise (e.g., unintended consequences).

One way to increase the probability of reaching anchored goals (based on full consensus) for a region is to share people's visions and understanding of the dynamics of the region (Elias, 2008; Elias & Jackson, 2003). This is exactly what mediated modeling tries to accomplish as it allows for mapping the different stakeholder perspectives in an attempt to arrive at a shared vision for the region. Such a process results in a mediated model that has a higher probability of including the most important feedback loops. Misperception of feedback is also eliminated as simulation software does not encounter the limitations of the human mind when processing information and complexity. Applying mediated modeling can in a first iteration generate counterintuitive outcomes for many of its participants. If the model is perceived as internally valid, counterintuitive outcomes can cause stakeholders to revise their belief systems (i.e., "mental models"). Hence, it can foster double-loop learning. This is exactly what has happened in this study. Participants tested their intuitive visions through the mediated model. The model outcomes were, however, not in line with their expectations causing the stakeholders to at least reflect on or even revise their visions. Hence, the findings of this study can be seen as the results of a first iteration in a regional planning process, part of an adaptive management process fostering double-loop learning (van den Belt, 2010).

Now that the inconsistency of the goals and concerns is unveiled through the mediated modeling, the next step is to assist with the revision of the underlying visions in an attempt to build consensus on a more anchored vision for the Wellington region. Additional mediated modeling workshops are planned and preparations are underway to use the models capabilities of visualizing and rehearsing futures for the Wellington region within an adaptive management learning process.

Conclusion

This paper illustrates how a mediated model (i.e., a model that has emerged from a mediated modeling process) can support regional planning. When applied in an adaptive management process, it can generate double-loop learning opportunities if counterintuitive outcomes unveil discrepancies between what people believe and what the model outcomes are. In the case of the Wellington region, it was clear that most of the concerns the participants in the mediated modeling process brought to the table were not "real" concerns for the region. Similarly, some goals envisioned for the region may fail to address their concerns effectively. This illustrates that mediated modeling can be used as a tool to increase shared understanding and build consensus among stakeholders. The mediated model helps this process with identification and visualization of inconsistent goals. It can also play a role in revising such goals in an attempt to build consensus on a more anchored vision.

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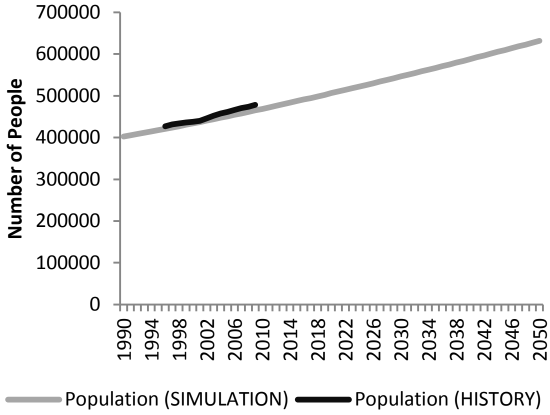
Appendix A

Validity of the simulation model

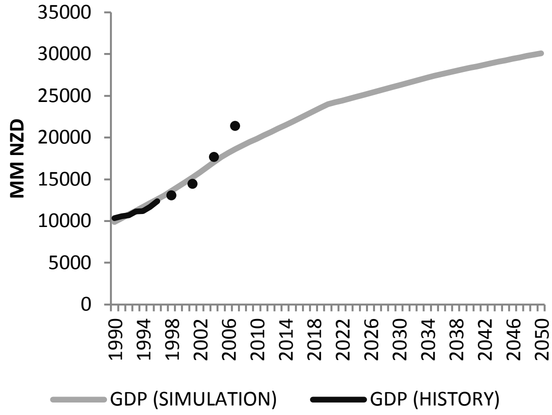
The model cannot be rejected based on (1) ability to reproduce historic behavior (i.e., data trends) and (2) the post test-questionnaire in which the participants of the mediated modeling workshops were asked about their perception of the model. Figure A.1 gives the results for some key model variables on model fit. Formal metrics were not obtained to assess the goodness-of-fit because well established data series were scarce. As a result, qualitative tests of fit were used instead of quantitative tests. Qualitative tests of fit are widely used in practice and consist of "eyeballing the magnitude, shape, periodicity and phasing of simulated trajectories and comparing to past behavior" (Morecroft, 2008). When eyeballing the fit for (1) the population (Figure A.1.a), (2) GDP (Figure A.1.b), and (3) the consumer price index (Figure A.1.c) in the Wellington region, historical data points are abundant and the fit is very satisfactory. The fit for (1) natural area (Figure A.1.e) and (2) yearly waste (Figure A.1.f) is more difficult to assess as for both there are only two historical data points available. Nevertheless, the simulation results seem to give reasonably similar behavior as historical data and the fit with the two recognized data points for yearly waste is at least very satisfactory. Finally, at first glance, the fit between the historical and simulated data for the gini-coefficient might be perceived as troublesome. However, this is not necessarily the case because the behavior of the simulation results mimic the stability in inequality observed in historical data. The issues are its initial declining behavior prior to stabilization in year 1998 and being below the historical data trend. The first issue is the result of small adjustments by the model to some of its initial values. Hence, initial parameter estimation and setting can further be improved. The second issue results from not being able to capture the whole population and income distribution when calculating the gini-coefficient as we only deal in this model with population classes (i.e., farmers. workers, services workers, unemployed farmers, unemployed workers and unemployed service workers). Hence, based on this evidence, there is no reason to reject this model.

Figure A.1: Examples of the fit between simulated data and historic data for the following key variable in the model: (a) Population, (b) Gross Domestic Product (GDP), (c) Fisher Consumption Index, (d) Gini-Coefficient, (e) Natural Area, and (f) Yearly Waste.

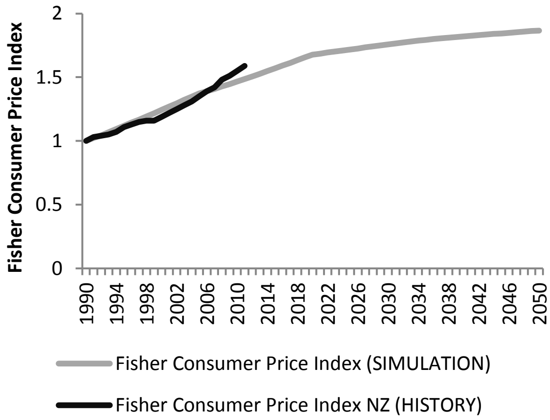
(a) Population in the Wellington region



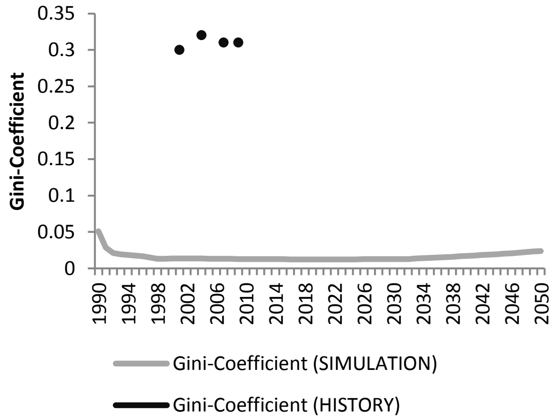
(b) GDP of the Wellington region



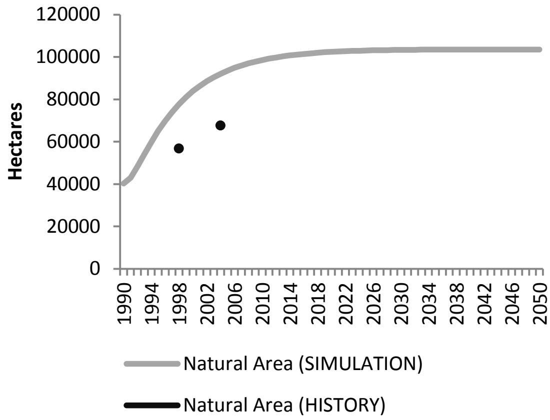
(c) Inflation in the Wellington region



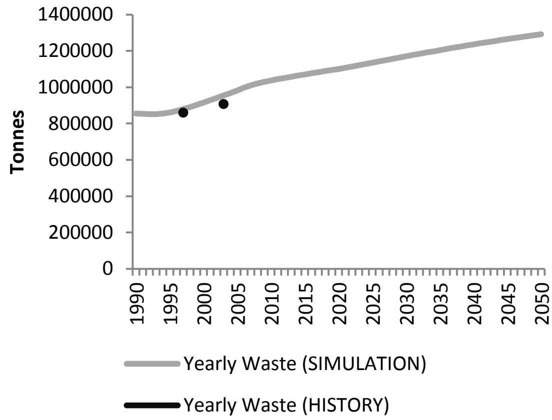
(d) Inequality in the Wellington region



(e) Natural area in the Wellington region

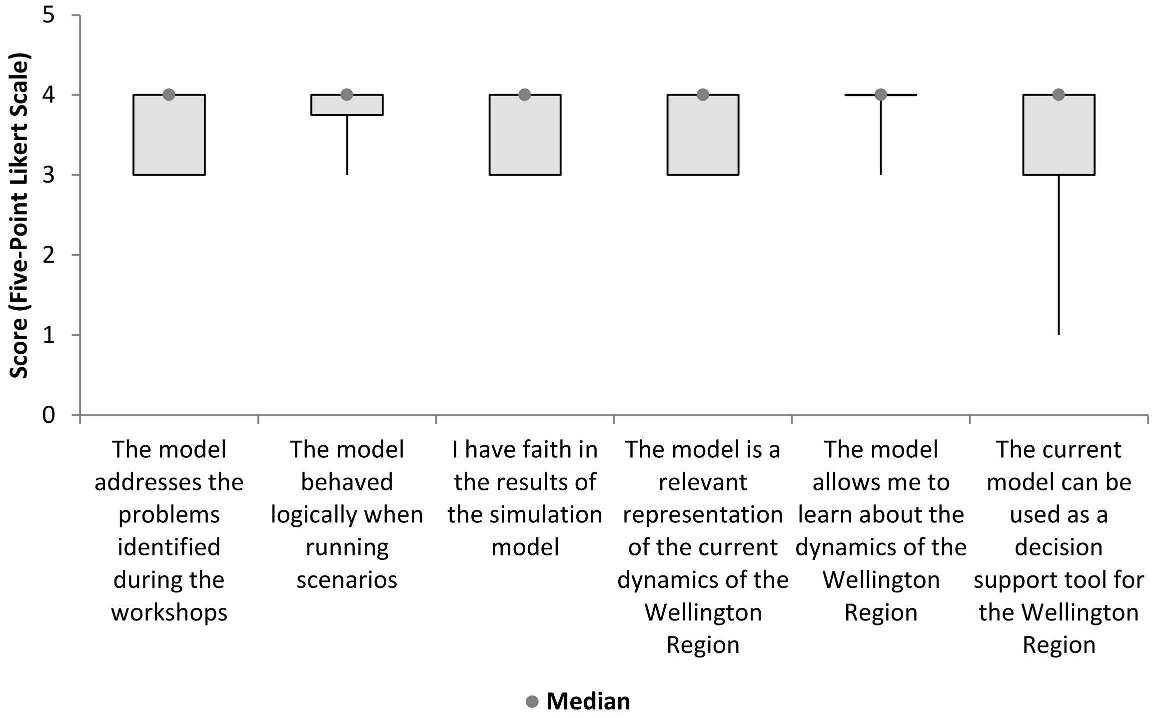


(f) Waste flow in the Wellington region



The results of the questionnaire in which participants of the mediated modeling workshops were asked about their perception of the model are given in the boxplots of Figure A.2. It is clear from these boxplots that the median score on all questions related to validity was high (median scores of 4) and the variance was low (except for the last question “the current model can be used as a decisions support tool for the Wellington region”).

Figure A.2: Results from the post-test questionnaire on the validity of the Wellington Regional Model



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