Discovering Alternative Scenarios for Sustainable Urban Transportation

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Abstract

Scenario techniques have already produced useful insights into creating the visions about the future of mobility as well as the potential implementation challenges associated with these visions. Unfortunately, scenario outcomes may appear to be an oversimplification of what is known as a complex issue in transportation, especially in determining how the future might unfold. The 'traditional way' of developing qualitative scenarios such as visioning activities often foreshadow the existence of a single best or a limited future option(s) for a given sector, community, or area. This is problematic as it views the target population as homogeneous, even though recipients may diverge widely in their value judgments over what a desirable future might be. As a result, without explicitly eliciting and negotiating this contested territory, scenario development runs the risk of creating opposition to sustainability futures rather than creating a common ground for different worldviews. In an effort to directly address the oversimplification that may be an artefact of the scenario planning process, we extend the scenarios developed in the scenario planning workshop on the Future of Urban Mobility conducted in Singapore to discover other 'missing' storylines that might be plausible but were not identified by the workshop participants. A scenario discovery method called the cross-impact balance (CIB) analysis will be employed to search for plausible alternative scenarios especially scenarios that were not discovered by the participants of the scenario planning workshop. Ultimately, we craft strategies that could be employed to trigger imaginative, transformative vision of the future, while navigating complex and potentially contradicting worldviews.

1. Introduction: Scenario biases

As urban areas continue to grow and develop rapidly, there is a growing demand for the use of scenario techniques in urban transportation planning. Scenario techniques have already produced useful insights into creating visions of the future urban mobility as well as the potential implementation challenges associated with these visions. Studies have shown that such visions

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expressed in scenarios are important elements for designing sustainable urban transport (see e.g., Moriarty and Honnery, 2008; Shiftan et al., 2003; Spickermann et al., 2014). Despite the credible track record, scenarios may appear to be an oversimplification of what is known as a complex issue in transportation, especially in determining how the future might unfold.

The visions of sustainable urban transport do not seem to be projected in a consistent manner by different scenario studies. While scenarios are illustrating the same topic or issue (e.g. future of urban transportation), different scenarios tend to communicate different meanings about what sustainable urban transport could or would be. In some cases, these studies might emphasize active mobility as the key element or driver of change for sustainable urban transport (Tight et al., 2011) for example. Yet, such notion may also underplay futures that revolve around the advancement of transport technologies (Fishman, 2012), which many believes that it is now inevitable (Kurniawan et al., 2018).

The reason for this, for the most part, is the 'traditional way' of developing qualitative scenarios such as visioning activities which often foreshadows the existence of a single best or a limited future options for a given sector, community, or area. Typically, scenario outcomes are constrained by the consensus process in a scenario planning workshop, where the scenario planning workshop participants, who are mostly the stakeholders, would arrive at a consensus on which scenarios they deem plausible and desirable. However, this could be problematic because an individual or a group who has a dominating voice (or epistemic power) could exert their agenda on other participants. That means the more powerful group or individuals may influence what scenarios to be insinuated. Therefore, scenario outcomes may not be a representation of a common vision but rather the vision that is subjected to political negotiations by a certain group of individuals.

Nevertheless, the produced scenarios are often oversimplified and treated as the desired future of the target populations. Clearly, scenario planning views the target population as homogeneous, even though scenario users may diverge widely in their value judgments over what a desirable future might be. In the real world, populations are not homogenous and not entirely consensual in which individuals may have different concerns about what their future would be. Hence, the question remains who is representing who in the scenario planning workshop? Obviously, when we select a different group of participants for the same workshop, the scenarios produced could potentially be different. Because different groups of participants may visualize futures differently, there is no common ground for understanding the transformative vision of the futures. These visions may differ much and could potentially be contradicting. As a result, without explicitly eliciting and negotiating this contested territory, scenario development runs the risk of creating oppositions to sustainability futures rather than creating a common ground for different worldviews.

2. Proposed method for discovering alternative scenarios

In an effort to directly address the oversimplification that may be an artefact of the scenario planning process, we extend the scenarios developed in the scenario planning workshop on the Future of Urban Mobility conducted in Singapore to discover other 'missing' storylines that might

be plausible but were not identified by the workshop participants. The scenario planning workshop is part of foresight research on the future of urban transport conducted by the Singapore University of Technology and Design (SUTD) (Zahraei et al., 2016). This study has already produced insights into the process of creating visions about the future of mobility and the potential implementations challenges associated with these visions[3]. Readers who are interested scenario development process, the detail description of the scenario planning workshop was documented by Kurniawan (2016) and can be downloaded from a public repository.

This study employs a scenario discovery method called the cross-impact balance (CIB) analysis (Weimer-Jehle, 2006) to search for plausible alternative scenarios especially scenarios that eluded the participants of the scenario planning workshop. Scenarios produced by CIB have a combinatorial structure involving combinations of scenario driver's end-states that are self-reinforcing; thus, these scenarios are internally consistent. Internally consistent scenarios, in this case, are plausible futures because the self-reinforcing mechanism embedded in the scenarios will continue to operate perpetually and thus making this specific configuration to be highly likely the future outcome.

Performing CIB analysis starts with constructing a cross-impact (CI) matrix. A technique for reconstructing a CI matrix by analyzing the verbal discourse has been previously employed by Schweizer & Kriegler (2012). Topics that were discussed by workshop participants could provide much richer information than the scenario outcome(s) alone. Hence, there could be the alternative outcomes when we investigate deeper into the potential scenario drivers and understand how these drivers would interact. Using a CI matrix, we map these influences or interactions among scenario drivers. We employ qualitative analysis to sift out participants' comments that describe interactions between two or more scenario drivers. For example, a comment on the possibility of reduced travel demands due to the socially acceptable telecommuting practice could be flagged for analysis. This condition may or may not be reflected in the scenario outcome, but it was certainly found embedded in the qualitative discourse. From the qualitative discussion recorded for these two events, we extract the underlying themes that would be incorporated as the scenario drivers and future end-states for building cross-impact matrices. The matrix captures values of interactions in the matrix cells. For instance, when a statement implying 'telecommuting reduces future travel demands' frequently appears in the discussion, it is inferred that 'telecommuting' is strongly influencing 'future travel demands.' This study will use this sort of rules to inform the judgments on the magnitude of the interactions between drivers. A meta-data of the verbal discussion for one of the break-out sessions was used for constructing a cross-impact matrix as shown in Figure 1.

[3] Detail information about the research project can be found on this website: https://mobility.sutd.edu.sg/foresight/

Descriptors/ States		Descriptor 1 E-Commerce				Descriptor 2 Innovation Capacity				Descriptor 3 Multi-zones District				Descriptor 4 Personal Mobility Device			Descriptor 5 Virtual Travel		
		State 1	State 2	State 3	State 4	State 1	State 2	State 3	State 4	State 1	State 2	State 3	State 4	State 1	State 2	State 3	State 1	State 2	State 3
Descriptor 1	**E-Commerce**																		
State 1	Pre-emptive Purchase					0	0	0	0	-2	0	1	1	0	0	0	1	0	-1
State 2	E-Social Shopping					0	0	0	0	-3	0	3	0	0	0	0	3	0	-3
State 3	Retail Malls Makeover					0	0	0	0	1	1	0	-2	0	0	0	0	0	0
State 4	Need for Touchy Feely					0	0	0	0	3	0	-1	-2	0	0	0	-3	0	3
Descriptor 2	**Innovation Capacity**																		
State 1	Single Ecosystem	-3	2	1	0					0	0	0	0	0	0	0	0	0	0
State 2	Collaboration	1	1	-1	-1					0	0	0	0	0	0	0	3	0	-3
State 3	Export Innovation	0	0	-1	1					0	0	0	0	0	0	0	0	0	0
State 4	First Adopter	0	0	0	0					0	0	0	0	0	0	0	0	0	0
Descriptor 3	**Multi-zones District**																		
State 1	Organic Evolution	0	0	-1	1	0	0	0	0					0	0	0	-3	0	3
State 2	Two-layer City	2	0	-2	0	0	0	0	0					0	0	0	0	0	0
State 3	Freight Nation	3	1	-1	-3	0	0	0	0					0	0	0	1	1	-2
State 4	Time-division Multiplex	0	0	0	0	0	0	0	0					0	0	0	-2	1	1
Descriptor 4	**Personal Mobility Device**																		
State 1	First and Last Mile	-3	0	0	3	0	0	0	0	-3	-1	1	3				0	0	0
State 2	PMD-Everything	1	0	-3	2	0	0	0	0	2	1	0	-3				0	0	0
State 3	Walking Nation	-3	0	1	2	0	0	0	0	2	2	-3	-1				0	0	0
Descriptor 5	**Virtual Travel**																		
State 1	Virtual Everything	3	1	-1	-3	1	1	1	-3	-3	1	1	1	-1	0	1			
State 2	Access-as-a-service	1	1	-1	-1	0	1	0	-1	1	0	0	-1	1	-2	1			
State 3	Virtual-not-reality	-3	-1	1	3	-1	-1	-1	3	3	0	0	-3	1	1	-2			

Figure 1 Cross-impact matrix populated with judgment scores derived from qualitative analysis of the recording of the discussion at the scenario planning workshop

Table A: List of descriptors and states for the Singapore's Future of Urban Mobility 2040 that will be used to construct the cross-impact matrix

S/N	Descriptors	States	Narratives
1	E-Commerce	Pre-emptive Purchase	Before one would think about buying anything, retailers (e.g. Amazon) have already sent the products and goods you intended to buy. This is made possible by an intelligent profiling algorithm that could predict individual's purchase intentions accurately.
		E-Social Shopping	Shopping malls are no longer physically present; malls now exist on the Internet. Unlike the traditional online shopping, the E-Social Shopping is a platform for users to socialize and shop for products with their friends and loved ones
		Retail Malls Makeover	The concept of shops is redefined where shops are now like a vending machine. People place their order and pay, and their purchase will be delivered to their home at the backend. As the shops are no longer occupies much floor space, retail malls become a place for social activities.
		Need for Touchy Feely	Society demands physical social interactions and clings on to the traditional way of shopping where physical interactions with others are still prevalent.
2	Innovative Capacity	Single Ecosystem	Innovations emerge from within the country without much assistance from research centres overseas. The government supports the growth of innovation and encourages the adoption of locally developed technologies.
		Collaboration	Innovation capacity increases due to collaborations in research and development among satellite 'silicon valleys' (or innovation hubs). Singapore has also grown to be one of the innovation hubs eventually.
		Export Innovation	Innovations are treated as 'tradeable commodities.' Singapore has developed the ability to import innovations from overseas, add value and repackage as 'new' innovations and export them to the world market.
		First Adopter	Similar to the current situation, the Singapore government will always be the first in the world to embrace and implement various innovations. Innovation capacity increases due to spillover effects.
3	Multi-zones District	Organic Evolution	Urban developments are unplanned and left to evolve on their own depending on demands.
		Two-layer City	Purposeful urban planning where one layer (e.g. underground) accommodates a type of transport mode and another layer (e.g. aboveground) accommodates a different transport mode.
		Freight Nation	Purposeful urban planning with the emphasis on the efficient movement of freight due to fewer individuals' travel demands (i.e. re-purpose the current infrastructure with minimum modification).
		Time-division Multiplex	No technical solutions are feasible, and the city has resorted to restricting people's mobility. to 18 hours a day and therefore leaving 6 hours a day for movement of goods.
4	Personal Mobility Device	First and Last Mile	All public transport commuters will have PMD for the first and last mile.
		PMD-Everything	Hi-tech PMD like a travel pod owned by individuals. The pods and the available infrastructures make travelling anywhere in the city possible.
		Walking Nation	Walking as the primary mode of transport is culturized into the society.
5	Virtual travel	Virtual Everything	Most of the physical travel has been made unnecessary because virtual reality connects everyone for study, work, and play.
		Access-as-a-service	Virtual travel is a service that can be accessed by certain privileged groups
		Virtual-not-reality	In contrast to 'Virtual Everything,' the virtual reality technology fails to manifest into social norms.

Following the convention of CIB analysis, scenario drivers or elements are called 'descriptors' (Weimer-Jehle, 2006). The list of descriptors and their corresponding future states presented on the matrix are explained in Table A. Judgments inferring the interactions among states, which were distilled from the participants' discussions, allow for CIB analysis that subsequently produces five internally consistent scenarios. The consistent scenarios were discovered using ScenarioWizard program (Weimer-Jehle, 2016). The result shows five consistent scenarios were found to be different from the two scenarios identified by the participants during the workshop as shown in Table B.

Table B: Scenario configurations produced by workshop participants in the Singapore's Future of Urban Mobility 2040 and the corresponding CIB analysis

	Descriptors/States				
Scenario #	**E-commerce**	**Innovative Capacity**	**Multi-zones District**	**PMD**	**Virtual Travel**
Scenarios produced by workshop participants:					
Telephone	Pre-emptive Purchase	Export Innovation	Organic Evolution	PMD-Everything	Access-as-a-service
Coconut Tree	Retail Mall Makeover	Single Ecosystem	Two-Layer City	Walking Nation	Access-as-a-service
Scenarios produced by CIB analysis:					
#1	**E-Social Shopping**	**Single Ecosystem**	Two-Layer City	Walking Nation	Virtual Everything
#2	**Pre-emptive Purchase**	**Collaboration**	Two-Layer City	Walking Nation	Virtual Everything
#3	**Pre-emptive Purchase**	**Export Innovation**	Two-Layer City	Walking Nation	Virtual Everything
#4	Need for Touchy Feely	First adopter	Organic Evolution	**First and Last Mile**	Virtual-not-reality
#5	Need for Touchy Feely	First adopter	Organic Evolution	**PMD-Everything**	Virtual-not-reality

3. Discussions

When subjecting the matrix to a CIB analysis (and also Monte Carlo simulations), alternative scenarios discovered in this research were found to be more plausible than those scenarios produced in the workshops. This is an interesting point in sustainable urban transport research because there could be other interesting scenarios worth pursuing. For instance, how useful would these alternative scenarios be in the field of sustainable transport research? Most of the workshop participants in Singapore have an engineering background, which may explain why scenarios produced in the scenario planning workshop tend to be "technological-driven" scenarios. However, our study produces not only technological driven scenarios but also more "socially-inclined" scenarios.

Based on their similar end-states, the discovered scenarios can be grouped into two scenario sets. First, scenario #1, #2, and #3 portray three dominant end-states, Two-layer City, Walking Nation, and Virtual Everything; and one somewhat dominant end-state, Pre-emptive Purchase. The end-states indicate that this scenario set expresses many aspects of technology infiltration in our daily lives. Unlike the first scenario set which tends to be technological-driven, the second scenario set is socially-inclined. The second group of scenarios comprises of scenario #4 and #5, which appears to be telling an opposing story in that societies tend to resist technological changes. Evidently, the dominant end-states of the group two scenario set points to business-as-usual situations such as there is no virtual reality and people still values social interactions in physical form.

Two descriptors distinguish the scenario sets apart; these are the concept of multi-zones district and virtual travel. While transport planners might have been dealing with planning activities related to multi-zones district, they may be less familiar with the concept of virtual travel as it does not relate to planning per se, but rather the socio-technical transition. The rise of virtual reality technology will promote travel in the virtual space that could potentially change the future of urban mobility (Kurniawan et al., 2018). With virtual travel, the urban mobility may not be like anything we experience today.

Another important aspect is the concept of the two-layer city. The two-layer indicates physical segregation of mobility services where the aboveground is often dedicated as social space while the underground houses the transport network—the 'artery' of the city. The concept of two-layer city pushes the boundary of imagination in that it is then imperative for us to change our mindset to accept that the traditional way of providing transport and mobility services would no longer be relevant in the future. For instance, the configuration of the two-layer city and virtual travel imply the slightest hint in that continuing to build roads would be pointless in the future and a waste of resources. In fact, we should proactively reduce the road density on the aboveground layer of the future cities when we anticipate this specific scenario set as the common vision.

The scenarios discovered by CIB analysis have the configurations that are plausible, but they are not discovered by the workshop participants. Our findings also suggest that the social acceptance of virtual travel and any unconventional mode of transport may prove to be one of the defining key elements that shape the urban mobility in the future—a key element that might be overlooked by the traditional scenario planning process.

4. Conclusions

In sum, we present a strategy that could be employed to trigger imaginative, transformative vision of the future, while navigating complex and potentially contradicting worldviews. On the broader sustainability context, this paper raises questions if studies conducted at a specific level (national or municipal) and with a specific subset of society would be adequate for addressing the future of transport and mobility issues that have manifested across multi-level and multi-actor governance. Therefore, scenario development process should not be defined by a niche sectoral perspective, because in doing so the scenario outcomes tend to project a narrower view of risk perception (Schweizer and Kurniawan, 2016). This is undesirable as it pays to be prudent and not to leave any stones unturned for identifying potential risks in any sectors, scales and levels that would impede sustainability transitions.

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