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Water pricing conflict in British Columbia

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Abstract:

The Water Sustainability Act in British Columbia, Canada is a source of conflict among citizens, the provincial government, and industrial groundwater users. The water extraction fees stipulated in the act highlight the issue of water commodification and its potential legal consequences. Complementary approaches for conflict analysis are used to study this emerging conflict in order to gain valuable strategic insights. Analysis is performed using the Graph Model for Conflict Resolution, a flexible methodology for analyzing and modelling conflicts. In addition, generalized metarationalities and metarational trees, which account for the role and influence of policies in decision-making, are used to explore possible resolutions of the conflict. The analyses show that the current situation, where protesters lobby the government but the fees are not increased, is an equilibrium and thus unlikely to change.

KEYWORDS Graph Model for Conflict Resolution; policy; water pricing; generalized metarationalities

INTRODUCTION

In May 2015, the government of the Canadian province of British Columbia (BC) passed the *Water Sustainability Act* (WSA), which then took effect in February, 2016. The WSA updates and replaces the *Water Act* of 1909 (Water Sustainability Act, 2014; Water Act, 1996). Until the WSA's introduction, use of groundwater in BC did not require permission or payment of fees and rental; the revision included, for the first time, regulations on groundwater use (Government of British Columbia, 2015).

The WSA's groundwater pricing regulations were controversial. A rate of up to $1.70 USD per million liters of groundwater extracted was set for industrial water users (IWUs); water bottling companies such as Nestlé are charged this maximum rate for extracting BC groundwater (Government of British Columbia, 2016b). According to the government of BC (GBC), the water prices set in the WSA were guided by the principles of full cost recovery and sustainability (Government of British Columbia, 2016a).

Once the pricing structure became known, citizens started an online petition and began to gather signatures (SumOfUs, 2015). A summer of droughts and wildfires pushed issues surrounding water regulation to the forefront. Many citizens felt there was a stark and unjust contrast between watering bans imposed on them and the government's treatment of Nestlé and other IWUs, who were seemingly permitted to extract large amounts of groundwater at a low cost.

The government responded by clarifying that the fees are intended to cover the costs of water extraction, not for the water itself. The provincial Environment Minister suggested that increased fees could leave open the possibility of commodifying water: "We don't sell the water. We never have in British Columbia. If you create water as a commodity for government – as a revenue stream – imagine what that does to conservation." (The Early Edition, 2015).

The commodification of water poses a potential threat under the North American Free Trade Agreement (NAFTA) between Canada, the United States, and Mexico. In particular, the worry is that the pricing of water will force the government to allow bulk water exports despite their ban under the Water Protection Act (Government of British Columbia, 2016a). There are concerns from both the government and its supporters that, if it seems as though the GBC is profiting from the fees, "the groundwater becomes a commodity and under the FTA [Free Trade Agreement] and NAFTA we cannot turn off the taps" (Tyabji, 2015).

Those protesting against the government's fees argue that they are simply too low (Brandes *et al.*, 2015; Lui, 2016). BC's fees are commonly contrasted with those of other Canadian provinces such as Nova Scotia, which in some cases charges over $105 USD per million liters of water extracted (Government of Nova Scotia, 2015). Protesters also contend that concerns over NAFTA and FTA are overblown and therefore do not provide a compelling reason for water rental prices to be so low. Legal and policy experts have stated that water pricing by the government has a low risk of contravening the obligations set forth in NAFTA (Coffin *et al.*, 2011; Gage, 2015; Woo, 2015).

There remain concerns, particularly from the GBC, of a challenge to the WSA by Nestlé (or other IWUs) citing NAFTA. This worry arguably impacts the government's decisions regarding water pricing. Furthermore, some legal experts argue that a future increase in fees could result in the government having to compensate IWUs (Gage, 2015). It is unclear whether IWUs would demand compensation in

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such a situation.

This water pricing dispute was studied using complementary approaches for conflict analysis in order to gain valuable insights into possible resolutions of the conflict. Analysis was performed using the Graph Model for Conflict Resolution (Graph Model), a methodology which supports users in analyzing and modelling conflicts (Fang *et al.*, 1993; Kilgour *et al.*, 1987). In addition, generalized metarationalities and metarational trees (MRTs) (Zeng *et al.*, 2005, 2006, 2007) are used to explore possible resolutions of the water conflict. These methodologies, which account for the role and influence of policies in decision-making, are a valuable extension of the Graph Model.

GRAPH MODEL ANALYSIS OF THE CONFLICT

The Graph Model for Conflict Resolution is used to model strategic interactions among several decision-makers (DMs). It is widely used due to its flexibility in analyzing conflicts using a range of solution concepts which reflect the diversity of human behavior under conflict. The Graph Model also requires relatively little information in order to produce meaningful strategic insights into possible resolutions of the conflict. The models presented here are calibrated based on publicly available articles, government documents, reports, and interviews. Analysis was performed using the GMCR+ decision support system (Kinsara *et al.*, 2015a, b).

Graph Model methodology

The Graph Model requires three main ingredients: DMs, their options, and each DM's preferences over the set of outcomes. Outcomes or states are created by combining options under each DM's control (see Table I). Letting $N = \{1, 2, ..., n\}$ and $S = \{1, 2, ...s, ...\}$ denote the set of DMs and the set of states, respectively, allows conflicts to be modelled as a finite set of directed graphs $D_i = (S, A_i)$ with i in N. The set of states is given by the vertices and the arc A_i between vertices s_k and s_j indicates that DM i can unilaterally move from one state to another in one step by changing the choice of options under its control (Fraser and Hipel, 1984; Kilgour *et al.*, 1987; Fang *et al.*, 1993).

A binary preference relation is defined for each DM on the set of states: for states s_k and s_j in S, $s_k <_i s_j$ indicates that DM i strictly prefers state s_j to state s_k, while $s_k =_i s_j$ means that the states are equally preferred. The set of unilateral moves (UMs) for DM i from a state is the set of states that DM i can unilaterally reach in one step from a starting state s. The set of unilateral improvements (UIs) is the set of states that DM i can reach in one step and are also more preferred to the starting state s.

Once the Graph Model is formed, solution concepts are used to model human behavior under conflict. They are intended to capture DMs having different levels of foresight, risk-aversion, and knowledge. The solution concepts most used in Graph Model analysis are Nash (1950, 1951), general metarational (GMR) (Howard, 1971), symmetric metarational (SMR) (Howard, 1971), and sequential (SEQ) (Fraser and Hipel, 1979, 1984) stabilities, summarized in Table III. States which satisfy a solution concept are said to

Table I. Decision-makers and options: by convention, a 0 indicates that the option has not been selected by the decision-maker while a 1 means that the option has been selected by the decision-maker

Government of BC								
Increase prices	0	1	0	1	0	1	0	1
Protesters								
Lobby government	0	0	1	1	0	0	1	1
Industrial water users								
Trade agreement challenge	0	0	0	0	1	1	1	1
Conflict states	1	2	3	4	5	6	7	8

Table II. Preferences for Government of British Columbia (GBC): by convention, a 0 indicates that the option has not been selected by the decision-maker while a 1 means that the option has been selected by the decision-maker

Government of BC								
Increase prices	1	1	0	0	1	1	0	1
Protesters								
Lobby government	0	1	0	1	0	1	0	1
Industrial water users								
Trade agreement challenge	0	0	0	0	1	1	1	1
Conflict states	2	4	1	3	6	8	5	7

Table III. Graph Model solution concepts: This is a summary of the most common solution concepts used in the Graph Model: Nash, general metarational (GMR), sequential (SEQ), and symmetric metarational (SMR) stabilities. By convention, $s_k \leq_i s_j$ means that decision-maker i prefers state s_j to state s_k or is indifferent between the two; $R_i^+(s)$ denotes the set of unilateral improvements by decision-maker i; $R_{N-i}(s)$ denotes the set of unilateral moves by all DMs except for i ; and $R_{N-i}^+(s)$ denotes the set of unilateral improvements by all DMs except for i

Solution concept	Mathematical definition	Definition
Nash	A state $s_k \in$ S is Nash stable if and only if (iff) $R_i^+(s_k) = \varnothing$	A state is Nash stable for DM i if it has no unilateral improvements
GMR	A state $s_k \in$ S is GMR stable iff $\forall\ s \in R_i^+(s_k)$, $\exists\ s_x \in R_{N-i}(s)$ with $s_x < s_k$	A state is GMR stable for DM i if each of i's unilateral improvements is sanctioned by an opponent unilateral move
SEQ	A state $s_k \in$ S is SEQ stable iff $\forall\ s \in R_i^+(s_k)$, $\exists\ s_x \in R_{N-i}{}^+(s)$ with $s_x < s_k$	A state is SEQ stable or DM i *if* each of i's unilateral improvements is sanctioned by an opponent unilateral improvement
SMR	A state $s_k \in$ S is SMR stable iff $\forall\ s \in R_i^+(s_k)$, $\exists\ s_x \in R_{N-i}(s)$ with $s_x < s_k$ and $\forall\ s_y \in R_i(s_x)$, $s_y < s_k$	A state is SMR stable for DM i if each of i's unilateral improvements is sanctioned by an opponent unilateral move, even after i has the chance to counter-move

be stable for that solution concept; if a state is stable for a solution concept for every DM, the state is called an equilibrium with respect to that solution concept. By convention, *N-i* is used to denote the set of DMs excluding DM *i*.

Decision-makers and options

There are three main DMs in this conflict: the GBC, Protesters, and the IWUs. Each DM controls several options, which are shown in Table I in Option Form (Howard, 1971). By convention, 0 indicates that an option has not been taken, while 1 means that the option has been selected. A combination of all DMs' option selections represents a specific state or outcome.

Although some of the new water extraction rates set by the government were in effect as of February 2016, a further fee increase is not precluded as the rates may be altered in response to ongoing monitoring over the first year of implementation (Fumano, 2015). The government can thus increase the water extraction rates (1) or leave them as they currently stand (0).

Although the protesters' petition successfully gathered signatures and thereby impacted the provincial government, some protesters remain unsatisfied with the development of events. The petition website states that "in BC, we'll keep fighting to limit groundwater licenses altogether for bottling companies like Nestlé and other corporate freeloaders too" (SumOfUs, 2015). The WaterWealth Project, which supported the petition, encourages citizens to contact the GBC "to let [it] know that British Columbians are paying attention to this issue and will not sit out this once-in-a-century opportunity to secure our shared water wealth" (Stephen, 2016). Protesters can thus continue to lobby the government to change the WSA (1) or drop the issue (0).

Nestlé, which has been the focus of the protesters' campaign, issued a statement saying: "We have supported the requirement that companies, including Nestlé Waters Canada, pay for their groundwater withdrawals in order to fund the newly established Water Modernization Act" (Nestlé Waters Canada, 2015). The company, it seems, is prepared to pay the cost approved in the WSA for extracting BC groundwater. Nestlé and other IWUs have the option to pursue a legal challenge based on trade agreements (1) or not (0).

Conflict states

Given the number of options, there are $2^3 = 8$ mathematically possible states. For larger conflicts, it is common practice to remove infeasible states in order to reduce the conflict to a tractable size. Since this is already the case, no states will be removed from the conflict model.

Preferences

The GBC would like to increase the water rental fees and prefers that this happens without a NAFTA challenge from IWUs and without escalation from protesters. Next, the government prefers not to increase the price so long as there is no NAFTA challenge from IWUs. The government's least preferred states are those in which IWUs initiate a NAFTA challenge against the province. The government's preferences (shown in Table II) are, ranked from most to least preferred: 2, 4, 1, 3, 6, 8, 5, 7, with the numbers corresponding to the states outlined in Table I. In Figure 1, the government's moves are shown by solid lines.

Protesters believe that NAFTA or other trade agreements cannot be applied to the water pricing conflict, thus it is assumed that a NAFTA challenge on behalf of IWUs is not of great concern to them. The protesters' preferences are, ranked from most to least preferred: (2, 6), (4, 8), (3, 7), (1, 5). States which are equally preferred are grouped in parentheses. In Figure 1, the protester's moves are shown by dashed lines.

Finally, Nestlé and other IWUs prefer that the government does not increase the water rental fees. The IWUs do not prioritize free trade agreement challenges. The IWUs' preferences are, ranked from most to least preferred: 1, 3, 2, 4, (5, 6, 7, 8). In Figure 1, the IWUs' moves are shown by dotted lines.

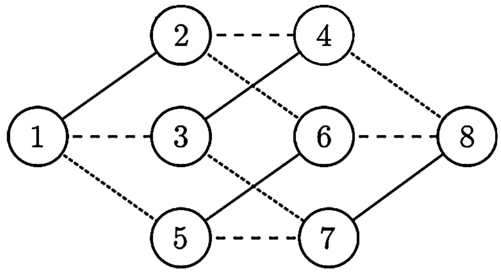

Figure 1. Graph model of the water pricing conflict: Moves available to GBC are shown by solid lines; moves available to the protesters are shown by dashed lines; moves available to the IWUs are shown by dotted lines

Graph Model analysis

An analysis of this conflict shows that there are three equilibrium states: state 2 is Nash, GMR, SEQ, and SMR stable; state 3 is GMR and SMR stable; state 4 is GMR and SMR stable. None of the equilibrium states has the IWUs challenging the provincial government under any trade agreement. State 3 represents the current state of the conflict: the government is not increasing water prices, protesters are lobbying the government to do so, and IWUs have not launched any trade agreement challenges.

Sensitivity analyses

Sensitivity analysis varies some of the model assumptions to explore 'what if?' scenarios. Several sensitivity analyses were conducted as follows. The first sensitivity analysis asked what would occur if the GBC's first choice was not to increase the water extraction fees. As a consequence, the GBC's preferences were altered to 1, 3, 2, 4, 6, 8, 5, 7. This change caused state 2 to no longer be Nash or SEQ stable although it remained GMR and SMR stable. State 3, on the other hand, became stable under all solution concepts while state 4 remained unchanged. Next, an analysis was conducted under the assumption that the IWUs preferred to launch trade agreement challenges; their preference ranking was changed to (5, 6, 7, 8), 1, 3, 2, 4. This caused a major shift in conflict equilibria, with state 6 being Nash, GMR, SEQ, and SMR stable and state 8 being a GMR and SMR equilibrium. Finally, an analysis explored the scenario in which the GBC were more sensitive to protesters than to a trade agreement challenge. To reflect this, the GBC's preferences were changed to 2, 1, 6, 5, 4, 8, 3, 7. This change did not disrupt the original equilibria very much; states 2 and 3 remained as before, while state 4 was no longer at GMR or SMR equilibrium. Based on these analyses, it is clear that a change in preferences from the IWUs would have important consequences for the conflict – namely shifting it into state 6 where the GBC increases prices and the IWUs launch trade agreement challenges.

Note that many assumptions were required to construct this Graph Model, particularly with respect to the ordering of the DM's preferences. In practice, a DM may not have a clear definition of their opponent's preferences; they may, however, have a general idea of how their opponents might behave when a certain state arises. Furthermore, DMs may be interested in longer time horizons, which are not provided by the solutions concepts used here. These observations are addressed by the methodology introduced in the next section.

GENERALIZED METARATIONALITY ANALYSIS OF THE CONFLICT

Generalized metarationalities describe the DM's interactions as a series of rounds, with the initial move made by the focal DM and counter-moves conducted by the remaining DMs (Zeng *et al.*, 2005, 2006, 2007). That is, each round consists of a series of turns taken by the focal DM and then by the remaining DMs. Rather than using each DMs' preferences, this methodology requires the focal DM's preferences and uses policies to analyze the behavior of the other DMs. A policy for DM i is a function P_i: $S \rightarrow S$ which specifies what the action will be at each state should it arise, irrespective of the DM's preferences (Zeng *et al.*, 2006). For a DM i, starting from state s_k, the DM will either move to a reachable state or remain at s_k, according to their policy.

This methodology is particularly well suited for cases in which a DM may not be able to generate preference rankings for an opponent due to a lack of information. Rather than calculating stability based on opponent preferences, state stability is calculated using opponent policies. Policies are commonly extrapolated from the expected behavior of that particular DM. These policies express the "rules" that a DM might follow when deciding how to act next; by assigning policies to opponents, a DM can, using this methodology, still execute an analysis of the conflict.

Generalized metarationalities methodology

Each round begins with the focal DM either staying at the current state or moving according to a UM; next, other DMs move according to their policies. A new round begins whenever the focal DM makes a move. The moves and counter-moves between DMs create a sequence of states. Two types of rounds can be considered depending on the last mover; i-sequences end with focal DM i as the last mover, while $\bar{i}$-sequences end once all the other DMs have made their moves but before the focal DM moves again. The series of moves and counter-moves is recorded using metarational trees (MRTs) with each branch of the MRT representing possible evolutions of the conflict.

Given some starting state s_k placed at the root of the tree, the first level of branches represents the focal DM's possible moves from s_k. Next, the DM's opponent(s) possible moves are recorded; these moves are determined by the opponent policies. Once all opponents have moved, it is once again the focal DM's turn. Details regarding metarational stability calculations can be found in the Supplemental Figures.

The following analysis will make use of i- and $\bar{i}$-metarational stability solutions concepts which correspond to i- and $\bar{i}$-sequences, respectively. A state s_k is i-metarational stable (MR_r) for DM i if for each of i's UMs from s_k there is a set of policies P_j of all the other DMs and an i-sequence of r rounds or shorter such that the result of this sequence is not more preferred to s_k by DM i. A state is $\bar{i}$-metarational stable ($\overline{MR_r}$) for DM i if for each there is a set of policies P_j of all other DMs and an $\bar{\imath}$-sequence of r rounds or shorter such that the result of this sequence is not more preferred to s_k by DM i. In both cases, the starting state s_k is compared to the states which can result from the application of possible opponent policies; if there is a result less preferred than the starting state, the state is said to be stable.

Generalized metarationalities analysis

In this analysis, the focal DM is the GBC. Its preferences remain the same as for the Graph Model analysis, in contrast to all other DMs, for which no preferences are assumed; instead, these DMs are ascribed policies based on their anticipated behaviors. From the government's perspective, the IWUs will attempt to invoke a trade agreement challenge only in the event of a price increase. A trade agreement challenge cannot be launched in the absence of a price increase, given that water pricing in and of itself is unlikely to contravene trade agreement obligations (Coffin *et al.*, 2011). The IWUs' policy is thus as follows: $P_{IWU}(2) = P_{IWU}(6) = 6$; $P_{IWU}(4) = P_{IWU}(8) = 4$; $P_{IWU}(1) = P_{IWU}(5) = 1$; and $P_{IWU}(3) = P_{IWU}(7) = 3$. Citizen protesters are unlikely to stop protesting until the government increases its water pricing fees. Once fees have been increased, however, protesters will cease lobbying activities. The protesters' policy is thus: $P_{Protesters}(1) = P_{Protesters}(3) = 3$; $P_{Protesters}(2) = P_{Protesters}(4) = 2$; $P_{Protesters}(5) = P_{Protesters}(7) = 7$; and $P_{protesters}(6) = P_{Protesters}(8) = 6$. The stability results of this analysis are shown in Table IV; each MRT constructed using the preferences and policies outlined above appears in the Supplements, assuming that the DMs move in the order GBC, protesters, and IWUs. Figure S1 is also accompanied by a detailed explanation of how each type of metarational stability is determined.

Insights are provided by the MRT analysis of each state. States 1 and 3, for example, are $\overline{MR}_1$, MR_2, $\overline{MR}_2$, MR_3, MR_4, and $\overline{MR}_4$ stable for the GBC; the Graph Model showed that those states are GMR and SMR stable. The additional stabilities show that after two, and four rounds, and regardless of the last mover, the GBC has little incentive to move away from state 1 or from state 3. This goes beyond GMR and SMR stabilities, which examine the conflict two and three steps into the future, respectively. Furthermore, both GMR and SMR stabilities have restrictions on the types of moves and counter-moves being considered since only unilateral improvements from the focal DM are examined. Metarational stabilities, on the other hand, consider all of the focal DM's possible unilateral moves, leading to broader results. Should a focal DM wish to focus exclusively on their unilateral improvements, they merely have to follow the appropriate branches in the MRT.

States 2 and 4, which are stable for the GBC under all Graph Model stability concepts are also stable for all of the metarational stability solutions concepts. Should the conflict move to either of these states, it is unlikely that the government will initiate a move away from them given the potential for sanctioning by other DMs. By contrast, states 5 and 7 are unstable for all solutions concepts for the GBC; regardless of the number of rounds and of the last movers, the government is better off moving away from states 5 and 7.

The MRT analysis sheds further light on state 6 which, when only considering the Graph Model analysis, is indistinguishable from states 2, 4, and 8. Unlike states 2 and 4 which are stable for all metarational solution concepts, state 6 is only stable when the GBC is the last mover, i.e., is MR_1, MR_2, MR_3, and MR_4 stable. This means that at the end of each round, the provincial government is worse off than state 6; however, this is remedied by the government moving once again. Compared to state 8, state 6 possesses additional metarational stabilities.

It is important to note that the stability of states for the GBC depends on the government's preferences; should these change, so would the stable states. The MRTs constructed for the analysis, however, still remain valid (as long as the policies ascribed to the IWUs and to the protesters stay the same) and can thus be re-used to conduct the analysis with different preferences for the GBC. An MRT analysis from a focal DM's perspective therefore requires little more than that DM's preferences and policies for the other DMs. So long as the policies are fixed, the analysis can accommodate changes in focal DM preferences. Furthermore, the MRT analysis is useful even when the focal DM is unsure of their preferences; since the MRTs provide possible developments of the conflict, the focal DM can examine how events are likely to transpire.

Table IV. Metarational and Graph Model analysis for GBC. A checkmark indicates that the given state is stable for GBC under a particular solution concept; a blank cell means that the state is not stable under the corresponding solution concept

	MR_1	$\overline{MR}_1$	MR_2	$\overline{MR}_2$	MR_3	$\overline{MR}_3$	MR_4	$\overline{MR}_4$	Nash	GMR	SEQ	SMR
1		√	√	√		√	√	√		√		√
2	√	√	√	√	√	√	√	√	√	√	√	√
3		√	√	√		√	√	√		√		√
4	√	√	√	√	√	√	√	√	√	√	√	√
5												
6	√		√		√		√		√	√	√	√
7												
8	√								√	√	√	√

COMPARISON OF ANALYSIS METHODS

The Graph Model and generalized metarationalities methodologies are alike in their use of DMs, options, and stability concepts to analyze conflicts. The main point of divergence occurs in how preferences are used. The Graph Model requires preference information from all DMs in order to proceed with analysis; generalized metarationalities, however, need only the preference information of the focal DM and use opponent policies to carry out stability analysis. In this case, the focal DM was the GBC; the generalized metarationalities analysis was thus conducted from this DM's point of view.

The results obtained from each analysis is, as expected, slightly different, since the Graph Model analysis is taken from the "outside analyst" perspective and provides information about possible global resolutions of the conflict, while the generalized metarationalities analysis is from the GBC's point of view and provides only that DM with possible outcomes. However, it should be noted that state 3, the current state and a predicted Graph Model equilibrium, is stable under most of the generalized metarationality solution concepts as well; both models agree that state 3 is stable for the GBC.

CONCLUSIONS

An emerging water pricing conflict in BC was analyzed using both the Graph Model and generalized metarationalities methodologies, which offer insights for DMs and analysts. The Graph Model analysis of the conflict yielded several equilibrium points and showed that the current state of the conflict (state 3) is an equilibrium point for GMR, and SMR stabilities. Analysis using generalized metarationalities and metarational trees with the GBC as the focal DM also shows that state 3 is stable for the GBC under the majority of the metarational solution concepts. Such an analysis is particularly helpful to focal DMs unsure of their opponents' exact preferences but with a general idea about how opponents might behave. What's more, the focal DM can construct the MRTs without having to supply its own preferences; the preferences can be formed once the analysis has been conducted and the focal DM has a better vision of how events might unfold.

Going forward in this conflict, it is expected that the current state will hold for some time given its stability characteristics. In fact, this state has held for over a year; although the GBC was scheduled to review its pricing in February 2017, it has yet to do so. As long as the provincial government does not increase its water prices, evolution of the conflict is unlikely: protesters will continue to lobby the government for increased rates while IWUs will not launch any trade agreement challenges. Should the government wish to increase groundwater extraction prices in the future, it will have to take the risk of a trade agreement challenge into account.

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SUPPLEMENTS

Text S1. Detailed explanation of metarational calculations for state 1 for GBC

Figure S1. Metarational tree for Government of British Columbia starting at state 1

Figure S2. Metarational tree for Government of British Columbia starting at state 2

Figure S3. Metarational tree for Government of British Columbia starting at state 3

Figure S4. Metarational tree for Government of British Columbia starting at state 4

Figure S5. Metarational tree for Government of British Columbia starting at state 5

Figure S6. Metarational tree for Government of British Columbia starting at state 6

Figure S7. Metarational tree for Government of British Columbia starting at state 7

Figure S8. Metarational tree for Government of British Columbia starting at state 8

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