RPR
REVIEW OF POLICY RESEARCH

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Journal:	*Review of Policy Research*
Manuscript ID	RPR-OA-19-08-0077.R2
Manuscript Type:	Original Article
Keywords:	energy, governance, regional governance, civil society, environment, media

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Introduction

The practice of hydraulic fracturing[1] has dominated the North American oil and gas industry over the last decade, fundamentally transforming global markets for natural gas, coal, and liquefied natural gas (Neville et al. 2017; IEA 2019). Hydraulic fracturing has emerged as a dynamic area of policy making. Jurisdictions have adopted different regulatory designs to manage the practice, ranging from minimal regulations, comprehensive frameworks, moratoria, and bans (Rabe and Borick 2013; Rabe 2014; Carter and Eaton 2016). Policy scholars have also identified variation in processes of regulatory development. Some jurisdictions have engaged in highly technical internal reviews with a limited number of analysts and consultants (Precht and Dempster 2012; ERCB 2011). Others have engaged in wider ranging processes involving scientific panels and extensive public consultation (Neville and Weinthal 2016; Crow, Albright, and Koebele 2016; Wheeler et al. 2015).

Comparative policy scholars have identified the structural power of the oil and gas industry and/or contentious politics as strong determinants of regulatory outcomes. Jurisdictions with a historical legacy of oil and gas production, such as Texas and Saskatchewan, have engaged in minimal changes to their regulatory frameworks (Davis 2012; Carter and Eaton 2016). Alternatively in jurisdictions where anti-fracking mobilization has been significant, such as Quebec, Scotland, and Bulgaria, governments have implemented precautionary measures such

[1] Other terms for this process include: "fracking," "hydro-fracking," "fraccing," and "high volume hydraulic fracturing." For the purposes of this article I use the term "hydraulic fracturing" to encompass the entire process of extraction, including well pad construction, well drilling and completion, the transportation of water and chemicals to the well pad, the actual "frack" of injecting pressurized water into the well, and the disposal of produced waters.

as moratoria and bans (Montpetit, Lachapelle, and Harvey 2016; Stephan 2020; Goldthau and LaBelle 2016). Despite these broad trends there are exceptions. The Canadian province of British Columbia has developed a limited regulatory framework for hydraulic fracturing (Carroll, Stephenson, and Shaw 2012). This regulatory outcome is unexpected given a long history of environmental mobilization in the province (Pralle 2006; Bernstein and Cashore 2000); strong public support for environmental regulation (Canadian Election Survey 2008); and the provincial government's ongoing commitment to climate policy including spearheading North America's first revenue-neutral carbon tax in 2008 (Harrison 2012). Conversely, despite Nova Scotia's extensive experience with offshore oil and gas, including offshore hydraulic fracturing (Clancy 2007; Government of Nova Scotia 2014a), the province of Nova Scotia has pursued a precautionary approach by introducing a legislated ban.

This study demonstrates that these discrepancies can be explained through a closer attention to the politics of regulatory development, and in particular mechanisms of regulatory change. Policy learning frameworks are useful for understanding variation in processes of regulatory development. Hydraulic fracturing regulations can be developed through highly insular processes of *technical learning,* in which a limited number of bureaucrats, government officials, and industry technicians engage in specialized knowledge production (such as hydrology and seismology) to update their beliefs about the efficacy of policy instruments. Alternatively, regulations can be negotiated through more expansive processes of *social learning* in which larger swaths of society engage in collective puzzling about regulatory instruments as well as deeper debates about broad policy goals. Finally, changes to regulatory frameworks can be managed through a collective process of *political learning* in which regulators, advocacy groups, academics, and elected officials update their beliefs about the political feasibility of a given policy solution (Hall 1993; May 1991; Freeman 2006; Dunlop and Radaelli 2013; Moyson, Scholten, and Weible 2017).

Policy learning scholarship has identified institutional insularity and problem uncertainty as key factors determining variation in modes of learning. First, *institutional insularity* refers to the degree of openness of a policy subsystem to public engagement, in particular whether decision makers are insulated from broader electoral dynamics (Pierson 1993). Studies of rule-making processes in hydraulic fracturing have documented that increased stakeholder and public engagement can foster precautionary regulatory outcomes (Crow, Albright, and Koebele 2016; Goldthau and LaBelle 2016). Conversely, when regulators are engaged primarily with industry actors through internal processes, minimal regulation is more likely (Baka et al. 2018; Davis and Hoffer 2012; Carter and Eaton 2016; Rinfret, Cook, and Pautz 2014).

Second, *problem uncertainty* refers to actors' collective understanding of the scope and dimensions of the policy problem at hand (Dunlop and Radaelli 2013). Comparative research on hydraulic fracturing has found focusing events and framing contests to have a strong influence on regulatory outcomes (Stephan 2020; Bomberg 2012; Jaspal and Nerlich 2013; Yordy et al. 2019). Learning theory suggests that the social construction of problem uncertainty impacts what knowledges, information, and values, are considered to be appropriate inputs into policy design. When problem uncertainty is low, regulators will rely on existing systems of policy advice to guide their decisions. As problem uncertainty increases, regulators are more likely to turn to scientific studies, Indigenous knowledge, environmental perspectives, and citizens' attitudes through processes of social learning (Dunlop and Radaelli 2017).

This article demonstrates *how* institutional insularity and problem uncertainty influence processes of policy learning through a detailed examination of two exemplary cases of provincial hydraulic fracturing regulatory development: British Columbia and Nova Scotia. The study uses process tracing to demonstrate how institutional characteristics interacted with the social construction of problem uncertainty to foster processes of technical learning in British Columbia and social learning in Nova Scotia. The study finds that in British Columbia, regulators within the BC Oil and Gas Commission were insulated from both environmental advocates and electoral politics. Bolstered by a lack of salient narratives regarding scientific uncertainty or public opposition to fracking, regulators engaged in processes of technical learning about specific regulatory settings, based on conventional frameworks for oil and gas. In Nova Scotia an external review provided an ad-hoc institutional venue through which environmental advocates, experts, members of Indigenous communities and other residents could vocalize strong narratives regarding scientific uncertainty and the public's anxiety regarding environmental risks. These conditions fostered processes of social learning among advocates and the general public and political learning among elected officials resulting in a hydraulic fracturing ban.

The article proceeds as follows. The next section provides a brief review of the policy learning literature, identifying key drivers of processes of technical, social and political learning. The third section sets out the research design and methodology of the study; the fourth section establishes the political context and timeline of hydraulic fracturing regulatory development in British Columbia and Nova Scotia from 2010-2014. The next two sections demonstrate how the social construction of problem uncertainty and institutional insularity fostered different modes of learning in each province. The article concludes with a discussion of empirical and theoretical implications and opportunities for future research.

Modes and drivers of policy learning

One of the challenges governments face in developing regulations for hydraulic fracturing is that the practice is a nascent policy area in which both elected officials' and mass publics' particular regulatory preferences are under-defined (Ingold, Fischer, and Cairney 2016; Heikkila et al. 2014). In addition, heterogeneity in existing conventional oil and gas regimes and limitations of national jurisdiction have made it difficult for regulatory frameworks to diffuse across subnational boundaries through interest-driven mechanisms of competition or vertical coercion, making learning processes more influential in determining regulatory outcomes (Rabe 2014; Neville et al. 2017). Although policy learning can occur throughout the policy process, it is especially crucial during policy formulation in which government officials consider different elements of regulatory design (May 1991; Heikkila and Gerlak 2013). Understanding the political dynamics of learning processes thus presents an opportunity to examine how regulators sift through conflicting information, interests, and values to develop rules for hydraulic fracturing.

Broadly defined as the process through which actors update their beliefs based on experience, analysis, rules, and social interaction (Dunlop and Radaelli 2018a), policy learning has been identified in the policy studies literature as a key mechanism of regulatory change (Hall 1993; Sabatier 1988; Dunlop and Radaelli 2017). Despite a plethora of conceptual and empirical challenges in determining the subjects, objects, and sources of learning (Bennett and Howlett 1992; Moyson, Scholten, and Weible 2017), the literature coalesces around three dominant modes of learning: 1) technical 2) social and 3) political (Heikkila and Gerlak 2013; O'Donovan 2017; Crow et al. 2018).

Technical learning occurs when actors update their beliefs about the efficacy of a particular policy instrument or setting (including regulation) based on new information from different jurisdictions, epistemic communities, or past experiences (May 1992; Hall 1993; Boyd 2017; Sabatier 1988). Often termed "instrumental" (May 1992) or "single-loop" learning (Argyris and Schön 1978), technical learning focuses particularly on the elements of programmatic or regulatory design, rarely examining the fundamental ideological or normative underpinnings of a particular policy (Stark 2019; Hall 1993). Technical learning tends to occur primarily among government officials and bureaucrats, occasionally involving scientific experts (Haas 1992; Lindvall 2009; Rietig 2018; May 1991). Analytical work by Dunlop and Radaelli (2013; 2016; 2018a; 2018b) identifies two variants of technical policy learning: first *learning in the shadow of hierarchy* – in which learning (and policy design) is constrained within hierarchies by institutional norms of appropriateness (March and Olsen 1996) and second *epistemic learning*, in which policy elites consult with scientific experts to inform more complex regulatory design (Dunlop 2017). This article uses technical and hierarchical learning interchangeably, reserving epistemic learning to refer to processes driven more extensively by scientific experts.

Social learning, sometimes termed "reflexive" (Dunlop and Radaelli 2013), or "double-loop learning" (Argyris and Schön 1978) occurs when actors change their causal and normative beliefs. This type of learning is concerned with more deeply held "core beliefs" (Sabatier 1988; Jenkins-Smith et al. 2014), paradigmatic worldviews (Hall 1993) and values (Stark 2019) and often includes reflections on the assumptions and implicit knowledge underpinning regulatory design (Stark 2019; May 1992). As the term implies, this mode of learning is "social," involving a broad spectrum of actors such as government officials, bureaucrats, experts, interest groups, journalists, and members of the public (Dunlop and Radaelli 2018b; Hall 1993).

In modes of *political learning*, actors update their perceptions of the political feasibility of a given solution, also based in information gained either across time or space (May 1992; Trein

2018). Unlike technical learning, which is concerned with the nitty-gritty efficacy of regulatory design, political learning is concerned with "learning about strategies for advocating policy ideas or drawing attention to policy problems" (May 1992, 339). Advocacy coalition framework scholars refer to these ideas as "secondary beliefs," which are shared understandings within coalitions as to the most viable means of advancing political goals (Jenkins-Smith et al. 2014). Dunlop and Radaelli (2018b) term this learning mode as "a by-product of bargaining" in which "decision-makers learn about the composition of preferences on an issue … [and the costs of] reaching agreements" (262). The distinction between political learning and technical learning draws on the classic distinction between powering and puzzling (Heclo 1974; Pierson 1993). Although Trein (2018) argues that powering and political learning are interchangeable terms, this article argues that political learning provides a focus on the *process* through which elites acquire information about their material and political position, a process which is often elided in structural accounts of policy change (Parsons 2007). Political learning occurs primarily among government officials, bureaucrats and interest groups, as different coalitions learn and assess each other's' strategic interests.

Drivers of variation in modes of learning

Variation in collective processes of learning can be explained by the interaction of institutional and ideational characteristics in a given jurisdiction (Dunlop and Radaelli 2013; 2018a; 2018b; Moyson 2017; Heikkila and Gerlak 2013). First, when institutional structures are more closed, either because of delegated authority to independent regulators, or because of tight policy networks comprised of bureaucrats, incumbent industries, and government officials, policy change is more likely to occur at the level of instruments and settings (Skogstad 2008;

Culpepper 2011; Hall 1993). For example, energy scholars have noted the propensity of different administrative agencies such as stand-alone oil and gas commissions to limit the extent of regulatory change by engaging primarily in processes of technical learning (Cook 2014; Hoberg and Phillips 2011; Pralle 2006). When institutional structures are more open to a broader set of actors – because of stakeholder consultation processes, court challenges, or municipal town hall meetings for example – more radical policy change, such as instituting a moratorium on hydraulic fracturing, is possible (Hoberg 2013; Atkinson and Coleman 1992; Hall 1993; Schattschneider 1960). Pierson (1993) refers to this concept as "institutional insularity," suggesting that technical learning is more likely when decision makers are insulated and "a small number of actors are involved" (617). This article proposes that institutional insularity is significant because it determines the scope of who is considered a legitimate participant in policy formulation and design. In their synthetic review of policy learning studies, Dunlop and Radaelli (2013) argue that learning modes are generated in part by levels of "actor certification," or collective perceptions that a given (singular) source of information, or "teacher" is considered credible. High levels of institutional insularity tend to privilege bureaucratic or scientific expertise, leading to higher levels of actor certification, resulting in the predominance of technical and epistemic learning. When the institutional context validates a wider range of "teachers," allowing for a plurality of knowledges to inform regulatory design, actor certification is likely to be low, resulting in either social or political learning (Dunlop and Radaelli 2018b). This study contends that if we observe shifts in institutional insularity in a given province, we can expect to see movement away from technical learning toward broader processes of social or political learning as polities seek to engage a greater plurality of stakeholders into regulatory design in order to bolster legitimacy.

Canadian provincial hydraulic fracturing policy making is an ideal test case in which to examine the effect of institutional insularity on modes of policy learning. The institutional locus for regulatory development in Canada varies according to province. Some provinces delegate regulatory responsibility almost completely to independent energy regulators such as the BC Oil and Gas Commission and the Alberta Energy Regulator (BC Oil and Gas Commission 2014a; AER 2013; Carter, Fraser, and Zalik 2017). Other provinces situate responsibility for hydraulic fracturing in various provincial ministries, ranging from natural resources, energy, to the environment (Government of Newfoundland and Labrador 2013; Carter and Eaton 2016). Governments have also struck legislative task forces and cross-ministerial working groups to develop regulatory frameworks (New Brunswick Natural Gas Group 2012; Precht and Dempster 2012). This institutional variation presents an opportunity to operationalize institutional insularity and examine its effect on modes of learning.

The second determinant of variation in learning modes is the degree of problem uncertainty. Problem, or issue definition, refers to the construction of policy problem, specifically the perceived normative and causal drivers of the policy challenge facing a polity (Stone 1989; Baumgartner and Jones 1993; Schon and Rein 1995; Jones 2017). Pierson (1993) refers to this as “policy complexity” arguing that when the relationship between policy and outcomes is perceived to be direct, powering or political learning dominates, while technical learning is more likely to occur when “causal chains are more complex and uncertain” (618). Similarly, Dunlop and Radaelli (2013) argue that a key determinant of different learning modes is whether policy actors see the problem as “tractable,” namely the degree to which a particular policy demonstrates “radical uncertainty” (602). When problem uncertainty is low, actors are more likely to have clearly defined interests, making either technical learning within bureaucracies or political bargaining between advocacy groups more likely (May 1991; Dunlop and Radaelli 2018b; Pierson 1993). Conversely, high problem uncertainty can foster collective modes of social learning as policy makers seek out a broader set of inputs. Through processes of social learning alternative sources of knowledge, information, and values are more likely to be incorporated into policy formulation and design (Hall 1993; Dunlop and Radaelli 2013; Rose 1991).

Although policy learning scholars have theorized the impact of problem uncertainty on modes of learning, the influence of different facets of uncertainty is less developed. Drawing on policy studies literature on hydraulic fracturing and public risks, I suggest that frames of scientific uncertainty, public anxiety, and public trust are key dimensions of problem uncertainty in hydraulic fracturing. Perceptions of scientific uncertainty, that is whether there is scientific consensus regarding estimated harms and probabilities, determines in part whether polities see themselves as facing a tractable problem with clearly defined means and ends, or dealing with "unknown unknowns" in which historical patterns provide limited blueprints for action (Blyth 2009; 2013; Falkner and Jaspers 2012). In hydraulic fracturing policy making, scientific consensus regarding environmental risks generated by hydraulic fracturing has varied across time and place (Neville et al. 2017; Small et al. 2014). Early expert opinion varied with regard to the safety of the practice (Rivard et al. 2014) and scientists have subsequently debated the potential for hydraulic fracturing to result in groundwater contamination, seismic activity, habitat fragmentation, and increased GHG emissions (Howarth, Santoro, and Ingraffea 2011; Johnson and Johnson 2012; Schultz et al. 2018; Olive 2018; Lauer, Harkness, and Vengosh 2016; Kondash and Vengosh 2015; Jackson et al. 2014). This variation in perceived scientific consensus on hydraulic fracturing, particularly across time, presents an opportunity to tease out the relationship between frames about scientific uncertainty and modes of learning.

Problem uncertainty can also be driven by the degree to which the public perceives a risk as uncontrollable and involuntary, with the potential for fatal consequences, often termed "dread" risk (Slovic 1987; 1993; 2000). Risk scholars argue that the salience of dread risks can shift problems from tractable issues easily dealt with through quiet politics driven by experts, to intractable policy issues which demand more wide ranging public dialogue and debate (Slovic 1987; 1993; Wildavsky 1988; May 1991; Sunstein 2005; 2009). Public opinion scholarship on hydraulic fracturing has demonstrated distinct empirical variation with regard to intensity of public attention to environmental risks (Andersson-Hudson et al. 2016; Clarke et al. 2015; Evensen et al. 2014; Christenson, Goldfarb, and Kriner 2017; Bullock and Vedlitz 2017; Brasier et al. 2013; Jacquet 2012; Jacquet and Stedman 2013). Risk scholars note that public attention to dread risks is often mediated through public trust in institutions. When citizens' trust in government institutions decreases, their attention to environmental risks increases (May 1991; Slovic 1993; Douglas and Wildavsky 1983). Scholarship on hydraulic fracturing has also demonstrated significant variation with regard to lack of trust in regulators, noting that public attention to environmental risks has increased in jurisdictions where there is a legacy of distrust of governments' capacity to manage environmental challenges (Neville and Weinthal 2016; Lachapelle, Montpetit, and Gauvin 2014; Fisk 2013). Problem uncertainty can thus be influenced by the salience of environmental harms in the public eye as well as lack of trust in government, facilitating different modes of learning.

Analytical Framework

This study proposes the following framework to explain variation in provincial processes of policy learning in hydraulic fracturing. The interaction of institutional insularity and problem uncertainty presents four potential pathways to toward different modes of learning (see Table 1).

[INSERT TABLE 1 HERE]

In jurisdictions with high institutional insularity and low problem uncertainty, bureaucrats and experts within governments are certified to manage potential environmental risks, resulting in a process of technical learning regarding regulatory instruments and settings and single-issue regulation. When institutional insularity remains high but problem uncertainty increases governments are more likely to turn to outside scientific expertise to develop regulatory outcomes, reflecting a variant of technical learning, "epistemic learning." Depending on the ability of experts to resolve problem uncertainty, processes of epistemic learning could either produce changes to technical instruments and settings, or more comprehensive regulatory frameworks. Conversely, in polities demonstrating low institutional insularity and low levels of uncertainty, we can expect to see processes of political learning among advocacy groups and government officials as groups battle for their preferred regulatory instruments (May 1991; Dunlop and Radaelli 2018b). In this pathway, the most politically feasible regulatory framework will prevail. Finally, when jurisdictions demonstrate low institutional insularity and high levels of uncertainty, the scope of certified participants engaging with regulatory design is more likely to be wide ranging, involving journalists, advocacy groups, and members of the general public. When perceived risks are high, driven by scientific uncertainty, public fears of "dread" environmental harms and fueled by lack of trust, polities may be more likely to engage in processes of social learning that challenge underlying policy assumptions, values, and worldviews, leading actors to collectively update their beliefs. How social learning influences policy design will likely be dependent on the speed with which new interest groups mobilize and solidify their policy preferences regarding a particular policy design (May 1991). Ultimately, different learning modes shape how regulators perceive of and assess the relative weight of environmental harms and take action through regulatory design.

Although this study focuses how institutional and ideational conditions influence regulatory outcomes through processes of learning, the intention of the article is not to diminish the influence of structural factors such as historical legacies of oil and gas industries and the extent of environmental mobilization in a given polity. Indeed, this framework suggests that by changing (or protecting) the institutional siting of regulatory development or by increasing the salience of scientific uncertainty and dread risks, advocacy groups can transform (or reinforce) the processes of learning through which regulations are developed, affecting regulatory outcomes. Determining the specific relationship between structural power and institutional insularity or contentious politics and problem uncertainty is beyond the scope of this article.[2] However the analytical framework put forward here provides an opportunity for hydraulic fracturing scholars to examine the intermediary mechanisms through which corporate power and contentious politics determine regulatory outcomes.

Research design and methodology

To probe the plausibility of this analytical framework, this study compares processes of hydraulic fracturing regulatory development from 2010-2014 in two Canadian provinces: British Columbia and Nova Scotia. The study focuses on BC and Nova Scotia as exemplary cases of technical and social learning respectively. The two cases demonstrate cross-section and temporal variation with regard to the phenomenon under study: in British Columbia, regulatory

[2] See (Author 2019) for a comprehensive exploration of these dynamics.

development has been primarily internal (EY 2015; Montpetit, Lachapelle, and Harvey 2016), while Nova Scotia has engaged in first internal and subsequent external reviews (Atherton et al. 2014; Precht and Dempster 2012). The cases are most likely cases (Eckstein 1991; Levy 2008) in that we would expect technical learning in British Columbia, given high levels of institutional insularity and low levels of problem uncertainty. In Nova Scotia, theory suggests social learning is more likely given reverse levels of low institutional insularity and high problem uncertainty. The selection of these provinces complements recent studies examining processes of epistemic and political learning in hydraulic fracturing regulatory development in New Brunswick and Alberta respectively (Author, Forthcoming).[3] As two subnational units within the Canadian federal structure the two provinces are broadly comparable with regard to political culture, pro-industry regulatory regimes, and public support for the environmental concerns. The study focuses on the period of 2010-2014 as this was a significant period of regulatory development in Canada, the US, and Europe (Mazur 2016; Stephan 2020)[4]. As discussed in more detail below, British Columbia implemented various single-issue pieces of regulation over the time period, while Nova Scotia implemented a moratorium in 2012 and a legislated ban in 2014. Regulatory developments post-2014 have been minimal, with both provinces reaffirming their initial positions in recent years (Scientific Hydraulic Fracturing Review Panel 2019; Laroche 2019).

[3] Although the study considers these learning processes to be most likely cases, from the perspective of the relationship of structural variables and regulatory outcomes the BC case stands out as a potential least likely case. As discussed in the following section below during the period of study, BC had an extensive, organized environmental movement, a history of Indigenous leadership, high levels of public support for environmental issues and a government with an interest in climate policy. These factors would usually be correlated with a precautionary regulatory outcome, such as a moratoria or a ban.

[4] Alberta and New Brunswick released comprehensive regulatory frameworks for hydraulic fracturing in 2012 and 2013. Quebec announced a partial moratorium in 2011, followed by a full moratorium in 2014. Newfoundland announced a moratorium on shale gas and oil production in 2013; in 2014 New Brunswick followed suite, announcing a moratorium on High Volume Hydraulic Fracturing, which it reaffirmed in 2016. Saskatchewan has introduced minimal regulations for shale oil (Author 2019; Carter and Eaton 2016; Carter and Fusco 2017; Montpetit et al. 2016).

The study uses process tracing to examine how degrees of institutional insularity and social constructions of problem uncertainty interacted in each province to foster different processes of learning. Process tracing is increasingly used in environmental politics qualitative research to identify causal mechanisms within a case study (Gerring 2008; Beach 2016; Stokes and Breetz 2018). Drawing on policy documents, provincial Hansards, news articles, grey literature, and scholarly studies, the author constructed case summaries and regulatory timelines for each province, paying close attention to the sequence of events and within-case regulatory change over time. To measure how institutional insularity changed or remained the same during regulatory formulation the study assessed whether the policy subsystem was initially open or closed in each province, attending to institutional characteristics such as whether the province has an independent regulator for oil and gas, the statutory environment, and whether the government struck cross-ministerial working groups to develop regulation.

To trace how problem uncertainty was constructed over time in each province the study draws on thematic and content analysis of over 400 news articles. Media analysis is a useful technique in tracing changes in problem uncertainty over time because of the ability to isolate particular frames regarding fracking, as well as the actor, source and date of each claim (Lodge and Matus 2014; Olive 2016; Olive and Delshad 2017; Bronson, Dobson, and O'Doherty 2019; Blair et al. 2015). The author and a research assistant developed a database of articles gathered using keyword searches of terms "hydraulic fracturing", "fracking", "unconventional gas", or "shale gas". The search yielded 220 articles from the *Chronicle Herald* in Nova Scotia and 218 articles from the *Vancouver Sun*, regional newspapers with the highest circulation in each province. We coded articles inductively, drawing out the thematic arguments, or frames, used by different actors over the course of public debates (Braun and Clarke 2006). To measure problem uncertainty we used four measures and calculated the frequency of frames in the data set: 1) references to environmental harms and/or economic benefits; 2) references to scientific uncertainty 3) references to public opposition to fracking[5] and 4) references to lack of public trust in government. Each argument was coded to a specific actor type (e.g. industry, environmental advocate, academic expert, elected official), while unattributed claims were tagged to "journalist." The media analysis provides pattern and sequence evidence (Beach 2016) for collectively held understandings of problem uncertainty in the policy subsystems described below.

The case summaries and media analysis are complemented by account evidence gathered from semi-structured key informant interviews with political staffers, regulatory managers, policy analysts, scientists, and environmental advocates in each province. The interview schedule was designed to elicit comment on processes of regulatory development, including information sources, institutional characteristics, and perceptions of scientific uncertainty. Five interviews were conducted in person in Halifax in November 2014 and four interviews were conducted in person in Victoria and Vancouver in June 2015, with a final interview conducted by phone in January 2018.[6]

Provincial political context and regulatory timelines[7]

Jurisdiction over the "development, conservation, and management of non-renewable natural resources" lies with provincial governments in Canada, including the extraction of natural gas (*The Constitution Act* 1867, sec. 92A). Gas production was established in the north-

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[5] This category includes references to "public opposition," "public concern," "public alarm," "public threats," "public backlash" and "public anxiety."

[6] These interviews were conducted as a part of a larger comparative research project examining provincial hydraulic fracturing across Canada. See Author (2019) for more detail.

[7] This section draws on economic and political data from 2010 to provide policy context of each province prior to the period of interest.

east of British Columbia in 1954 and throughout the second half of the twentieth century BC was Canada's second largest producer of natural gas, contributing approximately 10-11% of Canada's total gas production annually (CAPP 2014). Since the 1990s, Nova Scotia has also become an oil and gas producer, first with the offshore Cohasset-Panuke oil field, which began production in 1992, followed by the Sable Offshore Energy Project in 1999 and the Deep Panuke project in 2013 (CCEI 2007; Taylor 2013). In 2010 mining, quarrying, and oil and gas extraction accounted for 4.78 per cent of BC's GDP as compared to 2.37 per cent in Nova Scotia (Statistics Canada 2014). Nova Scotia's electricity mix is considerably more dependent on fossil fuels: natural gas and coal provide 14.3 and 47.9 per cent of Nova Scotia's provincial electricity supply respectively (NRCAN 2017). In comparison, hydroelectricity provides 90.5 per cent of British Columbia's electricity supply, with natural gas contributing only 1.1 per cent (NRCAN 2017). From the perspective of industry, both provinces are considered to have pro-industry regulatory regimes. A 2010 survey conducted by the Fraser Institute found that petroleum industry executives and managers ranked British Columbia sixth in the country (based on a composite index of 17 variables), followed by Nova Scotia at seventh place (Angevine and Cervantes 2010).

At the same time, both provinces have pursued climate mitigation strategies with the support of their populace. In 2007 both provinces announced GHG emission targets, with BC committing to a 33% reduction below 2007 levels by 2020 and Nova Scotia announcing a target of 10% below 1990 levels by 2020 (Macdonald 2020, 78). British Columbia has been a leader in developing sub-national climate change policy, implementing a carbon tax in 2009 (Harrison 2012) and the *Climate Leadership Plan* in 2016 (Government of British Columbia 2016). In 2009 the Nova Scotia Progressive Conservative government released an energy strategy outlining a firm commitment to increase renewable electricity energy to 25% by 2020 (Nova Scotia Department of Energy 2009). The provinces demonstrate similar levels of public support for environmental concerns. The 2008 Canada Election Study found that residents of both provinces held a concern for the environment in similar regard: 68% of respondents in British Columbia and 74% of respondents in Nova Scotia rated protecting the environment as a high priority (Canadian Election Survey 2008). At the same time, there are differences between the two provinces with regard to political ideology. During the period of study, British Columbia was governed by the BC Liberal party, a right of centre party with strong ties to the oil and gas industry (Graham, Daub, and Carroll 2017).[8] From 2009-2013, Nova Scotia was governed by the Nova Scotia New Democratic Party, which had moved to the centre under the leadership of Premier Darrell Dexter (Turnbull 2009). The NDP was replaced after one term in 2013 by the (also centrist) Nova Scotia Liberal Party, however observers noted minimal differences in the environmental platform of both parties (Ross 2013).

British Columbia also has a strong environmental non-governmental organization (ENGO) network that developed during the anti-logging movement in the 1990s (Pralle 2006). Together with many First Nations (the majority of British Columbia is located on unceded traditional territories) the BC environmental movement has been highly successful in mobilizing against pipeline developments in British Columbia and oil sands development more generally (Hoberg 2013; Hoberg and Phillips 2011). Indigenous communities have also been at the forefront of environmental organizing in Nova Scotia, achieving significant gains in the 1990s towards recognition of Mi'kmaq sovereignty and rights over fisheries (Steigman 2009).

Regulatory development in British Columbia

[8] Graham et al. (2017) find that between 2008-2015 the majority (92%) of political donations from fossil fuel companies went to the BC Liberal Party.

The provincial government in British Columbia has gradually developed single-issue regulation for hydraulic fracturing, complemented by broad pro-development policy directives. Initially, the government relied on its conventional oil and gas regulatory framework to manage hydraulic fracturing applications in the province (Stephenson, Doukas, and Shaw 2012). In 2012 the provincial government began to make changes to the regulatory structure to address environmental risks. In January 2012 BC Oil and Gas Commission, the independent regulator in the province, introduced a new mandatory requirement for producers to file the chemical composition of their hydraulic fracturing fluids on fracfocus.ca, a government website (BC Oil and Gas Commission 2011). In August 2012 the Commission also amended its drilling and production regulations to introduce new well spacing requirements to increase the allowable number of wells within a target area (BC Oil and Gas Commission 2012b). In April 2013, the Commission released a report outlining an "Area-based-Analysis" approvals process, which was intended to facilitate regional long-term development while addressing environmental and social outcomes (BC Oil and Gas Commission 2013).

In 2012, the government also released two linked strategies pertaining to unconventional development in the province: the *Natural Gas Strategy* and the *Liquefied Natural Gas Strategy* (Government of British Columbia 2012a; 2012b). The *Natural Gas Strategy* positioned industry as a key driver of job growth and focused on streamlined regulation and royalty regimes to encourage sector growth. The *Liquefied Natural Gas Strategy* committed to the development of three liquefied natural gas (LNG) plants by 2020 with the aim of accessing Asian gas markets.

Regulatory development in Nova Scotia

In contrast to British Columbia's single-issue approach to regulatory development, provincial governments in Nova Scotia pursued a more precautionary approach, implementing a de-facto moratorium in 2012, followed by a legislated ban in 2014. In early 2011 provincial Energy Minister Charlie Parker, of the Nova Scotia New Democratic Party (NDP), began to meet with officials in other jurisdictions to explore potential regulatory frameworks for shale gas development (Baxter 2011). In April 2012, the Nova Scotia government announced a two year "hold" on hydraulic fracturing to study the policy issue, indicating that it would not approve new applications for hydraulic fracturing (Government of Nova Scotia 2012; Canadian Press 2012). In August 2013, a few months before the general election, the NDP government commissioned a new independent external review of hydraulic fracturing, to be headed by Cape Breton University President David Wheeler (Gorman 2013a; Government of Nova Scotia 2013a).

Despite the attention garnered by the independent review, hydraulic fracturing was not a particularly salient issue during the election (Davene 2013; Ross 2013) and in October 2013 the NDP lost to the Nova Scotia Liberals (CBC News 2013). In December, the new government passed the *Importation of Hydraulic Fracturing Wastewater Prohibition Act* preventing import of fracking waste water from other jurisdictions (Gorman 2013b; Government of Nova Scotia 2013b) and affirmed their commitment to the external review.

Beginning in February 2014, the nine-member expert external review committee began to release bi-monthly discussion papers focusing on different aspects of hydraulic fracturing (Ross 2014b). Town hall meetings were conducted in July in ten different communities throughout the province (Ross 2014c; Ayers 2014a). In August 2014, Wheeler released the independent review report, recommending a slow, incremental approach to policy development in full consultation with municipalities and aboriginal governments (Gorman 2014b).

In September 2014 Energy Minister Andrew Younger announced the government's intention to introduce legislation prohibiting fracking during the fall session of the legislature (Erskine

2014). On November 14th, 2014 Bill 6, *An Act to Amend Chapter 342 of the Revised Statutes, 1989, the Petroleum Resources Act* passed third reading in the House; the Amendment prohibits "high-volume hydraulic fracturing in shale unless exempted by regulation for the purpose of testing or research" (Government of Nova Scotia 2014b).

Technical learning in British Columbia

This study finds that British Columbia's pursuit of single-issue regulation was fostered through a process of technical learning facilitated by low levels of problem uncertainty and high institutional insularity. Early frames put forward by government officials and industry representatives were that the practice of hydraulic fracturing would be of net benefit to the province. Figures 1 and 2 present the causal arguments for and against hydraulic fracturing in the *Vancouver Sun* over time and by actor type. The majority of pro-development arguments focused on economic benefits, such as domestic job creation. These benefits were linked energy security, reinforcing the argument that unconventional gas production would reduce economic uncertainty and build self-sufficiency into North American markets (Vancouver Sun 2013). Media stories also highlighted the potential for LNG exports to reduce global greenhouse gas emissions by facilitating other countries' transitions to low carbon, primarily in Asia (Coleman 2013). These frames were complemented by the assertion of elected officials and industry representatives that hydraulic fracturing was a safe technology that had been used by the industry for decades (Hamilton 2011).

[INSERT FIGURES 1 and 2]

Despite government officials' bullish pronouncements on the economic benefits of hydraulic fracturing, discussion of environmental risks did emerge in media debates primarily through the opinions of environmental advocates, indigenous groups, and elected officials in opposition (see Figures 1 and 2). However environmental activists in British Columbia were less successful in generating sustained attention to ecological risks over time (Montpetit, Lachapelle, and Harvey 2016). One of the reasons for this was that government officials consistently framed hydraulic fracturing primarily as a regulatory issue rather than a broader policy concern. When discussing broad policy goals of clean energy and investment, elected officials have been more likely to use the term LNG, reserving "hydraulic fracturing" for discussion of specific regulation, such as mandatory chemical disclosure (Stephenson, Doukas, and Shaw 2012). Textual analysis of the 2012 *Natural Gas Strategy* and the 2012 *Liquefied Natural Gas Strategy* finds that LNG is mentioned 104 times, while "hydraulic fracturing" is mentioned only 14 times. This distinction between LNG and hydraulic fracturing made it challenging for environmental groups to draw public attention to the potential for dread risks of hydraulic fracturing such as groundwater contamination. As one interviewee noted:

> The [Liberal] government was pushing LNG, LNG as the economic boom for the province. So LNG was all over everything, and she [Premier Christy Clark] never talked about fracking. We've been trying hard to connect those dots, but probably the general public and even journalists – they probably understand a bit better now – but that connection was not fully understood [9]

This ideational delineation between the economic benefits of LNG on the one hand and the environmental risks of hydraulic fracturing on the other has remained surprisingly durable in the public consciousness in BC. In 2016 an Insights West poll found that while only 23% of British Columbians supported fracking, 43% of survey respondents supported LNG (Insights West 2016). These findings are in line with national survey experiment data with general populations in the US demonstrating that the frame "fracking" is associated with negative environmental

[9] Personal interview conducted by phone January 12 2018

harms, while “shale gas development” is associated with positive economic benefits (Clarke et al. 2015; Evensen et al. 2014).

Anti-fracking campaigns in BC have also been influenced by a greater range of positions among Indigenous Nations than in Nova Scotia. Some of the most vocal advocates against hydraulic fracturing have been members of the Fort Nelson First Nation, whose traditional territory is located in north eastern BC (Garvie and Shaw 2016). Members of the nation have raised significant concerns regarding groundwater contamination and cumulative land and health risks impacting their treaty rights (Garvie and Shaw 2016; Rayher and Gillis 2015). At the same time other Indigenous Nations in BC have held that LNG development is preferable to the ecological harms posed by bitumen pipelines. For example the Nisga'a Lisims Government has supported LNG pipeline development (Meissner 2014) despite opposing bitumen pipelines a few years earlier (Noble 2012). In the interior some elected officials of the Wet’suwet’en have also provided consent for LNG pipelines to go through their territory. However hereditary members of the Gilseyhu been organizing against natural gas pipelines since 2009, including ongoing action at Unist’ot’en (McSheffrey 2015; Unist’ot’en Camp 2017).

Activists’ aims to increase the salience of environmental risks in British Columbia were also hampered by conflicting positions taken by members of the official opposition, the BC New Democratic Party. During the 2013 provincial election, party leader Adrian Dix called for a scientific review of hydraulic fracturing, citing environmental risks, but stopped short of calling for a moratorium (Hoberg 2013; British Columbia New Democratic Party 2013). Media analysis confirms a slight peak in scientific uncertainty during the 2013 campaign (see Figure 3), but does not show a significant increase in either references to public opposition or to lack of trust in government. References to all three measures taper off in 2014, reflecting lower levels of salience of dread risks and scientific uncertainty in media debates after the election. As summarized by a *Vancouver Sun* editorial:

> The recent provincial election boiled down to a fight between jobs and the environment. The Liberals, with their focus on jobs, liquefied natural gas and exports to Asia, won. The NDP, with their emphasis on the environment and opposition - real or perceived - to pipelines, tanker traffic and natural gas fracking, lost (Melton and Peters 2013).

The Liberal government's framing of hydraulic fracturing as a tractable problem was reinforced by an institutional context that facilitated a high level of actor certification, centered on the BC Oil and Gas Commission. In contrast to jurisdictions in Atlantic Canada, where responsibility for oil and gas regulation tends to be split among ministries of natural resources, energy, or the environment, in BC regulatory authority has been delegated to an independent regulator. The BC government established the BC Oil and Gas Commission in 1998 as a crown corporation with the aim of being a "one-stop shop" to streamline environmental assessment, licensing, and other regulatory requirements for producers (BC Oil and Gas Commission 2014a; Parfitt 2011; Graham, Daub, and Carroll 2017). As such, the Commission is insulated from broad energy policy making processes at the Ministry level as well as from the provincial Cabinet.[10]

At the same time that hydraulic fracturing was emerging as a regulatory issue in the late 2000s, the government was also finalizing legislation (*Oil and Gas Activities Act, SBC* 2008) designed to further delegate authority to the BC Oil and Gas Commission, enabling the Commission to amend and create new regulation. According to Paul Jeakins, Commissioner and CEO of the BC Oil and Gas Commission, the revisions to OGAA provided the Commission with the flexibility to consider substantial regulatory changes without engaging Cabinet or the

[10] Personal Interview conducted with Paul Jeakins, July 14th, 2015 in Victoria, BC

legislature.[11] The regulatory authority generated by the changes to the OGAA insulated bureaucrats from political interference while at time provided regulators with the opportunity to be more responsive to the demands of industry.[12] The BC Oil and Gas Commission thus initially enjoyed high levels of actor certification, making technical learning more likely.

The high institutional autonomy of the Commission combined with low levels of problem uncertainty to inoculate the position of the technical staff as appropriate sources of expertise, facilitating a process of technical learning. In the absence of province-wide environmental mobilization and urgent public attention to environmental risks, technical experts and policy analysts within the Commission were insulated from political pressures.[13] Technical staff developed regulatory responses at an incremental pace, beginning with well spacing in 2008 and moving on to seismicity and chemical disclosure by 2012[14] (BC Oil and Gas Commission 2012b; 2011). In addition to learning from experiences of regulators in other jurisdictions, the Commission also strengthened in-house technical expertise through two major research projects: one examining induced seismicity in the Horn River and Montney Shale and the other mapping ground water resources through the development of the North East Water Portal (BC Oil and Gas Commission 2012a; 2014b). The engagement of hydrologists and seismologists in regulatory formulation suggests a limited form of epistemic learning, although less wide-ranging than would be evident in a broad scientific review.

The British Columbia case demonstrates the role of low levels of problem uncertainty and high levels of institutional insularity in driving modes of technical learning. Elected officials' focus on economic benefits of LNG served to dampen public attention to potential environmental

[11] Ibid

[12] Confidential personal interview conducted the morning of July 14th 2015 in Victoria, BC.

[13] Personal interview, Jeakins.

[14] Confidential personal interview conducted the morning of July 14th 2015 in Victoria, BC.

harms of hydraulic fracturing. Anti-fracking activists were unable to gain widespread traction regarding scientific uncertainty or the potential for dread environmental risks. [15] Low levels of problem uncertainty limited pressure on government officials to engage in broader, more encompassing processes of social learning. The 2008 amendments to the OGA reinforced high levels of institutional insularity. Together these conditions created the space for bureaucrats to engage in incremental technical learning generated predominantly by their own researchers in concert with industry.

Social and political learning in Nova Scotia

The initial period of regulatory development in Nova Scotia reflected a brief state of technical learning. Early direction from cabinet was that staff from the departments of Energy and the Environment should engage in an internal technical review of environmental impacts (Government of Nova Scotia 2011a; 2011b), suggesting that political leadership perceived the problem of hydraulic fracturing to be relatively tractable. However, throughout 2011, environmental advocates, including the Sierra Club and the Ecology Action Centre had begun to mobilize around a narrative of scientific uncertainty and potential environmental risks, calling for a ban on high volume hydraulic fracturing (Bundale 2011). Members of an anti-fracking umbrella group organized a range of public actions, including lobbying MLAs' constituency offices and bringing in scientific experts to speak on potential environmental risks (Minkow 2015; Gorman 2011).[16]

[INSERT FIGURE 4]

In contrast to British Columbia, media debate in Nova Scotia demonstrates the dominance of environmental harms in discussions of hydraulic fracturing. Figure 4 shows the

[15] Personal interview conducted January 12 2018; personal interview conducted July 21 2015 in Vancouver, BC.
[16] Confidential personal interview conducted by phone, December 17th, 2014.

relative frequency of references to environmental harms and economic benefits of hydraulic fracturing in the dataset. Although industry representatives continued to provide assurances that the practice was safe, and journalists specified the potential for economic growth (Chronicle Herald Editorial Board 2012), environmental concerns, especially regarding groundwater contamination maintained a high degree of salience in media reports. Figure 5 demonstrates the breakdown of arguments and actor type in the dataset. Unlike government officials in British Columbia, elected officials in Nova Scotia remained quiet on the potential for economic benefits, speaking very rarely about environmental risks. At the same time, local residents were more vocal in expressing concerns about potential environmental harms than their BC counterparts. Figure 5 shows that journalists in the *Chronicle Herald* also reported on potential environmental risks more often than their counterparts at the *Vancouver Sun*. Interview data suggests that the perception of growing public pressure in Nova Scotia regarding the uncertain environmental risks of hydraulic fracturing was a key factor in the NDP's decision to announce the two-year hold in April 2012. [17]

Although policy decision makers anticipated that the de-facto moratorium would dampen public attention to hydraulic fracturing, throughout 2012, environmental advocates and local anti-fracking groups, including members of Mi'kmaq First Nations continued to raise concerns regarding the legitimacy of the internal review. Advocates challenged the institutional insularity of the policy making process, calling for an external review (Langdon 2019).[18] The unspoken assumption for many government officials was that the internal review was intended to neutralize the potential for public debate, but that the limited scope of the review left the

[17] Personal interview with Paul Black; confidential personal interview conducted November 27th, 2014.
[18] Confidential personal interview conducted November 27th 2014 in Halifax, Nova Scotia; Confidential personal interview conducted November 28th, 2014, in Halifax, Nova Scotia.

government open to critique.[19] Within this context, the government began considering establishing an independent external review. From a political perspective, delegating responsibility for the review to an external body would inoculate cabinet from potential electoral risks.[20] From a bureaucratic perspective, the external review also addressed the civil services' concern that trust deficits were increasing among the public.[21] The goal of the independent review was to convene a panel of experts, conduct public consultations on hydraulic fracturing, and conduct a literature review of potential risks (Wheeler et al. 2015; Atherton et al. 2014). The scoping process of the review reflects a much higher level of perceived risk than in British Columbia. Wheeler used a precautionary approach as a key guiding principle for the panel and defined precautionary in reference to the UN Conference in Environment and Development, and the Mi'kmaq concept of Netuklimk (Atherton et al. 2014). As such, the terms and scope of the review reflect the characteristics we would expect with higher problem uncertainty in which policy ends and means are perceived to be ambiguous.

The design of the external review process also opened up the policy design process to a greater number of actors, facilitating lower levels of institutional insularity. Wheeler asserted that the "quasi-academic" scope of the review provided the panel with greater flexibility to include a wide range of inputs, from technical expertise to traditional Indigenous knowledge (Ross 2014b; 2014a). Wheeler was experienced in designing public consultations on energy issues[22] and included a range of mechanisms to incorporate public input, including soliciting suggestions for panel members' skill sets and panel nominees, inviting general submissions to the panel, and

[19] Personal interview with Paul Black, Former Director of Policy for the Dexter government, conducted November 25th, 2014 in Halifax, Nova Scotia; Confidential personal interview conducted November 24th in Halifax, Nova Scotia.
[20] Personal interview with Paul Black.
[21] Confidential personal interview conducted November 28th, 2014 in Halifax, Nova Scotia.
[22] Wheeler was known on both the political and bureaucratic levels in Nova Scotia because of his work leading earlier public consultations on energy efficiency and renewable energy (Adams, Wheeler, and Woolston 2011)

gathering written feedback on specific discussion papers released online (Wheeler et al. 2015). The discussion papers covered a range of aspects such as potential economic benefits, health risks, socio-economic effects, well integrity and environmental impacts (Wheeler et al. 2015). After each discussion paper was released, the public had two to three weeks to submit commentary back to the panel, which was then incorporated into the final draft under the discretion of the expert who drafted the chapter (Wheeler et al. 2015; Ross 2014b). Beyond written input, the panel held two informational meetings on the general design of the review, three online forums on specific topics related to the discussion papers, and eleven public meetings across the province on the full draft report and tentative recommendations, which took place in the summer of 2014 (Wheeler et al. 2015; Atherton et al. 2014). The open design of the consultation process, together with high levels of problem uncertainty created favourable conditions for social learning.

Despite the panel's extensive efforts to engage the public in a process of social learning, throughout 2013 there were growing concerns among environmental advocates, Mi'kmaq Nations and local community groups that the panel was highly technocratic and top-down in its approach (Langdon 2019).[23] Environmental groups were disappointed in the first few reports that examined the processes of hydraulic fracturing, resource potential, and groundwater impacts. They argued that their perspectives had not been incorporated into the review.[24] After the independent panel's release of the groundwater discussion paper, the Ecology Action Centre expressed concerns publicly that the panel's reports reflected an industry bias and lacked scientific rigour (MacDonald 2014). Advocates' frustration with the perceived lack of receptivity of the panel culminated in five different anti-fracking groups coordinating attendance at the town

[23] Confidential personal interviews conducted November 27th, 2014 and December 17th, 2014.
[24] Ibid.

hall meetings in the summer of 2014 (Minkow 2015).[25] In particular, the organizing team put together toolkits for residents attending meetings to be able to bolster confidence of speakers in commandeering scientific rationales in support of their arguments against hydraulic fracturing (Minkow 2015).[26]

As a result of these mobilizing efforts, the Nova Scotia public meetings in the summer of 2014 became an ad-hoc venue within which anti-fracking advocates were able to reframe the debate and to challenge the legitimacy of the independent review, and by extension, the government. Figure 6 shows references to scientific uncertainty, public opposition to fracking, and lack of trust in the dataset. Despite the panel's original intent to facilitate dialogue between opposing views (Wheeler et al. 2015), the majority of the public meetings were dominated by anti-fracking narratives that wove together frames questioning the scientific credibility of the panelists and the trustworthiness of the government to regulate environmental harms (Ayers 2014a; Campbell 2014; Gorman 2014a; Delaney 2014). Early critiques of the discussion papers argued that the reports did not include available peer-reviewed evidence (MacDonald 2014), while later arguments levied attacks against the scientific autonomy of Wheeler himself (Ayers 2014b). Together, these arguments served to affirm a narrative of problem uncertainty within public debate, namely that the risks of hydraulic fracturing were scientifically uncertain and that the government could not be trusted to manage these harms, making a ban the most appropriate course of action (CBC News 2014).

The final report of the panel attempted to thread the needle between technical risk assessment and summarizing public opinion by acknowledging that the province was currently unable to accurately assess the risks of hydraulic fracturing. The report suggested that it was not

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[25] Ibid
[26] Ibid

the right time for rapid development, although the panel stopped short of recommending an outright moratorium (Atherton et al. 2014; Gorman 2014b). Nevertheless, shortly after the release of the report, Energy Minister Andrew Younger announced that the government would legislate a prohibition on the practice of high-volume hydraulic fracturing in Nova Scotia (Younger 2014a).

The speed and magnitude of Younger's response to the Wheeler report suggests that the social conditions fostered during the review had spurred a mode of political learning among elected officials. The open forum of the external review provided a venue for participants to develop and harden their beliefs that fracking would lead to severe environmental harms. Media analysis finds that the two key arguments used by government officials to describe the government's response were that 1) the government had listened to Nova Scotians (10 coded references in the dataset) and 2) found that they were not ready for development (26 coded references). Younger provided a clear example of this type of argument during the press conference announcing the ban, arguing that "Nova Scotians have put their trust in our government, that we will listen to the concerns and not allow a process that most Nova Scotians are just simply not comfortable with at this time" (Erskine 2014). Younger's defense of the ban in the House focused on the lack of social license among Nova Scotians for hydraulic fracturing, referring to public opposition from concerned residents, Mi'kmaq Nations, and the Union of Nova Scotia Municipalities (Government of Nova Scotia 2014b).

Younger's references to public opinion reflect a process of political learning regarding the mobilization of the public against hydraulic fracturing. The town hall meetings demonstrated a significant degree of public discontent that the government was unwilling to exacerbate, especially without the guarantee of economic benefits. Data also suggests that Younger was aware of the potential pitfalls of public unrest.[27] As Younger commented to the *Times and Transcript*

> "What I've learned from … from the history here is that I have a responsibility to show people we are listening to them … I'm concerned about how this issue is tearing certain communities apart" (Morris 2014).

Younger's personal beliefs were likely that the environmental risks of the practice could be managed through regulation (Younger 2014b). However Younger was keenly attentive to the hardening of public opposition. His remarks introducing the second reading of the ban in the House refer multiple times to the need for social license, namely to increase public trust in the government's regulatory processes (Government of Nova Scotia 2014b), reflecting a strong understanding of the public's policy preferences. Ultimately, the ban represented the government's political calculation that the strength of opposition to hydraulic fracturing far outweighed potential economic benefits, reflecting a process of political learning among elected officials.

Discussion

The cases examined in this study demonstrate how institutional and ideational factors inform different processes of regulatory development for hydraulic fracturing. In energy dominant jurisdictions such as British Columbia, independent regulators such as the BC Oil and Gas Commission function at a distance from Energy and Environment line departments, making it difficult for environmental advocates, social scientists, Indigenous groups, and members of the public to access processes of regulatory development. Elected officials framed LNG as a clean energy source generating economic benefits. These frames made more difficult for anti-fracking advocates to increase the salience of environmental risks, inuring regulators from public

[27] Personal interview with Paul Black, 2014.

attention. In the absence of political pressure to open up regulatory governance, bureaucrats and technical experts within the BC Oil and Gas Commission engaged in processes of technical learning to develop chemical disclosure regulations, stopping short of developing a comprehensive regulatory framework. Technical learning within the Commission was an informal process, with bureaucrats reaching out to select regulators in other jurisdictions to complement in-house expertise. As such the BC case demonstrates similar dynamics to hydraulic fracturing rule-making in Pennsylvania and Michigan in which informal consultation with interest groups limited citizen influence on regulatory outcomes (Crow, Albright, and Koebele 2016). The British Columbia case demonstrates that processes of technical learning can constrain the extent of regulatory change, facilitating smaller incremental changes to regulatory regimes for hydraulic fracturing. More research is needed as to whether this is always the case, or whether in other regulatory areas technical learning can empirically lead to substantial environmental policy change, perhaps through rapid successive regulatory developments (Pierson 2004; Levin et al. 2012).

In contrast anti-fracking advocates in Nova Scotia used frames of scientific uncertainty and dread environmental risks to increase perceived problem uncertainty among both policy makers and the general public. The open structure of the external review in Nova Scotia provided a venue in which stakeholder groups were able to engage in debates about specific regulatory design, broader environmental policy goals, and express skepticism of government capacity to protect the public interest. Similar dynamics have been identified in other Canadian jurisdictions (Fast and Nourallah 2018; Carter and Fusco 2017). The Nova Scotia case illustrates how just how difficult it is for governments to maintain a truly uncertain position on both policy ends and means without facing challenges to their credibility, legitimacy, or expertise. Although the external review was initially positioned as an opportunity for social learning, through their participation in the consultations residents became more confident and assertive of their interests, articulating support for a precautionary regulatory framework. As advocacy groups' preferences and public opinion hardened, officials recalculated their political interests and implemented a ban. The Nova Scotia case thus provides preliminary evidence for a complimentary pathway to the "irony of epistemic learning" identified by Dunlop (2017). In the *irony of epistemic learning*, processes of puzzling among experts provide interest groups with a greater sense of their own interests, leading to more overt processes of powering between actors, a dynamic in which experts are often poorly equipped to engage (Dunlop 2017, 228–29). The Nova Scotia case suggests an *irony of social learning* in which processes of puzzling among members of the general public serve to solidify and entrench citizens' ideas about environmental harms, facilitating more strategic processes of political learning among government officials in order to contain public debate. The importance of political learning in the Nova Scotia case presents an important counter to the notion that significant environmental policy change necessarily stems from processes of social learning in which all actors update their deep core beliefs (Hall 1993; Dunlop and Radaelli 2018a).

Finally, the case studies illustrate that the social construction of problem uncertainty is multifaceted, with different political actors weaving together strands of scientific uncertainty, skepticism in government capacity, and dread environmental risks to influence regulatory debate. The British Columbia case demonstrates that simply increasing scientific uncertainty is not always enough to transform learning modes in a polity. Despite the BC NDP's campaign focus on the benefits of a scientific review, concerns about scientific uncertainty had limited influence on processes of technical learning among regulators. In contrast, the findings from the Nova

Scotia case demonstrate that the perception of public opposition and anxiety regarding dread environmental risks can be a powerful driver of problem uncertainty. Future research could disaggregate these influences further, tracing the relative impacts of scientific uncertainty versus public urgency on processes of regulatory development and change (Bromley-Trujillo and Karch 2019).

Conclusion

This study investigates variation in regulatory development, exploring why one jurisdiction introduced a limited regulatory framework for hydraulic fracturing while another introduced a legislated ban. The article draws attention to the role of institutional insularity (the degree of openness of a policy subsystem to public engagement) and problem uncertainty (actors' collective understanding of the dimensions of the policy problem) in provincial rule-making. Institutional insularity and problem uncertainty interact to influence processes of policy learning. In turn, learning processes shape the regulatory frameworks that jurisdictions introduce.

In British Columbia, regulators were insulated from environmental advocates and electoral politics. The absence of salient narratives regarding scientific uncertainty and public opposition to fracking led regulators to engage in processes of technical learning, based on conventional frameworks for oil and gas. This led to the introduction of a limited regulatory framework. By contrast, in Nova Scotia, environmental advocates, experts, members of Indigenous communities, and other residents used the venue of public consultations to vocalize strong narratives regarding scientific uncertainty and dread environmental risks. These conditions fostered processes of social and political learning, leading to a fracking ban. These cases provide new empirical evidence for the role of policy learning in regulatory formulation and design.

The findings of the study demonstrate how independent regulatory bodies can reinforce the influence of industry experts and regulators from other jurisdictions in hydraulic fracturing rule making, diminishing opportunities for public input. Future research is needed as to whether these dynamics inevitably result in a form of regulatory capture at the subnational level with corresponding impacts on democratic outcomes (Hartley and Skogstad 2005). Conversely the study suggests that even ad-hoc public consultations can produce agenda-changing reforms when they prompt processes of social learning among advocacy groups and political learning among public officials. More research is needed as to the limits of public consultation in energy politics. When do processes of social learning build trust among citizens for new technologies and under what conditions will consultations deepen polarization (Neville and Weinthal 2016; Cleland and Gattinger 2017)? Are policy innovations that stem from social learning more or less likely to endure over time (Millar, Davidson, and White 2020)?

Second, the study reveals that problem uncertainty is multifaceted and shaped by distinct levels of scientific uncertainty, dread risks, and public trust. These elements are socially constructed and shift and change over time, with differing impacts on regulatory outcomes. Climate research has found that perceived scientific uncertainty can delay policy action while issue salience can spur regulatory development (Cann and Raymond 2018; Bromley-Trujillo and Poe 2020); it is less clear whether these dynamics hold true in other areas of energy politics. Future studies should explore the interaction of scientific uncertainty and dread environmental risk across issue areas, examining similarities among fracking research, climate politics and socio-technology studies more broadly. For example, when do industry and advocacy groups select frames of dread risk and/or scientific uncertainty to influence regulatory design? How do energy regulators respond to these frames? Parsing the politics of uncertainty will be crucial for policy makers attempting to design durable and legitimate energy policies in democratic settings.

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Problem uncertainty, institutional insularity, and modes of learning in Canadian provincial hydraulic fracturing regulation

Tables

Table 1: Drivers of modes of learning

problem uncertainty / institutional insularity	HIGH (UNCERTAIN)	LOW (CERTAIN)
HIGH (CLOSED)	Epistemic learning	Technical learning
LOW (OPEN)	Social learning	Political learning

Author, adapted from Dunlop and Radaelli (2013; 2018a; 2018b), Pierson (1993) and May (1992; 1991)

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Figures

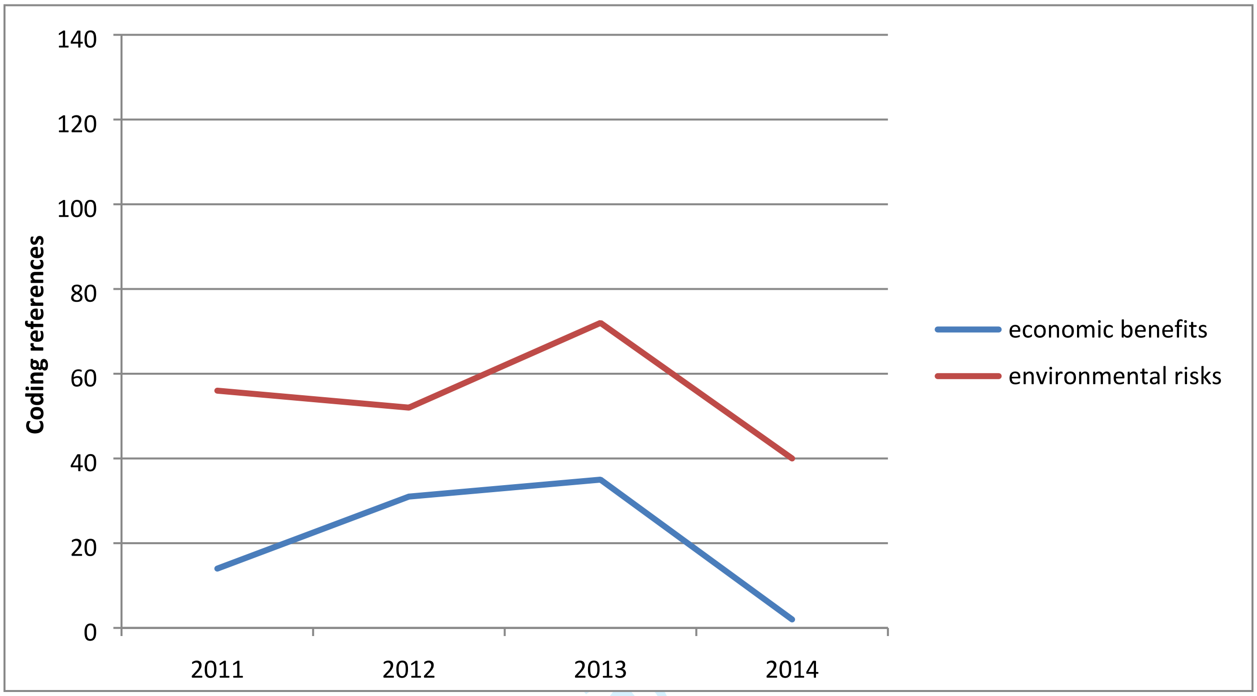

Figure 1: Risks/Benefits over time in BC

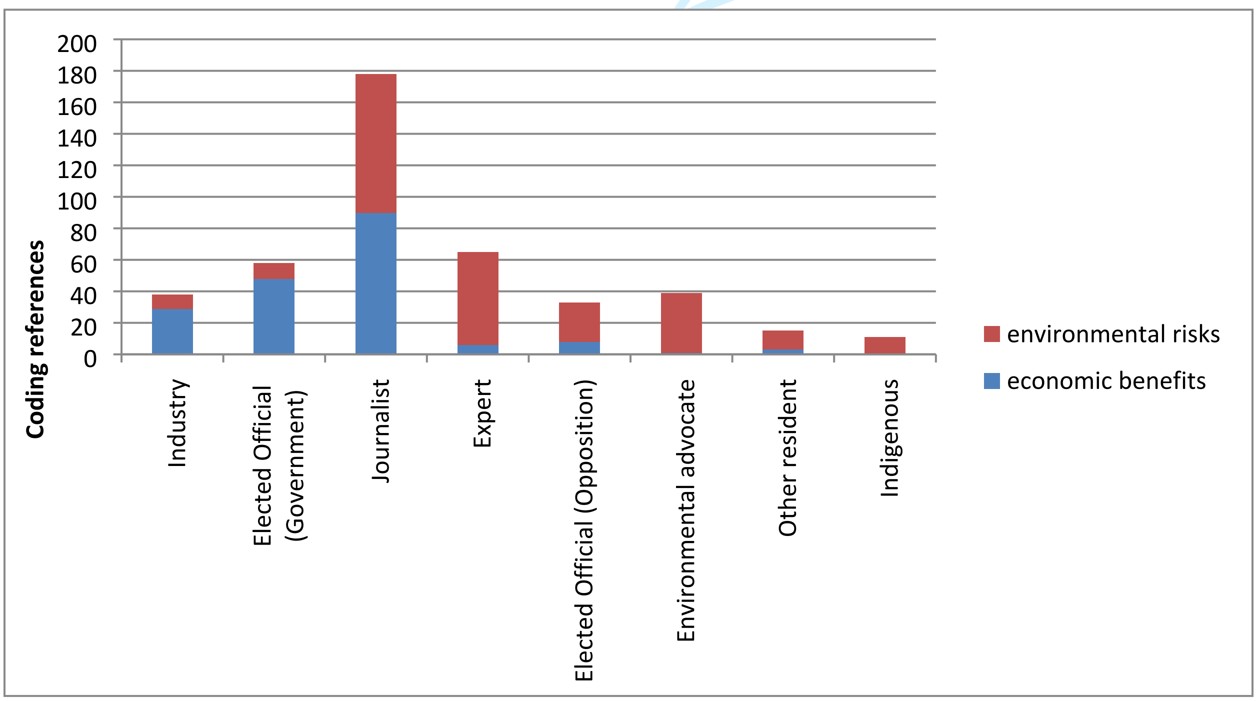

Figure 2: Risks/Benefits by Actor Type, BC

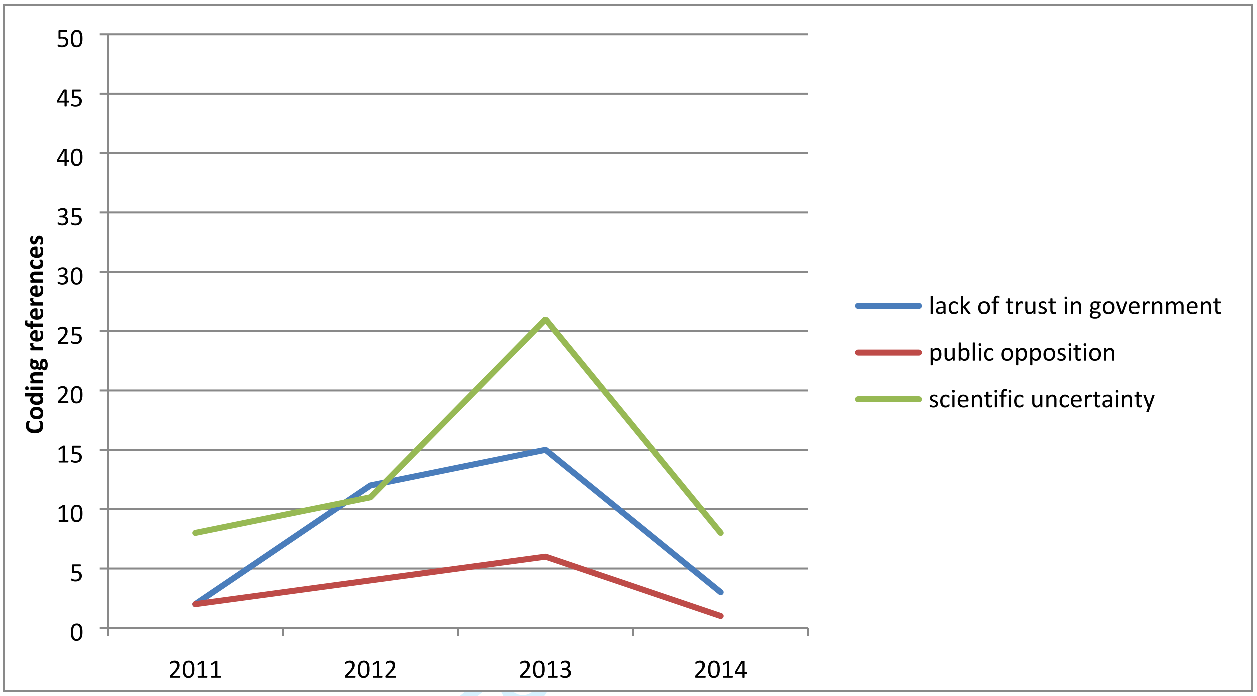

Figure 3: Problem uncertainty over time, BC

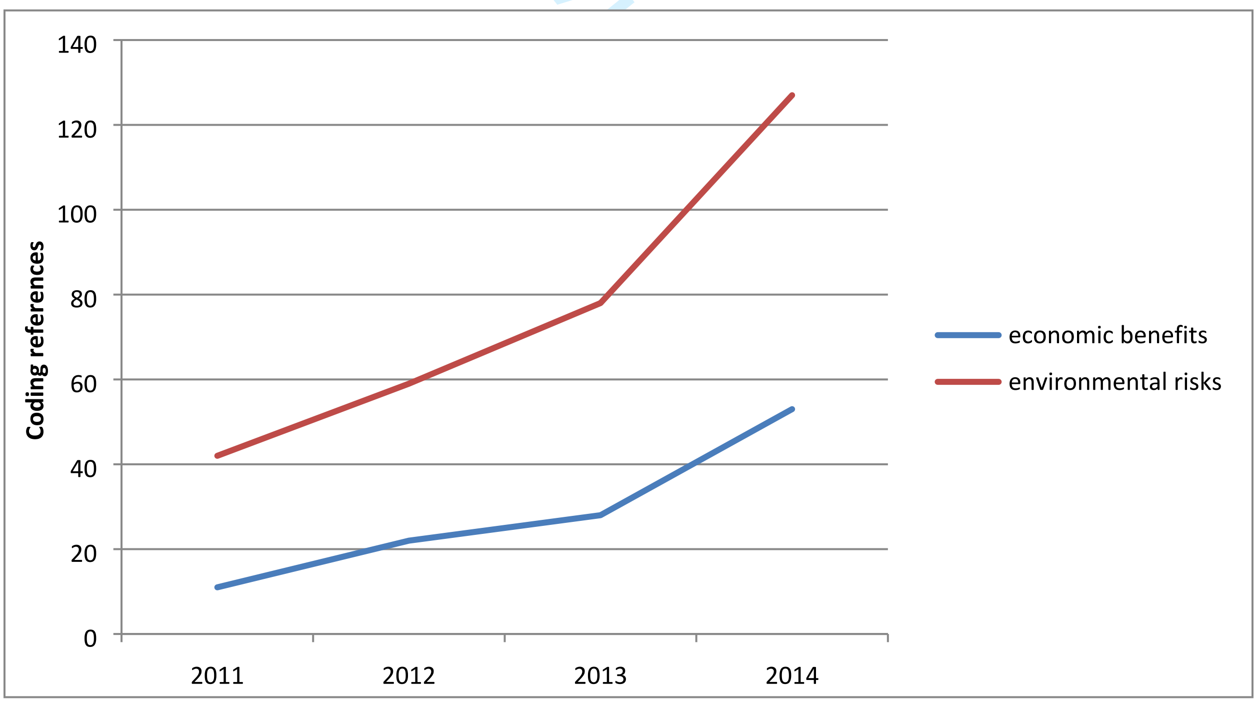

Figure 4: Risks/Benefits over time, NS

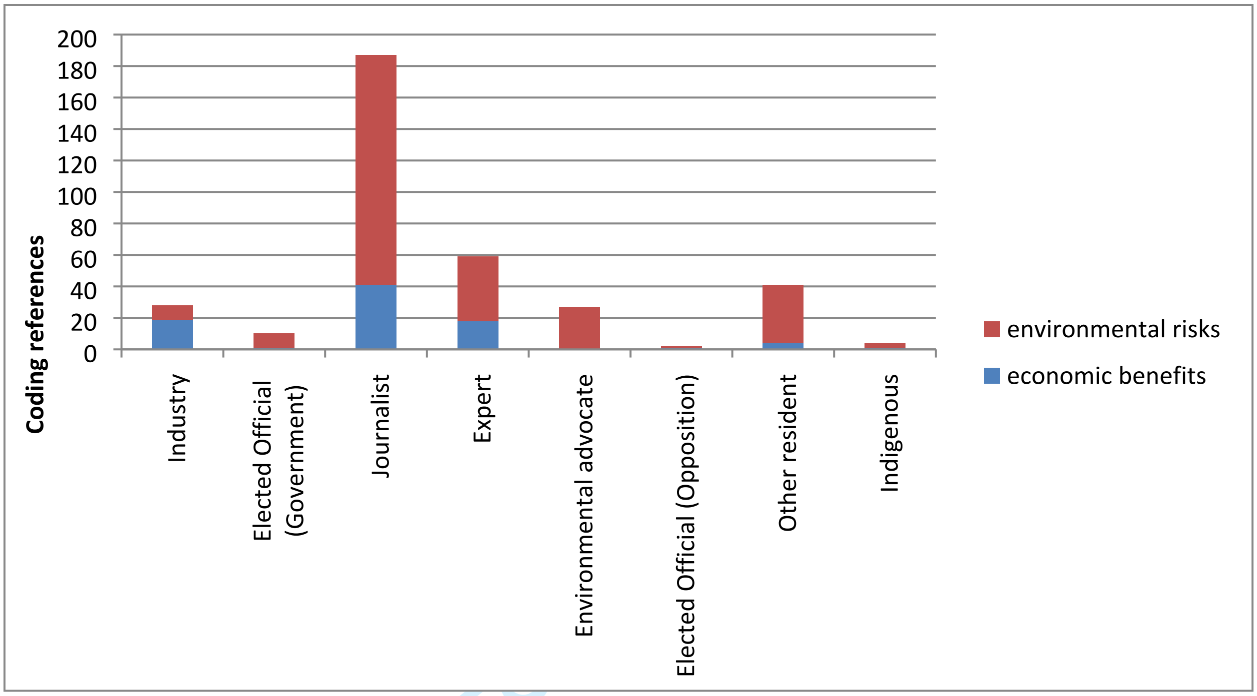

Figure 5: Risks/Benefits by actor type, NS

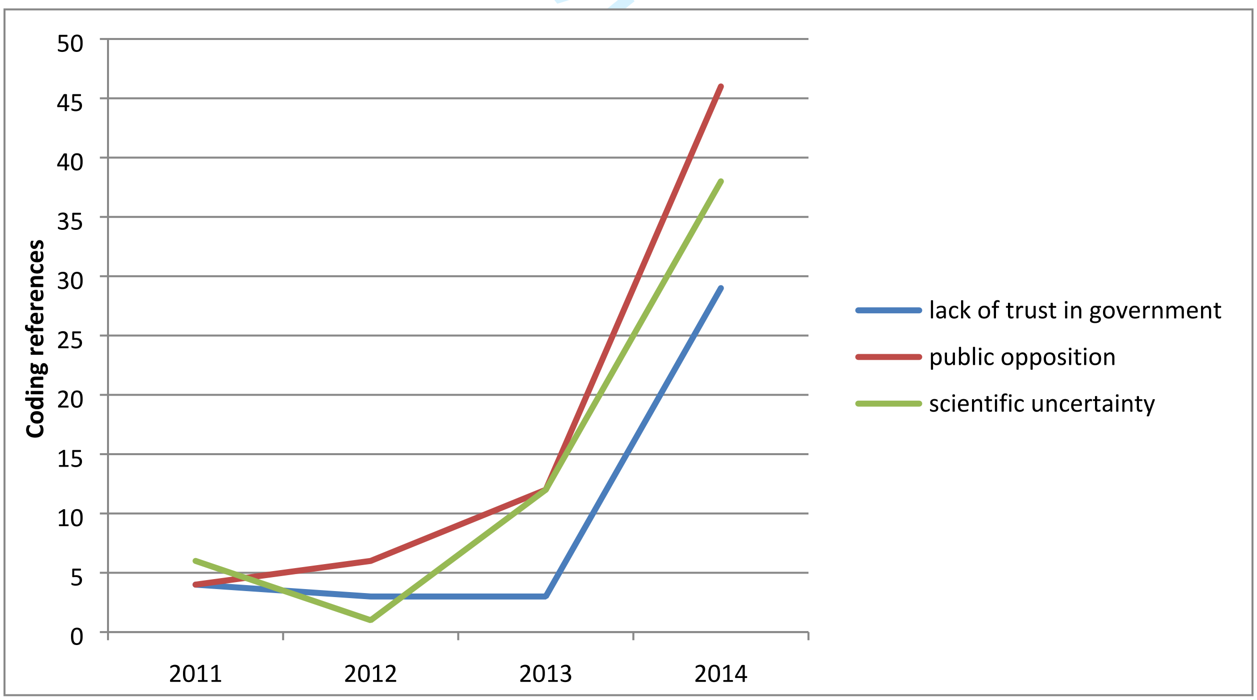

Figure 6: Problem uncertainty by time, NS

2020-09-28

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https://doi.org/10.1111/ropr.12401