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RESEARCH ARTICLE

Understanding policy instrument preferences under conflicting beliefs and uncertainty

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Abstract
Anticipating policy instrument preferences can be an important step in policy design to address pressing sustainability problems. But studying preferences for policy instruments is a difficult task because sustainability problems involve a non-negligible degree of trade-offs and uncertainty. We therefore study the role of actors' underlying ideologies (policy core beliefs) and risk attitudes in forming their preferences for different instruments. Combining the advocacy coalition framework with multi-attribute utility theory, both ideologies and attitudes toward uncertain policy consequences can influence instrument preferences. So far, policy studies literature has paid little attention to trade-offs between policy core beliefs or risk attitudes. Using Bayesian regression models on data from actors in Swiss pesticide risk reduction policy, we found that attitudes toward trade-offs and risk are indeed relevant to explain preferences for different regulatory and market-based instruments addressing agricultural pesticide use. Therefore, when designing policies for sustainability problems, considering the relative importance of policy core beliefs for different actors can help to find effective and broadly supported solutions. In addition, risk attitudes should be considered when policy design involves more coercive and stimulative policy instruments.

Keywords: advocacy coalition framework; beliefs; multi-attribute utility theory; pesticides; policy instrument preferences; risk attitudes

Introduction
The choice of policy instruments and the formation of corresponding preferences are rarely straightforward in the context of complex sustainability problems. In this context, multiple, often conflicting ideologies, so-called policy core beliefs, about what causes the problem and what needs to be solved exist (Munda 2009). Trade-offs between satisfying different policy core beliefs have to be made. Moreover, uncertainty remains about the cause of the problem and the consequences of

implementing specific policy instruments (Ingold et al. 2019; Koppenjan and Klijn 2004). Actors may have different responses to uncertainty and differ in their willingness to take risks. Therefore, we study the role of key actors' policy core beliefs and risk attitudes in forming their preferences for different policy instruments. To what extent do risk attitudes matter in policymaking in addition to and in relation to policy core beliefs? We aim to contribute to a better understanding of policy instrument preferences under conflicting beliefs and under uncertainty typical of sustainability problems. Building support for new, ambitious policy instruments to address pressing sustainability problems requires an understanding and consideration of how actor preferences for particular instruments are formed (Dermont et al. 2017).

In our study, we draw on frameworks and theories from policy studies and decision analysis. Policy studies literature has strongly focused on the relationship between policy core beliefs and actors' instrument preferences (e.g., Dietz et al. 2007; Glaus et al. 2022; Ingold et al. 2019; Lahat 2011). Thereby, scholars have drawn on the advocacy coalition framework (ACF; Sabatier and Jenkins-Smith 1993), which suggests that policy core beliefs direct the preferences for concrete instruments to solve a problem (Sabatier and Weible 2007; Weible et al. 2020). However, the ACF has remained vague on how to anticipate actors' policy instrument preferences in the case of multiple conflicting policy core beliefs (Kammermann and Angst 2021). Although understanding the relative importance of certain policy core beliefs to actors seems relevant in this case (Tetlock 1986), recent studies have operationalized and studied this only to a limited extent. Bolognesi et al. (2024) used, for example, the top objective of a priority ranking to operationalize the policy core belief about water supply policy, assuming that objectives with lower priority levels were less important to instrument preferences. In contrast, Kammermann and Angst (2021) asked actors about the importance of specific objectives in relation to others for operationalizing policy core beliefs. Literature from decision analysis, especially multi-criteria decision analysis (MCDA; Eisenführ et al. 2010), can contribute to this discussion about how to study instrument preferences under conflicting beliefs. MCDA offers theories on the response to conflicting beliefs, such as multi-attribute utility theory (MAUT; Keeney and Raiffa 1993). From the perspective of a decision analyst following MAUT, complex policy questions about how to address a sustainability problem are viewed as value-based decisions. These decisions involve evaluating trade-offs and responding to uncertainty (Keeney 2006). Evaluating trade-offs entails translating policy core beliefs into specific objectives[1] and comparing the consequences of policy instruments for achieving those objectives. It also entails assessing the importance of achieving one objective relative to another, potentially conflicting objective.

[1]The two literature strands, policy studies and MCDA, use the term "objectives" very differently. In policy studies, policy objectives are located at the level of secondary aspects and together with instruments as part of a policy program. In MCDA, objectives capture the overarching goal and personal values and come close to the policy core beliefs in a policy subsystem. We mostly refrain from using the term "objectives" in this study but mention it here and in the methods sections. Thus, we refer to the MCDA term of overarching objectives, synonymous with policy core beliefs.

Responding to uncertainty is even less theorized in the ACF than dealing with trade-offs. So far, policy studies have overlooked the relationship between attitudes toward the uncertain consequences of policy instruments and instrument preferences. Based on MAUT, actors' attitudes toward perceived risks in a specific (objective) domain describe how they respond to uncertainty about the policy consequences for that domain. These risk attitudes are thus relevant to anticipating preferences for particular policy instruments under uncertainty. Several policy studies have investigated the relationship between actors' risk perceptions and preferences for instruments (e.g., Glaus et al. 2020; McGuire 2015; Verlynde et al. 2019; Wiedemann 2022). Yet risk perception alone does not allow for unambiguous conclusions about the instrument preferences of actors under uncertainty (Weber and Milliman 1997). An actor may perceive a high risk, but still be willing to take it. Using MAUT, we expect that domain-specific risk attitudes will better predict actors' behavioral preferences and thus their instrument preferences under uncertainty. Domain-specific risk attitudes not only describe actors' willingness to take risks, but also involve domain-specific risk perception considerations to some extent (Weber et al. 2002). To the best of our knowledge, no policy study has addressed the relationship between domain-specific risk attitudes and instrument preferences so far.

To fill the theoretical gaps in policy studies on instrument preferences in complex contexts such as sustainability problems, we combine the ACF with MAUT from MCDA. MCDA is a collection of methods for supporting complex decision problems, including those at the policy level (French and Argyris 2018; Gregory and Wellman 2001; Keeney 2006; Tsoukias et al. 2013). The established methods evaluate the decision alternatives such as policy instruments in terms of satisfying actors' policy core beliefs. The evaluation is based on how well alternatives achieve specific decision objectives and how actors value these consequences. MCDA methods allow for identifying conflicting policy core beliefs and integrating the beliefs of different actors when evaluating policies (Munda 2009). To date, MCDA has been applied in policy studies mainly as method to identify the policy beliefs of different actors (Ingold 2011). The theories behind the MCDA methods, such as MAUT, were less of a focus. However, MAUT finds implicit reference in policy studies, in the discourse on utility as a driver of individual or organizational behavior and in the maximization of social welfare through public policy (Andrews 2007; Weimer and Vining 2017). Hereby, utility functions assign a value to uncertain policy consequences and can be used to evaluate the effectiveness of policies and maximize social welfare in view of actors' policy core beliefs and uncertainty response. Against this background, we use MAUT in our exploratory policy study. We test whether actors evaluate policy instruments in terms of their utility under uncertainty (response to uncertainty) and in accordance with the relative importance of policy core beliefs (evaluation of trade-offs) and whether this is reflected in their instrument preferences.

We study the relationship between instrument preferences and the relative importance of specific policy core beliefs and domain-specific risk attitudes in Swiss pesticide risk reduction policy. This case is ideal for gaining new insights into this complex relationship: Agricultural pesticide use has become a serious sustainability problem owing to growing concerns about its adverse effects on human health and the environment (e.g., Chagnon et al. 2015; Schaub et al. 2020; Stehle and Schulz 2015; Tang et al. 2021; Zubrod et al. 2019). Policy choices to reduce these effects shape pesticide regulations, farming systems, and cultivated crops, which are three key factors that explain the agricultural pesticide lock-in, resulting pollution, and adverse health and environmental effects (Hüesker and Lepenies 2022; Wuepper et al. 2023). These choices require making trade-offs between conflicting policy core beliefs related to human health, environmental protection, agro-economic productivity, and socio-political costs. These choices also require dealing with great uncertainty, both about the adverse effects of pesticides (Möhring et al., 2020a; Spycher et al. 2018) and about the consequences of different instruments (Kaiser and Burger 2022; Pedersen et al. 2020; Schaub et al. 2023). The Swiss case is interesting because policy choices for pesticide regulation must also take into account a particularly large number of different actors and their instrument preferences. Switzerland is a consensus-oriented direct democracy (Varone and Ingold 2023). Popular initiatives or, retroactively, referenda and popular votes allow not only policymakers but also other affected or targeted actors to participate in policy processes. To ensure the support of the majority of actors who could potentially become politically active, they are proactively consulted for policy-making. For policymakers, understanding the instrument preferences of these actors is crucial to designing future policies to reduce the adverse effects of agricultural pesticide use —policies that are urgently needed (Candel et al. 2023; Möhring et al., 2020b).

Theoretically, this study contributes to policy studies by using MAUT in addition to the ACF to better understand the role of conflicting beliefs and uncertainty in forming policy instruments. Methodologically, we contribute by adapting MCDA tools to policy studies. MCDA provides tested and well-established tools to elicit the relative importance of policy core beliefs and the risk attitudes of actors. Empirically, we contribute by discussing the potential of different instruments to regulate agricultural pesticide use and reduce its adverse effects given conflicting policy core beliefs and risk attitudes of actors in Switzerland. The discussion could shed light on why certain policy instruments are supported and what adjustments could lead to broader support from various actors. Insights into how particular policy instruments and their characteristics might be related to actors' evaluation of trade-offs between conflicting policy core beliefs and their response to uncertainty in the form of domain-specific risk attitudes could be valuable beyond our case study.

Theory and hypotheses

Policy instrument preferences

Often, political negotiations involving diverse actors turn around the concrete design of public policies, including policy objectives and instruments. The formation of actors' preferences among possible policy instruments is complex and influenced by several criteria, such as the efficiency, effectiveness, equity, manageability, and legitimacy of the instruments (Howlett 2004; Salamon 2002). These criteria are in turn influenced by different instrument dimensions, namely the

Table 1. Examples and characteristics of policy instruments (adapted table from van der Doelen 1998). The approach (persuasive, market-based, or regulatory) and the strategy (stimulative or repressive) of the instruments determine their degree of coercion. The instrument examples stem from Swiss pesticide risk reduction policy

	Stimulative Instruments	Repressive Instruments
Persuasive Instruments	Information campaigns (e.g., improved access to risk information, advisory service, early warning systems)	Propaganda (= extrema) or education (e.g., training obligation)
Market-Based Instruments	Subsidies (e.g., agricultural direct payments, financial support for research)	Levy (e.g., tax incentives on pesticides, tax-financed water treatment)
Regulatory Instruments	Contract or covenant (e.g., voluntary agreement, certification program)	Order or prohibition (e.g., authorization, limit values, use/zone restrictions, substance ban)

instruments' *automaticity* (re-use of existing polity structures), *directness* (distance between adopters and implementers), *coerciveness* (degree of constraint), or *visibility* (appearance in budgeting or reporting processes) (Salamon 2002). The relevance of each criterion and dimension to instrument preferences is highly contextual (Howlett 2004; Rigby 2007). For example, the legitimacy of subsidies may depend on budget constraints in the respective policy subsystem (Howlett 2004). In our study, the dimensions of directness, automaticity, and visibility appear to be less relevant since the institutional and economic context is similar for all policy instruments discussed for pesticide risk reduction at the national level in Switzerland (Rigby 2007; Salamon 2002). The coerciveness, in turn, is more relevant to instrument preferences as it is strongly associated with ideological debates about policy instrument choice, instruments' consequences, and associated uncertainties (Salamon 2002; van der Doelen 1998). Conflicts among actors in subsystems can arise over policy instruments with different degrees of coercion exercised on the target groups of the policy.

There are several different policy instruments available to address the problem that arrived on the political agenda. The degree of coercion of these instruments heavily influenced the most traditional classification into regulatory, market-based, and persuasive instruments (Ingold et al. 2016; van der Doelen 1998). From the first to the last, the coercion exercised on the target actors, and thus the degree of freedom in these actors' individual decision-making decreases. The degree of coercion is further refined by subdividing stimulative and repressive instruments in each class (van der Doelen 1998; see overview in Table 1). In the end, it is the approach (persuasive, market-based, or regulatory) and the strategy (stimulative or repressive) of an instrument that determine the degree of coercion: *Regulatory instruments* approach a change in the behavior of the target actors causing the problem by using a legal basis. More repressive regulatory instruments for pesticide risk reduction are, for example, the approval or banning of pesticides. More stimulative (less repressive) regulatory instruments are industry agreements on the certification of pesticide-free products. *Market-based instruments* give more room of maneuver to the target actors and use monetary remunerations or sanctions to incite behavior change. Remunerations such as state subsidies aim to encourage a behavior (stimulative strategy). In contrast, sanctions through a levy tend to be more discouraging (repressive strategy). Examples of policy instruments to reduce pesticide risks include direct payments to farmers for pesticide-free production and incentive taxes on pesticide use based on the predicted adverse effects of the substance. Finally, *persuasive instruments* nudge target actors to change their behavior. Here, information campaigns, public appeals, education, or, in the extreme, propaganda aim to raise awareness of a problem and to promote behavior change. Nudging can be stimulative, or it can also be repressive if certain information is considered to be standard (e.g., training standard). We know from pesticide risk reduction policy, for instance, that there are information campaigns on risk prevention and a requirement for training in agricultural pesticide use. Among other dimensions, less relevant in our case, the degree of coercion is used to make assumptions about the effectiveness of these policy instruments in satisfying certain policy core beliefs, with preference given to more effective instruments (van der Doelen 1998). However, the definition of effectiveness, and thus policy instrument preferences, depend on individual core beliefs about what needs to be achieved and individual attitudes toward uncertainty in satisfying those beliefs.

Evaluation of trade-offs given conflicting policy core beliefs

The ACF illuminates policy processes and policy change, with a focus on advocacy coalitions, their belief system, and policy-oriented learning therein. The ACF speaks of a three-tiered belief system, which includes preferences for policy instruments (Sabatier and Weible 2007; Weible et al. 2020): *Deep core beliefs* are fundamental values rooted in the actors' religious and cultural ideology. *Policy core beliefs*, in turn, are the translation of the deep core beliefs into concrete, issue-related beliefs in policy subsystems. They refer to beliefs about what needs to be solved and guide *secondary beliefs*, actors' preferences for technicalities, and instrumental aspects of policy design, typically including preferences for policy instruments. The hierarchy of the belief system would thus tell us that (deep and policy) core beliefs are an important driver for understanding and explaining actors' preferences for certain policy instruments over the others. According to the ACF, actors with similar beliefs form coalitions in which they coordinate and share resources to strengthen their advocacy in negotiations (Weible et al. 2020). Negotiations are a fundamental part of policy processes, where actors agree or disagree on the choice of instrument(s) to address a problem or find compromises. In these negotiations, actors strive for preferred instruments that most effectively satisfy their policy core beliefs (rational choice paradigm; Geels 2010). Actors therefore make assumptions about the probability that a particular instrument will satisfy their core beliefs, given the actions of others and the institutional or economic context (Andrews 2007; Griggs 2007). To reach an agreement, actors may have to compromise on preferred policy instruments to accommodate the core beliefs of their negotiation partners while maximizing the utility of newly proposed instruments in light of their own core beliefs (Metz et al. 2021). However, the (deep or policy) core beliefs of actors remain rather stable (Sabatier and Weible 2007), and different core beliefs need to be considered to satisfy the various actors involved (e.g., Rosenow et al. 2017). Yet the

ACF remains vague about how actors account for multiple conflicting beliefs when forming instrument preferences.

In MCDA, decision analysts support actors in complex decision problems that require making trade-offs between multiple conflicting decision objectives, such as policy core beliefs (Eisenführ et al. 2010). One theory to decide about the "best" decision alternative among policy instruments when there are multiple policy core beliefs is MAUT (French and Argyris 2018; Reichert et al. 2015). Following MAUT, the utility of a policy instrument (decision alternative) for an actor is a function of all relevant consequences of the instrument and the value that the actor associates with these (uncertain) consequences (Keeney 2006; Keeney and Raiffa 1993). Values or the utility function are not a natural human expression, but a theoretical model and approximation of how policy core beliefs may translate into behavioral preferences (Beinat 1997; Eisenführ et al. 2010; Weimer and Vining 2017). In public policy, where decisions must ideally be transparent and plausible to be legitimate, the few axioms of the theoretical model (MAUT) are considered justified (French and Argyris 2018; Reichert et al. 2015). According to the model, actors first translate their policy core beliefs into concrete policy objectives. Second, the consequences of a policy instrument for these objectives are assessed. Third, the actors assign values to the consequences according to the satisfaction of their policy core beliefs, i.e., how well an instrument achieves a particular objective. When there are multiple policy core beliefs, one policy instruments can usually not satisfy all of them at the same time and to the same degree (Glaus 2021). For example, a ban on agricultural pesticides may be effective in protecting the environment but is not designed to secure farm incomes. In this situation, actors evaluate the policy instrument and resulting trade-offs based on which of their policy core beliefs is more important to satisfy. In the end, the utility of a policy instrument is an aggregation of these considerations.[2] The consequences of an instrument for each policy core belief are evaluated, weighed, and aggregated into an overall utility estimate. MAUT expects actors to prefer the policy instruments with the highest utility to them (Keeney and Raiffa 1993). Similar to the ACF, MAUT suggests that the policy core beliefs are ideally the main drivers of instrument preferences and decision-making. The values that actors assign to policy instruments as measures of utility are derived from their policy core beliefs and, in the case of conflicting policy core beliefs, the relative importance of those beliefs ("value-focused thinking"; Keeney 1982). This leads to our first hypothesis (**H1**):

H1: *The degree to which actors are likely to prefer a particular policy instrument depends on the relative importance they associate with specific policy core beliefs.*

[2]If multiple policy core beliefs must be considered, significant cognitive effort is required to predict the consequences and determine the utility of different policy instruments. The consequent limitations have implications for policy instrument preferences and political debates (i.e., "allocation of attention"; Jacobs 2008; Schneider et al. 2023). If actors cannot draw on experience or evidence for their predictions, they often use heuristics (Jacobs 2008). MCDA aims to compensate for the limitations and biases that result from applying heuristics. In MCDA, the preferences for policy instruments are not directly elicited. The utility of a policy instrument is modeled based on the predicted consequences and the actors' preferences for those (uncertain) consequences. According to MAUT, "rational" actors prefer the policy instrument that achieves the highest utility (Eisenführ et al. 2010; Keeney and Raiffa 1993).

Domain-specific risk attitudes as response to uncertainty

Although uncertainty is inherent in almost all public policy problems or decisions (Koppenjan and Klijn 2004), the ACF remains vague in how actors respond to it when forming their preferences for policy instruments. When policy analysts consider uncertainty, they assume that actors who perceive high risk in effectively achieving their policy core beliefs are more likely to prefer policies that reduce that risk (e.g., Glaus et al. 2020; McGuire 2015; Verlynde et al. 2019; Wiedemann 2022). This assumption is rooted in psychology: Because policy choice can have serious consequences, actors use risk assessments to hypothetically or empirically evaluate uncertainty, gain insight into the probable consequences (risks or benefits), and make decisions (Slovic 1987). Slovic (1987) describes risk perception as an intuitive risk assessment of an actor, i.e., a subjective risk judgment based on experience, evidence, or heuristics. Policy analysts use risk perception to anticipate actors' instrument preferences under uncertainty. However, this theoretical basis lacks in terms of behavioral conclusions as actors' behavioral preferences in situations of uncertainty do not necessarily correlate with their risk perception: Actors can perceive a risk as high but still want to take it because of anticipated benefits and their willingness to take the risk (Weber and Milliman 1997).

In MAUT, the actors' responses to uncertainty through their attitudes toward associated risks play an important role in deciding among alternatives with uncertain consequences (Eisenführ et al. 2010; Keeney and Raiffa 1993; Reichert et al. 2015). MAUT postulates that the preference for a decision alternative such as a policy instrument is based on the subjective expected utility associated with the alternative—that is, how effective the instrument satisfies policy core beliefs and achieves specific objectives given uncertainty (Keeney and Raiffa 1993). MAUT expects actors to prefer the instrument that has the highest expected utility associated with its probabilistic consequences. It is thus necessary to specify utility as a function of the consequences of a policy instrument, the probability of those consequences occurring, and the values assigned by actors to the uncertain consequences. The utility function represents how actors respond to uncertainty, their risk attitudes, and how these attitudes may translate into behavioral preferences (Keeney 2006). The function models the values that actors assign to possible lotteries between the probabilistic consequences of policy instruments for a specific policy core belief. In other words, actors' "risk attitudes" capture how willing actors are to take a risk and accept the consequences of an instrument when those consequences are uncertain (Keeney and Raiffa 1993). The actors' risk attitudes can be domain-specific (Weber et al. 2002). Thus, the willingness to take risks or the acceptance of uncertainty depends on the policy core belief at stake. For example, an actor could be relatively open to accepting uncertain consequences for agro-economic productivity, but reluctant to do so for environmental protection. Domain-specific risk attitudes are expected to better approximate behavioral preferences than risk perceptions alone. Psychological literature suggests that both risk perception and risk attitudes must be considered to understand decisions and preferences under uncertainty (Weber and Milliman 1997). Domain-specific risk attitudes result from considering risk benefits, the degree to which beliefs are expected to be satisfied (expected utility), and perceived risks, the degree of potential loss (Weber et al. 2002). Thus, a risk-tolerant attitude does not automatically imply acceptance of negative consequences, but rather a belief that there is a low risk that the consequences will be worse than the status quo. Taking the above example, a ban on pesticides might have a positive environmental impact with certainty, but the consequences for national food security are uncertain. In contrast, a less repressive and coercive instrument, such as direct payments for pesticide-free farming, might be more uncertain in protecting the environment because of uncertainty about the effectiveness of the instrument, which includes uncertainty about how many farmers will make use of such payments. Whether actors prefer the ban or the direct payments depends on their risk attitudes in the domain of agro-economic productivity and environmental protection. This leads to our second hypothesis (**H2**):

H2: *The degree to which actors are likely to prefer a particular policy instrument depends on their domain-specific risk attitudes.*

Methodology

Case

Swiss pesticide risk reduction policy is embedded in a consensus-oriented direct democracy and thus involves various actors and their instrument preferences (cf. Varone and Ingold 2023). Involved are the political parties represented in the federal parliament, the federal government, and associated executive agencies covering different jurisdictions (e.g., environmental protection, agriculture, food safety). But national trade associations of farmers, beekeepers, fishermen, water suppliers, the pesticide industry, or retailers, consumer and environmental organizations, scientific institutes, and agricultural experts are also involved (see *Data collection* section). Recent policy processes to reduce (agricultural) pesticide risks have largely been influenced by such non-governmental actors (Huber et al. 2024; Huber and Finger 2019). Different popular and parliamentary initiatives have put the issue of agricultural pesticide use at the top of the political agenda in Switzerland. In 2017, the national action plan "Risk Reduction and Sustainable Use of Plant Protection Products" was launched. The plan proposed about 50 action points to reduce pesticide risks by 50% until 2027 (Schweizer Bundesrat 2017). These action points mainly extend existing policy instruments, such as supporting pesticide-free production systems through higher direct payments or regulating the use of pesticides through a training requirement. In response, two popular initiatives requested more ambitious action, suggesting stricter cross-compliance standards and a ban on pesticides, respectively (Finger 2021). As a compromise, the Swiss federal assembly adopted the parliamentary initiative "Reduce the Risk Associated with the Use of Pesticides" (Pa.Iv. 19.475) in 2021 (Schweizer Bundesversammlung 2019). This initiative induced inter alia an obligation to report agricultural pesticide use, established a national risk evaluation system and the monitoring of set targets, and linked pesticide approval to observed effects. Despite this initiative, the search for policy instruments to reduce the adverse effects of agricultural pesticide use remains relevant, as trade-offs between agro-economic productivity and environmental protection persist (Candel et al. 2023; Möhring et al., 2020b).

Swiss pesticide risk reduction policy is an ideal policy subsystem for studying the role of trade-offs between conflicting policy core beliefs and of domain-specific risk attitudes in forming preferences for policy instruments. Trade-offs exist, for instance, between environmental protection and agro-economic productivity (Schmidt et al. 2019). While farmers use pesticides to protect their crops and meet market requirements (Bakker et al. 2020), the pesticide use exposes them and other non-target organisms to risks (Graczyk et al. 2018; Humann-Guilleminot et al. 2019). With respect to these trade-offs, different actors have different priorities. Two coalitions and an intermediate group exist among the actors in Swiss pesticide risk reduction policy (Wiget 2024). There are those actors who are less concerned about agro-economic productivity, fully supporting repressive regulatory instruments to reduce pesticide risks. Others are concerned about environmental protection, food security, and the economic viability of farming. They do not unconditionally support additional regulations and clearly oppose tax incentives to govern pesticide use and risks. The actors have to from their instrument preferences under substantive and strategic uncertainty.[3] Numerous ways of exposure, various environmental factors, missing analytics, misleading indicators, and the delayed occurrence of effects make risk assessments of agricultural pesticide use difficult (Kiefer et al. 2020; Möhring, Bozzola, et al. 2020; Möhring et al. 2019; Riedo et al. 2021; Schulz et al. 2021; Spycher et al. 2018). In addition, reactions to policy instruments are heterogeneous, as many actors and factors along the food value chain influence agricultural pesticide use (Bakker et al. 2020; Kaiser and Burger 2022; Pedersen et al. 2020; Schaub et al. 2023).

Data collection

The study data stem from an online survey and a focus-group workshop. In summer 2022, we conducted an online survey among 54 key actors in Swiss pesticide risk reduction policy with a response rate of 85% ($N = 46$; see also Wiget 2024). We considered decision-, position-, and reputation-relevant actors (Hoffmann-Lange 2018) and identified the actors using policy documents of the national action plan and parliamentary initiative, previous stakeholder analyses (Metz et al. 2019; Metz et al. 2021), and interviews (with four experts from administration and non-governmental organizations). We surveyed representatives in leading positions

[3]There are two types of uncertainties relevant to policy instrument preferences (see typology of Koppenjan and Klijn 2004). Both types can influence the actors' perspectives on whether the instruments promise to be effective or efficient. First, *substantive uncertainty* exists because information about the cause of the problem is not available or because actors interpret available information differently. Progress in science might have led to more knowledge but also to increased complexity and thus more context-specific and less unequivocal findings (Koppenjan and Klijn 2004). For example, depending on the perspective, a sustainability problem such as the use of pesticides in agriculture is caused not only by farmers but also by consumers, retailers, the agroindustry, or the authorities (with their choice of food, market requirements, missing alternatives, or risk assessment). Second, *strategic uncertainty* exists because information about the consequences of a suggested policy instrument is not available. Targeted actors might not react as expected, or different instruments might unintentionally interact (Koppenjan and Klijn 2004; Pedersen et al. 2020).

about the policy instrument preferences of their respective organizations or institutions (see actors list in appendix, Table A-1). In summer 2023, we conducted a follow-up workshop with a representative sub-sample ($N = 24$). The actors were selected based on a social network analysis considering the type, relevance, and coalitions of the actors (Wiget 2024). During the workshop, we elicited their policy core beliefs and risk attitudes. Finally, we studied the relationship of instrument preferences with policy core beliefs and risk attitudes based on the data from those actors who participated in both the survey and the workshop. Additional survey data were used for control variables.

Data operationalization

We operationalized the dependent variable, the policy instrument preferences, by measuring the actors' level of support for 15 examples of different policy instruments (Table 2). We considered regulatory, market-based, and persuasive instruments aiming at pesticide risk reduction in a stimulatory or repressive manner (Table 1). All the examples we used were discussed in the context of the national action plan and the Pa.Iv. 19.475 (see also Wiget 2024). We validated the instrument examples used with experts and based on a comprehensive, context-specific collection of instruments by Lee et al. (2019). In the survey, we asked: "How supportive is your organization of each of these policy instruments?" The actors had to rate their support on a Likert-scale ranging from 1 (*not at all*) to 5 (*fully*).

We elicited the actors' policy core beliefs (1st explanatory variable) in the workshop with tools from MCDA. The policy core beliefs and their relative importance were operationalized as relative weights assigned to the achievement of 16 objectives covering four domains (Table 3). The objectives were compiled based on the same policy documents used to identify the actors. In addition, we used our system knowledge and the actors' feedback on objectives in the survey (see also Wiget 2024). In an individual pen-and-paper questionnaire (see SI-1.2), we asked the workshop participants to rank the 16 objectives according to the importance of achieving them. The ranking was used to calculate the weights (Kuller et al. 2023). Although weight approximation can induce biases (Riabacke et al. 2012), the used rank sum calculation approach is a good substitute for more cognitively demanding weight elicitation methods (Roberts and Goodwin 2002). Objectives' weights are range sensitive. For example, actors might weight the objective "cost fairness" differently depending on the magnitude of external costs. Hence, weights are specific to the context, i.e., to information about the best and worst possible consequences across all considered policy instruments. To avoid a range insensitivity bias when eliciting weights, the ranges must be provided for each objective (Montibeller and von Winterfeldt 2018). For each objective, we thus identified suitable indicators, the status quo, and the best/worst possible consequences together with experts (see details in the supplementary information section SI-1). In our models, we included the most variant policy core beliefs of each domain (see appendix, Table A-1), as the variance in the relative importance indicates divisive beliefs between actors (Karimo et al. 2023).

We also elicited the actors' risk attitudes (2nd explanatory variable) in the workshop in groups of five to seven actors. Following common practice in MCDA,

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Table 2. Policy instruments to operationalize the actors' instrument preferences (adapted table from Wiget 2024)

Category	Type	Policy Instrument	Abbreviation
Regulatory Instruments	Authorization	Advancement of the pesticide approval process (e.g., through additional requirements for pesticide products or the further development of the risk assessment of pesticides)	Authorization
	Limit values	New limit values for pesticide residues in water, soil, or food (e.g., new cumulative or additional ecotoxicological limit values)	LimitValues
	Use restrictions	Stricter use regulations for pesticides regarding their application, storage, and disposal	UseRestrictions
	Zone restrictions	Identification of inflow areas of relevant ground waters as zones with special measures for the protection of water quality (e.g., conditional use of pesticides)	ZoneRestrictions
	Substance ban	Ban of particularly problematic pesticides	Ban
Market-Based Instruments	Tax incentives	Tax incentives on pesticides depending on their adverse effects on the environment and human health	TaxRisk
		Co-financing the technical upgrading of drinking water catchments by polluters	TaxUpgrade
	Subsidies	Direct payments to promote low-emission application techniques	DPappliTech
		Direct payments to promote pesticide-low/free production	DPfreeProduct
		Financial support for research on alternative crop protection practices, production systems, and protective measures	SubResearch
Cooperative Instruments	Voluntary agreements	Industry agreements with bulk buyers (e.g., regarding quality standards or the minimum share of resistant varieties and label products)	Agreements
	Certification	Labels for pesticide-low/free foods for the identification and traceability of agricultural production and quality criteria	Labels
Persuasive Instruments	Information campaigns	Improved access to information on pesticide risks and protective measures	InfoAccess
		Expansion of the national early warning service for monitoring and forecasting the occurrence of pests	EarlyWarning
	Training &advisory service	Expansion of advisory services and obligation to provide further training for pesticide users	Training

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Table 3. Policy objectives to operationalize the actors' policy core beliefs (adapted table from Wiget 2024). For information on the indicators for each objective and the best and worst possible consequences for them, see Table SI-1.1

Domain	Objective	Description	Abbreviation
Human Health Protection	High protection of users, downstream workers, passers-by	Low acute toxicity of pesticides and low direct exposure of users, downstream workers, and passers-by to pesticides	ApplicantsHealth
	High protection of consumers	Low chronic toxicity of pesticides and low uptake of (various) pesticides through the consumption of agricultural products	ConsumersHealth
	Low workload in agriculture	Low mental (e.g., well-being) and physical stress (e.g., ratio of needed vs. available labor force) of people working in agriculture	Workload
Environmental Protection	High protection of non-target organisms	Species richness and abundance on land, on and off the farm	NonTargetOrganisms
	High soil protection	Low land consumption and high soil fertility (low soil degradation and high soil microbiological activity, respectively)	SoilProtection
	High climate protection	Low greenhouse gas emissions and low energy consumption	ClimateProtection
	High water protection	High protection of aquatic organisms and high quality of surface water, groundwater, and drinking water resources	WaterProtection
Agro-Economic Productivity	High autonomy of farmers	High economic independence and high operational decision-making freedom	FarmersAutonomy
	High level of food security	High contribution of the domestic production in meeting the national food demand for agricultural products	FoodSecurity
	Low food costs	Low cost of food for consumers relative to their household budget	FoodCosts
	High economic viability	High added value and low expenses (investment and operating costs) for farmers	EconomicViability
Socio-Political Costs	High cost fairness	Low external costs borne by the public and true cost in accordance with the polluter-pays principle	CostFairness
	High international coherence	High compliance with international laws and standards	Coherence
	High innovation potential	Rapid adaptability of the national food production to new knowledge (e.g., on pesticide risks) and situations (e.g., climate change)	InnovationPotential
	High job security	Maintaining or creating agricultural jobs and farming businesses in rural areas	JobSecurity
	High landscape quality	Positive perception of the appearance of the cultural landscape (e.g., of agricultural infrastructure such as greenhouses)	LandscapeQuality

risk attitudes were elicited with a basic reference lottery using the bisection version of the variable certainty equivalent method (Eisenführ et al. 2010). In an iterative questioning process, the actors compared the uncertain consequences of a hypothetical policy instrument A with the certain consequences of a hypothetical instrument B (for the detailed process, see SI-2). They had to indicate the certainty equivalent (CE) at which they were indifferent between preferring A or B. The CE is the level to which the objective must be achieved with certainty by instrument B so that it is equivalent to instrument A and its uncertain consequences. It indicates the utility of the policy instrument A, where there is an equal chance that the objective will be either fully achieved or not achieved at all (i.e., 50/50 chance lottery). We elicited the risk attitudes in each of the four domains based on the objective that the respective group had considered as most important in that domain. Next, we normalized the resulting CEs on a scale between 1 (i.e., instrument B fully achieves the objective) and 0 (i.e., instrument B does not achieve the objective at all). Depending on the elicited CE, the actors were identified as risk-averse ($CE < 0.5$), risk-neutral ($CE = 0.5$), or risk-tolerant ($CE > 0.5$) of uncertain consequences for achieving the objectives in the corresponding domain.

As control variables, we included the collaboration partner support index (CPSI) and the actor type. To calculate the CPSI, we collected data on the actors' collaboration partners in the survey (see also Wiget 2024). The CPSI operationalizes the instrument preferences of an actor's collaboration partners. The coordination and exchange with other actors in policy processes can influence individual instrument preferences (e.g., Metz et al. 2019). Actors might adapt their policy instrument preferences to coordinate with allies with similar policy core beliefs but different instrument preferences or to find a compromise in negotiations with opponents (Metz et al. 2021; Sabatier and Weible 2007). We calculated the CPSI for each actor and policy instrument: The support ratings of an actor's collaboration partners for a given policy instrument were averaged and divided by the maximum possible support of the respective group of partners. The resulting index can take a value between 0 (none of the partners support the instrument) and 1 (all partners fully support the instrument). Furthermore, we differentiated between actors with an administrative role, particular interests, or a scientific background. Actor types differ in their experiences and role. These differences can influence their policy instrument preferences (e.g., Metz and Leifeld 2018). Our sample included six administrative actors, thirteen interest groups, and five science actors. As administrative actors can be expected to have less partisan policy instrument preferences than other actors (Jenkins-Smith et al. 2017), they served as the reference actor type in our analysis.

Data analysis

Our study aimed to understand actors' preferences for policy instruments in the face of multiple conflicting policy core beliefs and uncertainty. We used Bayesian ordinal logistic regression (OLR) models (Bürkner and Vuorre 2019) to assess the relationship between policy instrument preferences and the explanatory variables (Figure 1). Five separate models were created for regulatory, market-based, and persuasive policy instruments and their stimulative and repressive strategies (Table 1). In the case of the persuasive policy instruments, we did not distinguish

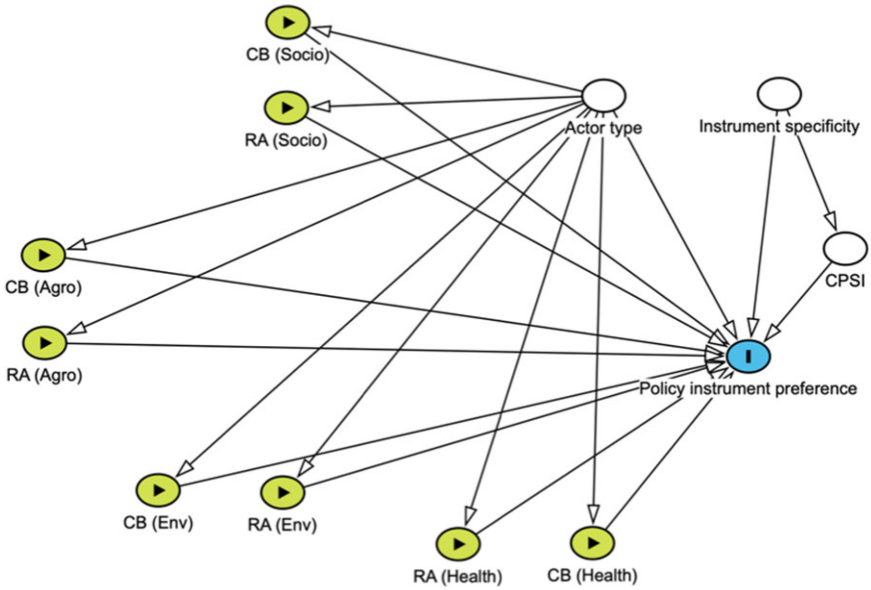

Figure 1. Causal model for policy instrument preferences. Blue: the policy instrument preference of an actor as the dependent variable; green: specific policy core beliefs (CB) and risk attitudes (RA) in the domains of human health (Health), environmental protection (Env), agro-economic productivity (Agro), and socio-political costs (Socio) as explanatory variables; white: the collaboration partner support index (CPSI), actor type, and policy instrument specificity as control variables that need to be adjusted for in the Bayesian ordinal logistic regression models.

between stimulative and repressive strategies. There was no clear example of a repressive persuasive instrument in our case. In each model, we controlled for the differences among individual examples for a particular instrument (Table 2) by comparing a reference example to all others. As references we used additional pesticide approval requirements (repressive regulatory instrument), voluntary industry agreements (stimulative regulatory instrument), risk-based tax incentives on pesticides (repressive market-based instrument), direct payments for low-emission application techniques (stimulative market-based instrument), and improved information access (persuasive instrument), respectively. OLR (Agresti 2010) was employed, as the dependent variable was polytomous (i.e., the level of support for an instrument was ranked in order: *not at all* < *mostly not* < *neutral* < *mostly* < *fully*).[4] For modeling, we centered all continuous variables and applied the *brms()* function of the *Stan* package (Bürkner 2017; 2018)

[4]The OLR model tests the odds that the dependent variable Y takes a certain category m (e.g., supportive position) versus other subordinate categories (e.g., neutral position and not supportive position) given the explanatory variables $X_1, \ldots, X_j$. The model is therefore based on the logits of the cumulative probabilities (Agresti 2010). The relation of the dependent variable and the explanatory variables is described with $M - 1$ cumulative logit equations. The model implies that the effect of a variable X on Y is the same for all M categories. Hence, we do not consider category-specific effects. For example, a category-specific effect is when beliefs influence whether actors support or are neutral about a policy instrument but do not influence whether actors are neutral or do not support the instrument (Bürkner and Vuorre 2019).

in R. Owing to limited prior knowledge, we used flat uniform priors for all explanatory variables. For model diagnostics, we conducted graphical posterior predictive checks using the *ppc_bars()* function of the *bayesplot* package (Gabry et al. 2019) and Rhat metrics (Bürkner and Vuorre 2019). We also conducted a descriptive analysis to check the model and understand how differences in the preferences for policy instruments relate to specific policy core beliefs, risk attitudes, the CPSI, and the type of actor (see details and results in SI-3).

Results

The Bayesian OLR models converged well, with Rhat convergence measures consistently being 1. The effective sample size was above 2,500 for all model parameters except for the stimulative market-based instrument model. Here, the effective sample size was above 1,300. All effective sample sizes were satisfactory. The posterior predictive checks revealed that the simulated data (i.e., posterior predictive distribution) fitted the observed data (distribution) quite well (Figure A-2). The results of the models were also consistent with those of the descriptive analysis (see SI-3).

The results of our model for *repressive regulatory policy instruments* showed a relationship between the actors' specific policy core beliefs about environmental protection and their instrument preferences. Actors who weighted the protection of non-target organisms higher were more likely to prefer additional pesticide approval requirements (Figure 2: violet CB (Env) estimate with 95% credibility interval). In other words, holding all other variables constant, the model estimated higher odds of fully supporting repressive regulatory instruments with an increasing weighting of environmental protection (Figure 3). The model results also revealed relationships between the preferences for repressive regulatory instruments and the actors' risk attitudes in the domains of environmental protection, agro-economic productivity, and socio-political costs. For example, the actors who were more risk-tolerant of uncertain consequences for the protection of non-target organisms and water bodies or for food security and the economic viability of farming were more likely to prefer additional pesticide approval requirements. Moreover, science actors were less likely to prefer additional pesticide approval requirements than administrative actors (Figure 4: difference in full instrument support between the actor types).

For *stimulative regulatory instruments (cooperative instruments)*, our model showed a relationship between the policy core beliefs about the relative importance of low agricultural workload and the actors' policy instrument preferences. If low workload was relatively important, the actors were more likely to prefer voluntary industry agreements between bulk buyers and farmers (Figure 2: orange CB (Health) estimate). We also noted a relationship between the actors' risk attitudes toward uncertain consequences for the health of applicants or consumers and their preferences for cooperative instruments (Figure 2: orange RA (Health) estimate). In addition, interest groups were more likely to prefer voluntary industry agreements than administrative actors if they did not differ in other matters (Figure 2: orange Actor type (IG) estimate).

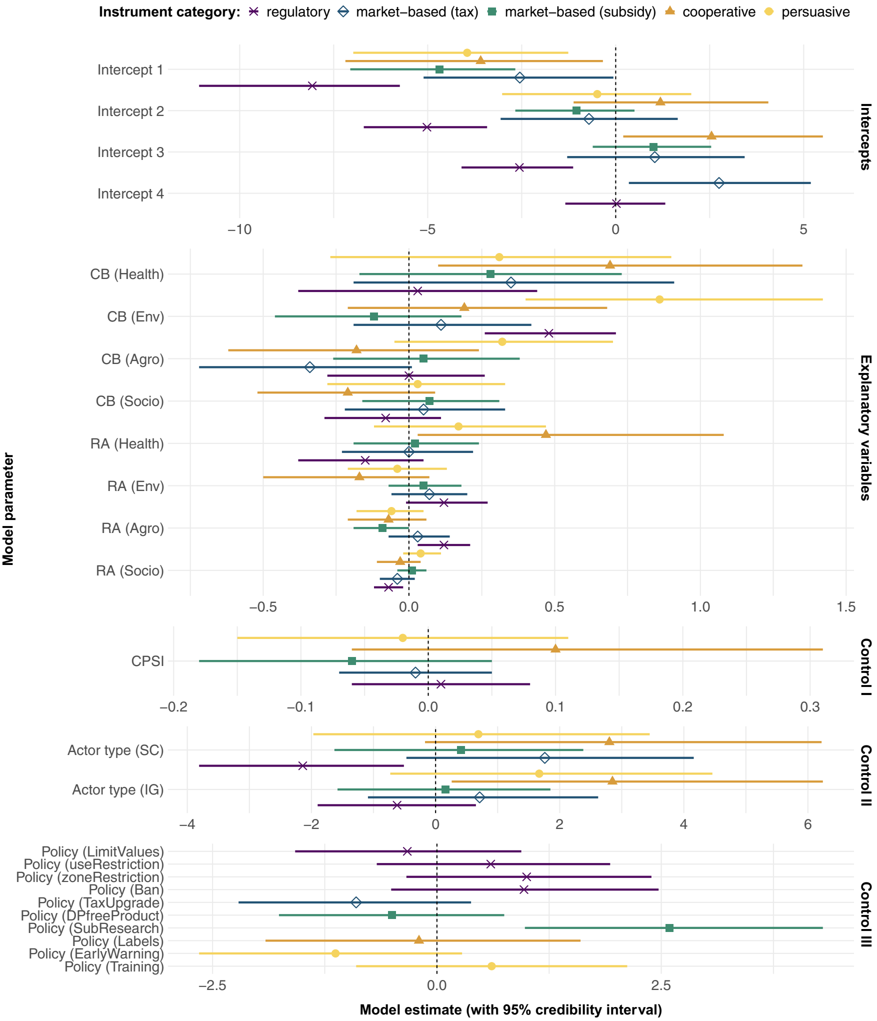

Figure 2. Result of the Bayesian ordinal logistic regression models. The upper point plot shows the estimates (x-axis) for the model intercepts, followed by a plot showing the estimates of the model parameters for the explanatory variables (CB: policy core beliefs; RA: risk attitudes). The last three plots show the parameter estimates for the control variables, the collaboration partner support index (CPSI), actor type (SC: science actors; IG: interest groups), and policy instrument specificity. Model estimates that differ from zero, including their 95% credibility interval, indicate a systematic and directional relationship between the corresponding variable and the actors' policy instrument preference for regulatory (violet), market-based (dark blue: tax incentives; green: subsidies), cooperative (orange), or persuasive (yellow) policy instruments. Reading example (black CB (Env) estimate): Actors who weighted the protection of the environment higher were more likely to prefer regulatory instruments with a 95% credibility interval (for details on the parameter estimates and credibility intervals, see Table A-2).

In the case of *repressive market-based instruments*, we found a relationship between the actors' policy core beliefs about agro-economic productivity and their preferences for tax incentives, considering a slightly smaller credibility interval than

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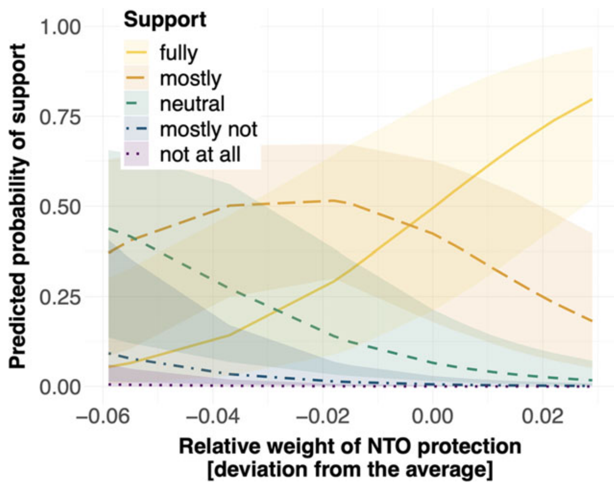

Figure 3. Marginal effect of policy core beliefs about the protection of the environment, and specifically non-target organisms (NTO), on the degree to which actors are likely to prefer a regulatory instrument such as additional pesticide approval requirements. The line plot illustrates the predicted probability of different levels of support (y-axis) depending on the weight the actors assign to the protection of non-target organisms (x-axis). The weights are shown as deviations from the average weight across all actors. The shaded areas indicate the 95% credibility intervals of the model predictions (for details on the marginal effects of other explanatory variables, see SI-4).

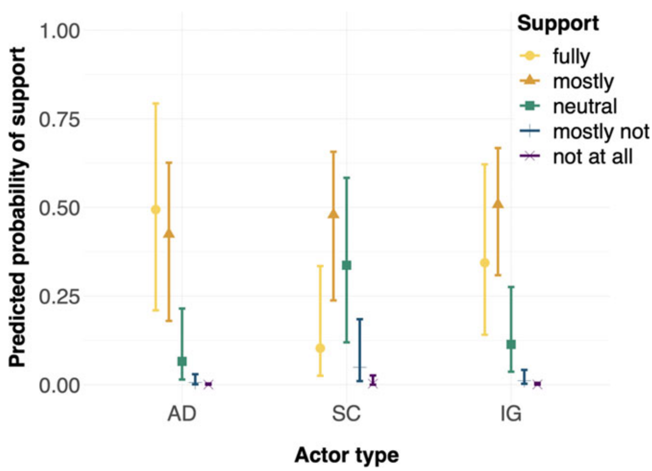

Figure 4. Marginal effect of the actor type (AD: administrative actors; SC: science actors; IG: actors with particular interests, so-called interest groups) on the degree to which an actor is likely to prefer a regulatory instrument such as additional pesticide approval requirements. The point plot illustrates the predicted probability of different levels of support (y-axis) depending on the type of actor (x-axis) with a 95% credibility interval (for details on the marginal effects of other control variables, see SI-4).

95% (Figure 2: dark blue CB (Agro) estimate). Actors who placed higher weight on the economic viability of farming were less likely to prefer tax incentives on pesticides based on health and environmental risks. We also found a relationship between the preferences for *stimulative market-based instruments* and the actors' risk attitudes in the domain of agro-economic productivity (Figure 2: green RA (Agro) estimate). Actors who were less risk-tolerant concerning the economic viability of farming were more likely to prefer direct payments for low-emission application technology. Controlling for the specific instrument examples, we found that all the actors more likely preferred subsidies for research on pesticide effects and crop protection practices than direct payments (Figure 2: green Policy (SubResearch) estimate).

Persuasive instruments received unanimous support from all actors (Figure SI-3.1). However, the degree to which the actors preferred the instruments depended on the relative importance they assigned to policy core beliefs about environmental protection. Actors who put more weight on the protection of non-target organisms were more likely to prefer improved access to information on pesticide effects and crop protection practices (Figure 2: yellow CB (Env) estimate). Table 4 summarizes our results.

Discussion

The results supported our first hypothesis that the actors' preferences for particular policy instruments depend on the relative importance they assigned to specific policy core beliefs. We found systematic relationships between the relative importance assigned to environmental protection, agro-economic productivity, or agricultural workload and the preferences for all instruments except stimulative market-based subsidies. The following three examples illustrate this result: First, the higher the actors weighted the protection of non-target organisms, the more likely they were to prefer additional pesticide approval requirements. This result is consistent with the findings of Hunka et al. (2015) that environmental concerns are one of the most important drivers of changes in risk assessment regulations for pesticides in the European Union. The key role of environmental concerns as drivers of pesticide approval regulations also appears to be true for Switzerland. Similar to the findings in Swiss agriculture policy (Metz et al. 2021), the actors in our study about Swiss pesticide risk reduction policy all assigned relatively high importance to the protection of human health and the environment. This shared policy core belief seems to be a key explanatory factor for the compromise reached in 2021 with the parliamentary initiative on linking pesticide approval to observed effects of pesticides in Switzerland (Schweizer Bundesversammlung 2019). Second, the more important the economic viability of farming was to actors, the less likely they preferred tax incentives on pesticides based on health and environmental effects. This result is consistent with earlier findings in Swiss water policy, where industrial and agricultural actors associated market-based instruments such as tax incentives to address micropollution in water bodies with rising costs for themselves (Metz and Leifeld 2018). Third, actors' policy core beliefs on the relative importance of agricultural workload played a role in their preferences for voluntary industry

Table 4. Summary of the Bayesian ordinal logistic regression model results for each of the five instrument categories. The table summarizes the relationships (R) of domain-specific policy core beliefs (CB), risk attitudes (RA), and control variables (CO) with the preferences for policy instruments. The (+) and (–) signs indicate the direction of the systematic relationship. Reading example: Actors who weighted the protection of the environment higher were more (+) likely to prefer repressive regulatory instruments

	Stimulative Instruments	Repressive Instruments
Persuasive Instruments	CB: Environmental protection (R+)	
Market-Based Instruments	RA: Agro-economic productivity (R-) CO: Instrument example (support for research)	CB: Agro-economic productivity (R-)
Regulatory Instruments	RA: Health protection (R+) CB: Health protection (R+) CO: Actor type (interest groups)	CB: Environmental protection (R+) RA: Environmental protection (R+) RA: Agro-economic productivity (R+) RA: Socio-political costs (R-) CO: Actor type (science actors)

agreements. This result is in line with the finding of Kaiser and Burger (2022) that depending on the crop protection practice, Swiss farmers' participation in voluntary pesticide-low/free production programs is more likely if the program does not require additional work. As a conclusion to these results, identifying the individual role of specific policy core beliefs in relation to potential consequences of policy instruments allows for developing consensus solutions. For example, for repressive market-based instruments targeting the use of hazardous pesticides, Finger et al. (2017) suggested a redistribution of tax revenues to financially support pesticide-low/free agriculture. Ideally, the redistribution would reduce the negative consequences for agro-economic productivity and thus increase the support for tax incentives. Ultimately, we found no pattern between the coerciveness of policy instruments and the relative importance of specific policy core beliefs. For example, the relative importance of environmental protection played a role in preferences for both persuasive and regulatory instruments. Although coercive policy instruments may be perceived as more efficient, the individual question remains as to which policy core belief is effectively satisfied and with what consequences for other policy core beliefs. The consequences of a stimulative instrument may be less costly to a high-priority (relatively important) policy core belief, even though less effective at satisfying another policy core belief.

Our results also supported the second hypothesis that the actors' preferences for particular policy instruments depend on their domain-specific risk attitudes. We found relationships between the actors' preferences for regulatory and stimulative market-based instruments and specific risk attitudes in all four domains. For example, in the case of repressive regulatory instruments, actors who were more risk-tolerant of uncertain environmental consequences regarding the protection of non-target organisms and water bodies were more likely to prefer additional pesticide approval requirements compared with actors who were less willing to accept such uncertainties. This finding might be counterintuitive at first sight. However, risk-tolerance should not be equated with accepting negative environmental consequences, but rather with believing that there is a low risk that the consequences are likely to be worse than the status quo. Similar observations were made among a sample of farmers (C. McCallum, personal correspondence, 04.10.2024): Farmers who did not use pesticides were more willing to take risks with respect to the environment. Current environmental risk assessments of pesticides have been criticized for focusing on individual substances rather than on substance mixtures and for misrepresenting exposure dynamics (Topping et al. 2020). Therefore, some actors believe that improving the approval process will likely be no worse than the status quo. Under the current authorization regime, an increasing number of agricultural pesticides are being withdrawn from the market due to new evidence of health or environmental risks. According to Topping et al. (2020), an advanced risk assessment based on an integrated systems approach would imply that pesticide authorization would be time- and context-specific, rather than a binary decision between "safe" and "unsafe". The remaining uncertainties and risks would have to be transparently communicated. In this respect, it is perhaps less surprising that those actors in our study who were more willing to accept (transparently communicated) risks preferred an advancement of the pesticide approval process. As another example, the actors' risk attitudes in agro-economic productivity played a key role in their preferences for stimulative market-based subsidies. Actors who were more risk-tolerant of uncertain consequences for food security and the economic viability of farming were less likely to prefer direct payments for low-emission application techniques or pesticide-low/free production. In Switzerland, direct payments are used to compensate for not using pesticides and thus taking the increased risk of yield and income losses. These payments are a key decision factor for farmers to participate in pesticide-low/free production programs, such as the Swiss Extenso program (Mack et al. 2023; Möhring and Finger 2022). Not surprisingly, actors who were less willing to accept uncertain consequences for farm income and yield tended to prefer direct payments. Based on our results, it remains to be explored whether the domain-specific risk attitudes of actors play a more decisive role in forming preferences for more coercive but less repressive instruments. We found that domain-specific risk attitudes played a role in preferences for regulatory rather than persuasive instruments using stimulative rather than repressive policy strategies. However, this trend needs further empirical verification. Our explanation for this trend is that the uncertainty in the consequences of policy instruments decreases as the repressiveness of the instrument increases. This is also reflected in the association between instruments' effectiveness and repressiveness (van der Doelen 1998). Because of their optional adaptability and uncertainty in the response of the target actors, stimulative instruments are perceived as less effective, with less certain consequences. However, the consequences of policy instruments are inherently uncertain, and the potential consequences of regulatory instruments are typically more severe than those of persuasive instruments. Therefore, potential benefits and risks and thus the relevance of domain-specific risk attitudes, even for non-targeted policy core beliefs, increase with the degree of coercion.

Regarding our control variables, the instrument specificity and actor type played a role only in the case of preferences for market-based subsidies and for regulatory and cooperative instruments, respectively. In the case of market-based instruments, the actors tended to prefer subsidies for research on the effects of agricultural pesticides and alternative crop protection practices over direct payments to farmers. We did not find clear differences in the preferences for particular examples of other instruments. We therefore applied our model results to all policy instrument examples in the respective categories except for market-based subsidies. In the case of regulatory or cooperative instruments, the instrument preferences of some actor types clearly differed. For example, interest groups were more likely to prefer cooperative policies than administrative actors. We explain this result by stating that voluntary industry agreements allow interest groups to have more influence on policy design than other instruments (Metz and Leifeld 2018). Moreover, science actors were less likely to prefer additional pesticide approval requirements than administrative actors. One explanation for this finding could be that scientists criticize the pesticide approval process, particularly the decision-making process after risk assessment, for not being transparent (Hunka et al. 2015). Our findings are consistent with those of Bolognesi et al. (2024): The role of the actor type in policy instrument preferences depends on the policy instrument. Finally, the fact that we did not find a relationship between the preferences of actors and those of their collaboration partners may be attributable to the institutionalized context. In the Swiss federal democracy, evaluations to prepare new policies are highly institutionalized, and the relevant information is made available to all actors (Varone and Ingold 2023). Functional interdependencies and rules for consensus decision-making also support collaboration between opposing actors. If the information does not match one's policy core beliefs or instrument preferences, this can be a barrier to the systematic uptake of the information (Hofmann et al. 2023). Consequently, actors might strategically use the information from collaboration partners to advocate for their instrument preferences instead of adjusting them based on the received information.

Conclusion

Various policy instruments can be used to address pressing sustainability problems such as the use of pesticides in agriculture. For successful implementation of new instruments, a majority of relevant actors must support these instruments. Support is negotiated but driven by individual instrument preferences. A better understanding of these preferences is thus key to anticipating potential conflicts and finding broadly supported policy instruments for solving the problems we face. The aim of this study was to shed light on actors' instrument preferences, and to explain differences therein in the context of sustainability problems. In this context, when forming instrument preferences, actors must navigate trade-offs between satisfying different policy core beliefs, which is also a risky endeavor due to uncertainty about policy consequences.

We found that not only the relative importance of specific policy core beliefs but also domain-specific risk attitudes are relevant to explain why actors display different preferences for policy instruments. So far, domain-specific risk attitudes have been less explored in policy studies, but our study shows that they can play a decisive role in forming preferences for more stimulative and coercive policy instruments (e.g., subsidy, contract, or order). Our explanation is that risk attitudes become more relevant as the uncertainty and severity of consequences of instruments for satisfying policy core beliefs increase. Based on our study findings, we argue that modeling policy instrument preferences without considering the actors' risk attitudes in addition to the relative importance of policy core beliefs is inadequate. The relative importance of policy core beliefs reflects the evaluation of trade-offs between conflicting consequences of policy instruments. The risk attitudes capture actors' responses to uncertain consequences in a specific domain. In the case of Swiss pesticide risk reduction policy, for example, it seems important to consider the relative importance of policy core beliefs and risk attitudes regarding objectives related to agricultural workload, protection of non-target organisms and water bodies, food security, economic viability of farming, innovation potential in crop protection, and cost fairness, as these beliefs and attitudes were relevant for the actors' instrument preferences.

Our findings are relevant to most sustainability problems, which come with conflicting policy core beliefs and uncertainty about policy consequences, and where any policy choice inevitably involves making trade-offs and dealing with risks. However, further research exploring the relationship between policy core beliefs and risk attitudes in preference formation is necessary. Particularly, the observed pattern between the coerciveness and repressiveness of policy instruments and the role of actors' risk attitudes needs further empirical verification. Our Bayesian framework allowed studying the individual role of specific policy core beliefs and risk attitudes in a complex decision context based on a quite small data sample. But our results need to be confirmed in other cases.

Our study contributes to a better understanding of policy instrument preference formation through an innovative combination of the ACF from policy studies and MAUT from MCDA. The role of policy core beliefs and risk attitudes for policy instrument preferences under conflicting beliefs and uncertainty are undertheorized in the ACF (Kammermann and Angst 2021; Weible et al. 2020). MAUT complements the ACF theoretically in terms of how actors evaluate trade-offs and deal with conflicting policy core beliefs, how they respond to uncertainty with domain-specific risk attitudes, and how these evaluations and responses are translated into preferences for policy instruments. Moreover, our adapted MCDA tools to elicit the relative importance of policy core beliefs and actors' risk attitudes could be an interesting methodological contribution to policy studies. Our theoretical and methodological approaches can be applied to other sustainability problems to assess instrument preferences and find instruments with the potential for sustainable policy transition.

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Data Availability Statement. Replication materials are available in the *Journal of Public Policy* Dataverse at https://doi.org/10.7910/DVN/MVVXPF

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References

Agresti, Alan. 2010. "*Analysis of Ordinal Categorical Data*." 2nd ed, Wiley Series in Probability and Statistics. Hoboken: John Wiley & Sons, Inc.

Andrews, Clinton J. 2007. "Rationality in Policy Decision Making." In *Handbook of Public Policy Analysis: Theory, Politics, and Methods*, eds. Fischer, Frank and Miller, Gerald J., 1st ed., 161–71. New York: Routledge.

Bakker, Lieneke, Wopke van der Werf, Pablo Tittonell, Kris A.G. Wyckhuys, and Felix J.J.A. Bianchi. 2020. "Neonicotinoids in Global Agriculture: Evidence for a New Pesticide Treadmill?" *Ecology and Society*. **25** (3): 26. doi: 10.5751/ES-11814-250326

Beinat Euro.. 1997. "Value functions for environmental management." In *Value Functions for Environmental Management*, ed. Beinat, Euro., 77–106. Dordrecht: Springer Netherlands..

Bolognesi, Thomas, Eva Lieberherr, and Manuel Fischer. 2024. "Identifying and Explaining Policy Preferences in Swiss Water Management." *Policy & Politics*. **52** (3): 384–411. doi: 10.1332/03055736Y2023D000000004

Bürkner, Paul-Christian. 2017. "brms: An R Package for Bayesian Multilevel Models Using stan." *Journal of Statistical Software*. **80** (1): 1–28. doi: 10.18637/jss.v080.i01

Bürkner, Paul-Christian. 2018. "Advanced Bayesian Multilevel Modeling with the R Package brms." *The R Journal*. **10** (1): 395–411. doi: 10.32614/RJ-2018-017

Bürkner, Paul-Christian and Matti Vuorre. 2019. "Ordinal Regression Models in Psychology: A Tutorial." *Advances in Methods and Practices in Psychological Science*. **2** (1): 77–101. doi: 10.1177/2515245918823199

Candel, Jeroen, Guy Pe'er, and Robert Finger. 2023. "Science Calls for Ambitious European Pesticide Policies." *Nature Food*. **4** (4): 272–272. doi: 10.1038/s43016-023-00727-8

Chagnon, Madeleine, David Kreutzweiser, Edward A. D. Mitchell, Christy A. Morrissey, Dominique A. Noome, and Jeroen P. Van der Sluijs 2015. "Risks of Large-Scale Use of Systemic Insecticides to Ecosystem Functioning and Services." *Environmental Science and Pollution Research*. **22** (1): 119–134. doi: 10.1007/s11356-014-3277-x

Dermont, Clau, Karin Ingold, Lorenz Kammermann, and Isabelle -SteffenStadelmann. 2017. "Bringing the Policy Making Perspective in: A Political Science Approach to Social Acceptance." *Energy Policy*. **108**: 359–368. doi: 10.1016/j.enpol.2017.05.062

Dietz, Thomas, Amy Dan, and Rachael Shwom. 2007. "Support for Climate Change Policy: Social Psychological and Social Structural Influences." *Rural Sociology*. **72** (2): 185–214. doi: 10.1526/003601107781170026

Eisenführ, Franz, Thomas Langer, and Martin Weber. 2010. "*Rational Decision Making*." Berlin, Germany: Springer.

Finger, Robert. 2021. "No Pesticide-Free Switzerland." *Nature Plants*. **7** (10): 1324–1325. doi: 10.1038/s41477-021-01009-6

Finger, Robert, Niklas Möhring, Tobias Dalhaus, and Thomas Böcker. 2017. "Revisiting Pesticide Taxation Schemes." *Ecological Economics*. **134**: 263–266. doi: 10.1016/j.ecolecon.2016.12.001

French, Simon and Nikolaos Argyris. 2018. “Decision Analysis and Political Processes.” *Decision Analysis.* **15** (4): 208–222. doi: 10.1287/deca.2018.0374

Gabry, Jonah, Daniel Simpson, Aki Vehtari, Michael Betancourt, and Andrew Gelman. 2019. “Visualization in Bayesian Sorkflow.” *Journal of the Royal Statistical Society: Series A (Statistics in Society).* **182** (2): 389–402. doi: 10.1111/rssa.12378

Geels, Frank W. 2010. “Ontologies, Socio-Technical Transitions (to Sustainability), and the Multi-Level Perspective.” *Research Policy.* **39** (4): 495–510. doi: 10.1016/j.respol.2010.01.022

Glaus, Anik. 2021. “Politics of flood risk management in Switzerland: Political feasibility of instrument mixes.” *Environmental Policy and Governance.* **31** (5): 492–519. doi: 10.1002/eet.1940

Glaus, Anik, Markus Mosimann, Veronika Röthlisberger, and Karin Ingold. 2020. “How Flood Risks Shape Policies: Flood Exposure and Risk Perception in Swiss Municipalities.” *Regional Environmental Change.* **20** (4): 120. doi: 10.1007/s10113-020-01705-7

Glaus, Anik, Ruth Wiedemann, and Laurence Brandenberger. 2022. “Toward Sustainable Policy Instruments: Assessing Instrument Selection among Policy Actors.” *Journal of Environmental Planning and Management.* **65** (9): 1708–1726. doi: 10.1080/09640568.2021.1944847

Graczyk, Halshka, Nancy Hopf, Zakia Mediouni, Irina Guseva Canu, Olivier Sanvido, Kaspar Schmid, and Aurélie Berthet. 2018. “Occupational Exposure to Plant Protection Products and Health Effects in Switzerland: What Do We Know and What Do We Need to Do?” *Swiss Medical Weekly.* **148**: 1–9. doi: 10.4414/smw.2018.14610

Gregory, Robin and Katharine Wellman. 2001. “Bringing stakeholder values into environmental policy choices: a community-based estuary case study.” *Ecological Economics.* **39** (1): 37–52. doi: 10.1016/S0921-8009(01)00214-2

Griggs, Steven. 2007. “Rational Choice in Public Policy: The Thory in Critical Perspectives.” In *Handbook of Public Policy Analysis: Theory, Politics, and Methods*, eds. Fischer, Frank and Miller, Gerald J., 1st ed., 173–85. New York: Routledge..

Hoffmann-Lange, Ursula. 2018. “Methods of Elite Identification.” In *The Palgrave Handbook of Political Elites*, eds. Best, Heinrich and Higley, John., 79–92. London: Palgrave Macmillan.

Hofmann, Benjamin, Karin Ingold, Christian Stamm, Priska Ammann, Rik I. L. Eggen, Robert Finger, Samuel Fuhrimann, Judit Lienert, Jennifer Mark, Chloe McCallum, et al. 2023. “Barriers to Evidence Use for Sustainability: Insights from Pesticide Policy and Practice.” *Ambio.* **52**: 425–439. doi: 10.1007/s13280-022-01790-4

Howlett, Michael. 2004. “Beyond Good and Evil in Policy Implementation: Instrument Mixes, Implementation Styles, and Second Generation Theories of Policy Instrument Choice.” *Policy and Society.* **23** (2): 1–17. doi: 10.1016/S1449-4035(04)70030-2

Huber, Robert, Nadja Benni El, and Robert Finger. 2024. “Lessons Learned and Policy Implications from 20 Years of Swiss Agricultural Policy Reforms: A Review of Policy evaluations.” *Bio-Based and Applied Economics.* **13** (2): 121–146. doi: 10.36253/bae-14214

Huber, Robert and Robert., Finger. 2019. “Popular Initiatives Increasingly Stimulate Agricultural Policy in Switzerland.” *EuroChoices.* **18** (2): 38–39. doi: 10.1111/1746-692X.12209

Hüesker, Frank and Robert Lepenies. 2022. “Why Does Pesticide Pollution in Water Persist?” *Environmental Science & Policy.* **128**: 185–193. doi: 10.1016/j.envsci.2021.11.016

Humann-Guilleminot, Ségolène, Łukasz J. Binkowski, Lukas Jenni, Gabriele Hilke, Gaétan Glauser, and Fabrice Helfenstein. 2019. “A Nation-Wide Survey of Neonicotinoid Insecticides in Agricultural Land with Implications for Agri-environment Schemes.” *Journal of Applied Ecology.* **56** (7): 1502–1514. doi: 10.1111/1365-2664.13392

Hunka, Agnieszka. D., Mattia Meli, Annemette Palmqvist, Pernille Thorbek, and Valery E. Forbes 2015. “Ecological Risk Assessment of Pesticides in the EU: What Factors and Groups Influence Policy Changes?” *Journal of Risk Research.* **18** (9): 1165–1183. doi: 10.1080/13669877.2014.913663

Ingold, Karin. 2011. “Network Structures within Policy Processes: Coalitions, Power, and Brokerage in Swiss Climate Policy.” *Policy Studies Journal.* **39** (3): 435–459. doi: 10.1111/j.1541-0072.2011.00416.x

Ingold, Karin, Peter P. J. Driessen, Hens A. C. Runhaar, and Alexander Widmer. 2019. “On the Necessity of Connectivity: Linking Key Characteristics of Environmental Problems with Governance Modes.” *Journal of Environmental Planning and Management.* **62** (11): 1821–1844. doi: 10.1080/09640568.2018.1486700

Ingold, Karin, Eva Lieberherr, Isabelle Schläpfer, Karin Steinmann, and Willi Zimmermann. 2016. "*Umweltpolitik der Schweiz. Ein Lehrbuch*" [Environmental policy in Switzerland. A textbook]. Zürich, St. Gallen: Dike Verlag AG.

Ingold, Karin, Isabelle Stadelmann-Steffen, and Lorenz Kammermann. 2019. "The Acceptance of Instruments in Instrument Mix Situations: Citizens' Perspective on Swiss Energy Transition." *Research Policy*. **48** (10): 103694. doi: 10.1016/j.respol.2018.10.018

Jacobs, Alan M.. 2008. "How Do Ideas Matter? Mental Models and Attention in German Pension Politics." *Comparative Political Studies*. **42** (2): 252–279. doi: 10.1177/0010414008325283

Jenkins-Smith, Hank C., Daniel Nohrstedt, Christopher M. Weible, and Karin Ingold. 2017. "The Advocacy Coalition Framework: An Overview of the Research Program." *Theories of the Policy Process*. **4**: 135–171. doi: 10.4324/9780429494284-5

Kaiser, Antonia and Paul Burger. 2022. "Understanding Diversity in Farmers' Routinized Crop Protection Practices." *Journal of Rural Studies*. **89**: 149–160. doi: 10.1016/j.jrurstud.2021.12.002

Kammermann, Lorenz and Mario Angst. 2021. "The Effect of Beliefs on Policy Instrument Preferences: The Case of Swiss Renewable Energy Policy." *Policy Studies Journal*. **49** (3): 757–784. doi: 10.1111/psj.12393

Karimo, Aasa, Paul M. Wagner, Ana Delicado, James Goodman, Antti Gronow, Myanna Lahsen, Tze-Luen Lin, Volker Schneider, Keiichi Satoh, Luisa Schmidt, et al. 2023. "Shared Positions on Divisive Beliefs Explain Interorganizational Collaboration: Evidence from Climate Change Policy Subsystems in 11 Countries." *Journal of Public Administration Research and Theory*. **33** (3): 421–433. doi: 10.1093/jopart/muac031

Keeney, Ralph L. 2006. "Eliciting knowledge about values for public policy decisions." *International Journal of Information Technology & Decision Making*. **05** (04): 739–749. doi: 10.1142/S0219622006002295

Keeney, Ralph L. 1982. "Decision Analysis: An Overview." *Operations Research*. **30** (5): 803–838. doi: 10.1287/opre.30.5.803

Keeney, Ralph L. and Howard Raiffa. 1993. "*Decisions with Multiple Objectives: Preferences and Value Tradeoffs*." Cambridge: Cambridge University Press.

Kiefer, K., T. Bader, N. Minas, E. Salhi, E. M. L. Janssen, U. Guntenvon, and J. Hollender 2020. "Chlorothalonil Transformation Products in Drinking Water Resources: Widespread and Challenging to Abate." *Water Research*. **183**: 11. doi: 10.1016/j.watres.2020.116066

Koppenjan, Joop and Erik-Hans., Klijn. 2004. *Managing Uncertainties in Networks: A Network Approach to Problem Solving and Decision Making*. London: Routledge.

Kuller, Martijn, Philipp Beutler, and Judit Lienert. 2023. "Preference Change in Stakeholder Group-Decision Processes in the Public Sector: Extent, Causes and Implications." *European Journal of Operational Research*. **308** (3): 1268–1285. doi: 10.1016/j.ejor.2022.12.001

Lahat, Lihi. 2011. "How Can Leaders' Perceptions Guide Policy Analysis in an Era of Governance?" *Policy Sciences*. **44** (2): 135–155. doi: 10.1007/s11077-010-9119-x

Lee, Rhiannon, Roos Uylden, and Hens Runhaar. 2019. "Assessment of Policy Instruments for Pesticide Use Reduction in Europe: Learning from a Systematic Literature Review." *Crop Protection*. **126**: 104929. doi: 10.1016/j.cropro.2019.104929

Mack, Gabriele, Robert Finger, Jeanine Ammann, and Nadja Benni El . 2023. "Modelling Policies towards Pesticide-Free Agricultural Production Systems." *Agricultural Systems*. **207**: 103642. doi: 10.1016/j.agsy.2023.103642

McGuire, Chad .J.. 2015. The Role of Risk Perception in Building Sustainable Policy Instruments: A Case Study of Public Coastal Flood Insurance in the USA. *Interdisciplinary Environmental Review*. **16** (2–4): 232–252. doi: 10.1504/IER.2015.071013

Metz, Florence and Philip Leifeld. 2018. "Governing Water with Market-Based Instruments: Preferences and Skepticism in Switzerland." In *A Critical Approach to International Water Management Trends: Policy and Practice*, eds. Bréthaut, Christian and Schweizer, Rémi., 147–76. London: Palgrave Macmillan UK.

Metz, Florence, Philip Leifeld, and Karin Ingold. 2019. "Interdependent Policy Instrument Preferences: A Two-Mode Network Approach." *Journal of Public Policy*. **39** (4): 609–636. doi: 10.1017/S0143814X18000181

Metz, Florence, Eva Lieberherr, Aline Schmucki, and Robert Huber. 2021. "Policy Change through Negotiated Agreements: The Case of Greening Swiss Agricultural Policy." *Policy Studies Journal*. **49** (3): 731–756. doi: 10.1111/psj.12417

Möhring, Niklas, Martina Bozzola, Stefan Hirsch, and Robert Finger. 2020a. "Are Pesticides Risk Decreasing? The Relevance of Pesticide Indicator Choice in Empirical Analysis." *Agricultural Economics.* **51** (3): 429–444. doi: 10.1111/agec.12563

Möhring, Niklas and Robert Finger. 2022. "Pesticide-Free but Not Organic: Adoption of a Large-Scale Wheat Production Standard in Switzerland." *Food Policy.* **106**: 102188. doi: 10.1016/j.foodpol.2021.102188

Möhring, Niklas, Sabrina Gaba, and Robert Finger. 2019. "Quantity Based Indicators Fail to Identify Extreme Pesticide Risks." *Science of The Total Environment.* **646**: 503–523. doi: 10.1016/j.scitotenv.2018.07.287

Möhring, Niklas, Karin Ingold, Per Kudsk, Fabrice Martin-Laurent, Urs Niggli, Michael Siegrist, Bruno Studer, Achim Walter, and Robert Finger. 2020b. "Pathways for Advancing Pesticide Policies." *Nature Food.* **1** (9): 535–540. doi: 10.1038/s43016-020-00141-4

Montibeller, Gilberto and Detlof von Winterfeldt. 2018. "Individual and Group Biases in Value and Uncertainty Judgments." In *Elicitation: The Science and Art of Structuring Judgement*, eds. Dias, Luis C., Morton, Alec and Quigley, John., 377–92. Cham: Springer International Publishing..

Munda, Giuseppe. 2009. "A Conflict Analysis Approach for Illuminating Distributional Issues in Sustainability Policy." *European Journal of Operational Research.* **194** (1): 307–322. doi: 10.1016/j.ejor.2007.11.061

Pedersen, Anders .Branth, Helle Ørsted Nielsen, and Carsten Daugbjerg. 2020. "Environmental Policy Mixes and Target Group Heterogeneity: Analysing Danish Farmers' Responses to the Pesticide Taxes." *Journal of Environmental Policy & Planning.* **22** (5): 608–619. doi: 10.1080/1523908X.2020.1806047

Reichert, Peter, Simone D. Langhans, Judit Lienert, and Nele Schuwirth. 2015. "The Conceptual Foundation of Environmental Decision Support." *Journal of Environmental Management.* **154**: 316–332. doi: 10.1016/j.jenvman.2015.01.053

Riabacke, Mona, Mats Danielson, and Love Ekenberg. 2012. "State-of-the-Art Prescriptive Criteria Weight Elicitation." *Advances in Decision Sciences* **2012**: 276584. doi: 10.1155/2012/276584

Riedo, Judith, Felix E. Wettstein, Andrea Rösch, Chantal Herzog, Samiran Banerjee, Lucie Büchi, Raphaël Charles, Daniel Wächter, Fabrice Martin-Laurent, Thomas D. Bucheli, et al. 2021. "Widespread Occurrence of Pesticides in Organically Managed Agricultural Soils—the Ghost of a Conventional Agricultural Past?" *Environmental Science & Technology.* **55** (5): 2919–2928. doi: 10.1021/acs.est.0c06405

Rigby, Elizabeth. 2007. "Same Policy Area, Different Politics: How Characteristics of Policy Tools Alter the Determinants of Early Childhood Education Policy." *Policy Studies Journal.* **35** (4): 653–669. doi: 10.1111/j.1541-0072.2007.00241.x

Roberts, Ron and Paul Goodwin. 2002. "Weight Approximations in Multi-Attribute Decision Models." *Journal of Multi-Criteria Decision Analysis.* **11** (6): 291–303. doi: 10.1002/mcda.320

Rosenow, Jan, Florian Kern, and Karoline Rogge. 2017. "The Need for Comprehensive and Well Targeted Instrument Mixes to Stimulate Energy Transitions: The Case of Energy Efficiency Policy. *Energy Research & Social Science.* **33**: 95–104. doi: 10.1016/j.erss.2017.09.013

Sabatier, Paul A. and Hank C. Jenkins-Smith. 1993 "*Policy Change and Learning: An Advocacy Coalition Approach, Theoretical lenses on public policy*." Boulder, USA: Westview Press.

Sabatier, Paul A. and Christopher M. Weible. 2007. "The Advocacy Coalition Framework: Innovations and Clarifications." In *Theories of the policy process*, ed. Sabatier, Paul A., 189–220. Boulder: Westview Press.

Salamon, Lester M. (2002) "*The tools of government: A guide to the new governance*." 1st ed. Oxford, England: Oxford University Press.

Schaub, Sergei, Jaboury Ghazoul, Robert Huber, Wei Zhang, Adelaide Sander, Charles Rees, Simanti Banerjee, and Robert Finger. 2023. "The Role of Behavioural Factors and Opportunity Costs in Farmers' Participation in Voluntary Agri-Environmental Schemes: A Systematic Review." *Journal of Agricultural Economics.* **74** (3): 617–660. doi: 10.1111/1477-9552.12538

Schaub, Sergei, Robert Huber, and Robert Finger. 2020. "Tracking Societal Concerns on Pesticides – a Google Trends Analysis." *Environmental Research Letters.* **15**: 084049. doi: 10.1088/1748-9326/ab9af5

Schmidt, Alena, Gabriele Mack, Anke Möhring, Stefan Mann, and Nadja BenniEl . 2019. "Stricter Cross-Compliance Standards in Switzerland: Economic and Environmental Impacts at Farm- and Sector-Level." *Agricultural Systems.* **176**: 102664. doi: 10.1016/j.agsy.2019.102664

Schneider, Kevin, Jesus HurleBarreiro-, and Emilio CerezoRodriguez-. 2023. "Pesticide Reduction Amidst Food and Feed Security Concerns in Europe." *Nature Food.* **4** (9): 746–750. doi: 10.1038/s43016-023-00834-6

Schulz, Ralf, Sascha Bub, Lara L. Petschick, Sebastian Stehle, and Jakob Wolfram. 2021. "Applied Pesticide Toxicity Shifts toward Plants and Invertebrates, even in GM Crops." *Science.* **372** (6537): 81–84. doi: 10.1126/science.abe1148

Schweizer Bundesrat. 2017. Aktionsplan zur Risikoreduktion und nachhaltigen Anwendung von Pflanzenschutzmitteln. Bericht des Bundesrates [Action plan for risk reduction and sustainable use of plant protection products. Report of the Federal Council]. Bern, Schweiz. Report No.: 554.00/2004/03590 \ COO.2101.101.4.1047154

Schweizer Bundesversammlung. 2019. Parlamentarische Initiative «Risiko beim Einsatz von Pestiziden reduzieren» [Parliamentary initiative "Reducing the risk of pesticide use"] [Pa.Iv. 19.475]. Kommission für Wirtschaft und Abgaben des Ständerats (WAK-S). Bern, Schweiz

Slovic, Paul. 1987. "Perception of Risk." *Science.* **236** (4799): 280–285. doi: 10.1126/science.3563507

Spycher, Simon, Simon Mangold, Tobias Doppler, Marion Junghans, Irene Wittmer, Christian Stamm, and Heinz Singer. 2018. "Pesticide Risks in Small Streams—How to Get as Close as Possible to the Stress Imposed on Aquatic Organisms." *Environmental science & technology.* **52** (8): 4526–4535. doi: 10.1021/acs.est.8b00077

Stehle, Sebastian and Ralf Schulz. 2015. "Agricultural Insecticides Threaten Surface Waters at the Global Scale." *Proceedings of the National Academy of Sciences.* **112** (18): 5750. doi: 10.1073/pnas.1500232112

Tang, Fiona H. M., Manfred Lenzen, Alexander McBratney, and Federico Maggi. 2021. "Risk of Pesticide Pollution at the Global Scale." *Nature Geoscience.* **14** (4): 206–210. doi: 10.1038/s41561-021-00712-5

Tetlock, Philip .E.. 1986. "A Value Pluralism Model of Ideological Reasoning." *Journal of Personality and Social Psychology.* **50** (4): 819–827. doi: 10.1037/0022-3514.50.4.819

Topping, C. J., A. Aldrich, and P. Berny. 2020. "Overhaul Environmental Risk Assessment for Pesticides." *Science.* **367** (6476): 360. doi: 10.1126/science.aay1144

Tsoukias, Alexis, Gilberto Montibeller, Giulia Lucertini, and Valerie Belton. 2013. "Policy Analytics: an Agenda for Research and Practice." *EURO Journal on Decision Processes.* **1** (1): 115–134. doi: 10.1007/s40070-013-0008-3

van der Doelen, Frans. CJ. 1998. "The "give-and-take" packaging of policy instruments: optimizing legitimacy and effectiveness." In *Carrots, sticks and sermons*, eds. Bemelmans-Videc, Marie-Louise, Rist, Ray C and Vedung, Evert, 129–46. Routledge.

Varone, Frédéric and Karin Ingold. 2023. "Switzerland, Public Policy in." In *Encyclopedia of Public Policy*, eds. van Gerven, Minna, Rothmayr Allison, Christine and Schubert, Klaus 1–10. Cham: Springer.

Verlynde, Nicolas, Louinord Voltaire, and Philippe Chagnon. 2019. "Exploring the Link between Flood Risk Perception and Public Support for Funding on Flood Mitigation Policies." *Journal of Environmental Planning and Management.* **62** (13): 2330–2351. doi: 10.1080/09640568.2018.1546676

Weber, Elke. U., Ann-Renée Blais, and Nancy E. Betz. 2002. "A Domain-Specific Risk-Attitude Scale: Measuring Risk Perceptions and Risk Behaviors." *Journal of Behavioral Decision Making.* **15** (4): 263–290. doi: 10.1002/bdm.414

Weber, Elke. U. and Richard A. Milliman. 1997. "Perceived Risk Attitudes: Relating Risk Perception to Risky Choice." *Management Science.* **43** (2): 123–144. doi: 10.1287/mnsc.43.2.123

Weible, Christopher M., Karin Ingold, Daniel Nohrstedt, Adam Douglas Henry, and Hank C., Jenkins-Smith. 2020. "Sharpening Advocacy Coalitions." *Policy Studies Journal.* **48** (4): 1054–1081. doi: 10.1111/psj.12360

Weimer, David L. and Aidan R. Vining. 2017. "*Policy analysis : concepts and practice.*" Six edition. ed. Boca Raton, FL: Routledge, an imprint of Taylor and Francis.

Wiedemann, Ruth. 2022. "To Intervene or Not to Intervene: Potential for Targeted Pesticide Policy in Uganda." *Environmental Science & Policy.* **129**: 168–178. doi: 10.1016/j.envsci.2022.01.003

Wiget, Milena. 2024. "Does (Dis)agreement Reflect Beliefs? An Analysis of Advocacy Coalitions in Swiss Pesticide Policy." *European Policy Analysis.* **10** (4): 488–514. doi: 10.1002/epa2.1219

Wiget, Milena, Judit Lienert, and Karin Ingold. 2025. "Replication Data for: Understanding Policy Instrument Preferences under Conflicting Beliefs and Uncertainty», https://doi.org/10.7910/DVN/MVVXPF, Harvard Dataverse, V1, UNF:6:lfoMCm0B9S3KvcLHdiYxCw==

Wuepper, David, Fiona H. M. Tang, and Robert. Finger. 2023. "National Leverage Points to Reduce Global Pesticide Pollution." *Global Environmental Change*. **78**: 102631. doi: 10.1016/j.gloenvcha.2022.102631

Zubrod, Jochen. P., Mirco Bundschuh, Gertie Arts, Carsten A. Brühl, Gwenaël Imfeld, Anja Knäbel, Sylvain Payraudeau, Jes J. Rasmussen, Jason Rohr, Andreas Scharmüller, et al. 2019. "Fungicides: An Overlooked Pesticide Class?" *Environmental Science & Technology*. **53** (7): 3347–3365. doi: 10.1021/acs.est.8b04392

Appendix

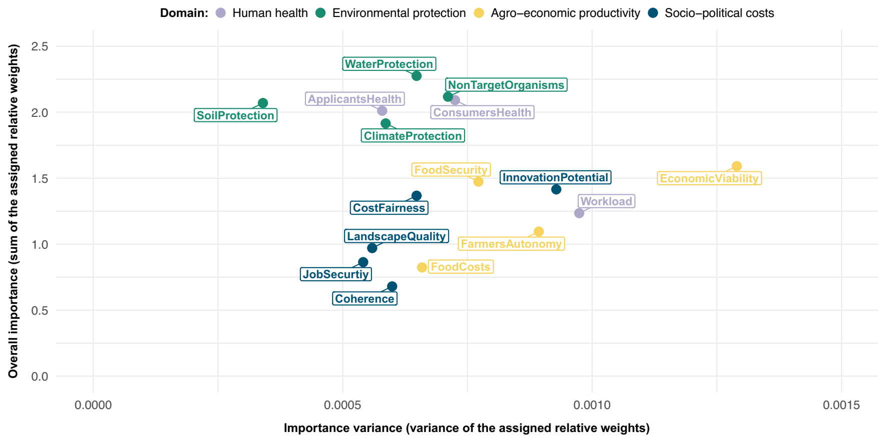

Figure A-1. Variance in the importance of policy core beliefs. The scatter plot illustrates the overall importance (y-axis) and the variance in importance (x-axis) of policy core beliefs across all actors (N = 24). The sum of the relative weights assigned to a policy core belief indicates its overall importance, and the variance of the assigned weights indicates the variance in importance. The policy core beliefs cover the domains of human health (violet), environmental protection (green), agro-economic productivity (yellow), and socio-political costs (dark blue).

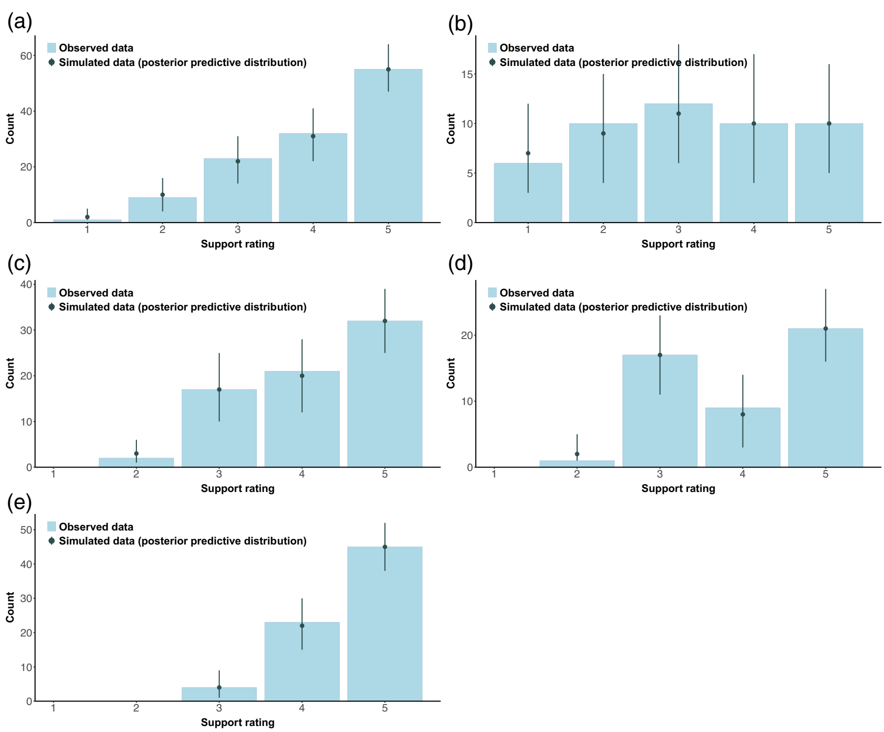

Figure A-2. Posterior predictive checks. The bar plots illustrate how well the data simulated by the Bayesian ordinal logistic regression models for regulatory instruments (A), market-based tax incentives (B), market-based subsidies (C), cooperative instruments (D), and persuasive instruments (E) fitted the observed data.

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Table A-1 Decision-, position-, and reputation-relevant actors in Swiss pesticide risk reduction policy who participated in the survey (S; N = 46) and the workshop (W; N = 24). Administrative actors (AD), science actors (SC), and interest groups (IG) participated in the workshop. The table is adapted from Wiget (2024)

Type	Subtype	Coding	Actor	Abbreviation	Participation
Political Actors	Political party	–	The Centre	Die Mitte	S
		–	FDP.The Liberals	FDP	S
		–	Swiss Green Party	GRÜNE	S
		–	Swiss Green Liberal Party	glp	S
		–	Swiss People's Party	SVP	no
		–	Swiss Social Democratic Party	SP	S
	Initiative committee	–	Association for a Switzerland without Synthetic Pesticides	Future3	S
		–	Association for Clean Water for All	Sauberes Wasser für alle	no
	Executive government	–	The Federal Council	BR	no
	Executive agency	–	Federal Department of Economic Affairs, Education, and Research	WBF	no
		–	Federal Department of the Environment, Transport, Energy, and Communications	UVEK	no
		–	Federal Department of Home Affairs	EDI	no
		AD	Federal Office for Agriculture	BLW	S/W
		AD	Federal Office for the Environment	BAFU	S/W
		AD	Federal Food Safety and Veterinary Office	BLV	S/W
		–	Federal Office of Public Health	BAG	no
		AD	State Secretariat for Economic Affairs	SECO	S/W
		–	Inter-cantonal Association for Employee Protection	IVA	S
		AD	Conference of the Heads of the Environmental Offices of Switzerland	KVU	S/W
		–	Conference of the Agricultural Offices of Switzerland	KOLAS	S
		–	Conference of Commissioners for nature and landscape conservation	KBNL	no
		AD	Cantonal of the Cantonal Plant Protection Services	KPSD	S/W
		–	Association of Cantonal Chemists of Switzerland	VKCS	S
Economic Actors	Trade association	IG	Swiss Farmers' Union	SBV	S/W
		IG	Umbrella organization of the Swiss beekeeper associations	apisuisse	S/W
		–	Swiss Grain Producers Association	SGPV	S
		–	Swiss Sugar Beet Growers Association	SVZ	S
		IG	Association of Swiss Potato Producers	VSKP	S/W
		IG	Swiss Fruit Association	SOV	S/W

(Continued)

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Table A-1 (*Continued*)

Type	Subtype	Coding	Actor	Abbreviation	Participation
		IG	Swiss Association for Sustainable Development in Viticulture	VITISWISS	S/W
		–	Association of Swiss Vegetable Producers	VSGP	S
		IG	Swiss Association of Integrated Producing Farmers	IP-Suisse	S/W
		IG	Association of Swiss Organic Agriculture Organizations	BioSuisse	S/W
		IG	Business Association Chemistry Pharma Life Sciences	scienceindustries	S/W
		–	Swiss Association for Agricultural Technology	SVLT	S
		–	Federation of Swiss Food Industries	fial	S
		–	Swiss Fishery Association	SFV	S
		IG	Swiss Gas and Water Association	SVGW	S/W
		IG	Association of Swiss Wastewater and Water Protection Professionals	VSA	S/W
	Retailer	–	Coop Group Cooperative	Coop	S
		–	Migros Cooperative	MGB	S
Non-Profit Actors	Consumer organization	IG	Foundation for Consumer Protection	SKS	S/W
	Environmental organization	IG	Swiss Nature Conservation Organization	ProNatura	S/W
		–	World Wide Fund for Nature Switzerland	WWF	S
		–	Swiss Bird Protection Association	BirdLife	S
	Agricultural expert	–	Association for sustainable, economically strong, multifunctional rural agriculture in Switzerland	Vision Landwirtschaft	S
		IG	Swiss Association for the Development of Agriculture and Rural Areas	Agridea	S/W
		–	Advisory Service for Accident Prevention in Agriculture	BUL	S
	Scientific institute	SC	Research Institute of Organic Agriculture	FiBL	S/W
		SC	Swiss excellence center for agricultural research	Agroscope	S/W
		SC	Swiss Centre for Applied Human Toxicology	SCAHT	S/W
		SC	Swiss Federal Institute of Aquatic Science and Technology	Eawag	S/W
		SC	Swiss competence center for applied, practice-oriented ecotoxicology	Oekotoxzentrum	S/W
		–	Swiss Academy of Sciences	SCNAT	S

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Table A-2. Result of the Bayesian ordinal logistic regression models for regulatory, market-based, cooperative, and persuasive instruments. The table includes the model estimates for the intercepts and parameters of the explanatory (CB: policy core beliefs; RA: risk attitudes) and control variables (CPSI: collaboration partner support index; actor type: science actors (SC), interest groups (IG); policy instrument specificity) with the upper and lower limits of the 95% credibility interval (CI).

	Regulatory Instruments			Market-Based Tax Incentives			Market-Based Subsidies			Cooperative Instruments			Persuasive Instruments		
Parameter	Estimate (est. error)	Lower 95% CI	Upper 95% CI	Estimate (est. error)	Lower 95% CI	Upper 95% CI	Estimate (est. error)	Lower 95% CI	Upper 95% CI	Estimate (est. error)	Lower 95% CI	Upper 95% CI	Estimate (est. error)	Lower 95% CI	Upper 95% CI
Intercept 1	−8.07 (1.37)	−11.08	−5.74	−2.55 (1.29)	−5.11	−0.06	−4.68 (1.13)	−7.06	−2.67	−3.59 (1.74)	−7.19	−3.59	−3.95 (1.44)	−6.98	−1.26
Intercept 2	−5.02 (0.84)	−6.7	−3.42	−0.71 (1.19)	−3.06	1.65	−1.04 (0.81)	−2.67	0.5	1.19 (1.31)	−1.12	1.19	−0.49 (1.27)	−3.02	2.01
Intercept 3	−2.56 (0.74)	−4.1	−1.13	1.04 (1.19)	−1.29	3.43	1 (0.81)	−0.61	2.54	2.55 (1.34)	0.2	2.55	–	–	–
Intercept 4	0.02 (0.68)	−1.34	1.32	2.75 (1.23)	0.35	5.19	–	–	–	–	–	–	–	–	–
CB (Health)	0.03 (0.21)	−0.38	0.44	0.35 (0.27)	−0.19	0.91	0.28 (0.23)	−0.17	0.73	0.69 (0.32)	0.1	1.35	0.31 (0.3)	−0.27	0.9
CB (Env)	0.48 (0.11)	0.26	0.71	0.11 (0.16)	−0.19	0.42	−0.12 (0.16)	−0.46	0.18	0.19 (0.23)	−0.21	0.68	0.86 (0.26)	0.4	1.42
CB (Agro)	0 (0.14)	−0.28	0.26	−0.34 (0.19)	−0.72	0.01	0.05 (0.16)	−0.26	0.38	−0.18 (0.22)	−0.62	0.24	0.32 (0.19)	−0.05	0.7
CB (Socio)	−0.08 (0.1)	−0.29	0.11	0.05 (0.14)	−0.22	0.33	0.07 (0.12)	−0.16	0.31	−0.21 (0.15)	−0.52	0.09	0.03 (0.15)	−0.28	0.33
RA (Health)	−0.15 (0.11)	−0.38	0.05	0 (0.11)	−0.23	0.22	0.02 (0.11)	−0.19	0.24	0.47 (0.27)	0.03	1.08	0.17 (0.15)	−0.12	0.47
RA (Env)	0.12 (0.07)	−0.01	0.27	0.07 (0.07)	−0.06	0.2	0.05 (0.06)	−0.07	0.18	−0.17 (0.15)	−0.5	0.07	−0.04 (0.09)	−0.21	0.13
RA (Agro)	0.12 (0.04)	0.03	0.21	0.03 (0.05)	−0.07	0.14	−0.09 (0.05)	−0.19	0	−0.07 (0.07)	−0.21	0.06	−0.06 (0.06)	−0.18	0.05
RA (Socio)	−0.07 (0.03)	−0.12	−0.02	−0.04 (0.03)	−0.1	0.02	0.01 (0.03)	−0.04	0.06	−0.03 (0.04)	−0.11	0.04	0.04 (0.03)	−0.02	0.11
CPSI	0.01 (0.04)	−0.06	0.08	−0.01 (0.03)	−0.07	0.05	−0.06 (0.06)	−0.18	0.05	0.1 (0.09)	−0.06	0.31	−0.02 (0.07)	−0.15	0.11

(*Continued*)

Table A-2. (*Continued*)

Parameter	Regulatory Instruments			Market-Based Tax Incentives			Market-Based Subsidies			Cooperative Instruments			Persuasive Instruments		
	Estimate (est. error)	Lower 95% CI	Upper 95% CI	Estimate (est. error)	Lower 95% CI	Upper 95% CI	Estimate (est. error)	Lower 95% CI	Upper 95% CI	Estimate (est. error)	Lower 95% CI	Upper 95% CI	Estimate (est. error)	Lower 95% CI	Upper 95% CI
Actor Type (SC)	−2.14 (0.84)	−3.81	−0.51	1.76 (1.16)	−0.47	4.16	0.41 (1.01)	−1.63	2.38	2.8 (1.61)	−0.17	6.22	0.69 (1.36)	−1.97	3.45
Actor Type (IG)	−0.62 (0.65)	−1.9	0.65	0.71 (0.94)	−1.09	2.62	0.16 (0.88)	−1.58	1.85	2.85 (1.52)	0.26	6.24	1.67 (1.32)	−0.73	4.46
Policy (LimitValues)	−0.33 (0.64)	−1.58	0.94	–	–	–	–	–	–	–	–	–	–	–	–
Policy (UseRestrictions)	0.6 (0.65)	−0.67	1.93	–	–	–	–	–	–	–	–	–	–	–	–
Policy (ZoneRestrictions)	1 (0.7)	−0.34	2.39	–	–	–	–	–	–	–	–	–	–	–	–
Policy (Ban)	0.97 (0.76)	−0.51	2.47	–	–	–	–	–	–	–	–	–	–	–	–
Policy (TaxUpgrade)	–	–	–	−0.9 (0.65)	−2.21	0.38	–	–	–	–	–	–	–	–	–
Policy (DPfreeProduct)	–	–	–	–	–	–	−0.5 (0.63)	−1.76	0.75	–	–	–	–	–	–
Policy (SubResearch)	–	–	–	–	–	–	2.59 (0.83)	0.98	4.3	–	–	–	–	–	–
Policy (Labels)	–	–	–	–	–	–	–	–	–	−0.2 (0.9)	−1.91	1.6	–	–	–
Policy (EarlyWarning)	–	–	–	–	–	–	–	–	–	–	–	–	−1.13 (0.74)	−2.65	0.28
Policy (Training)	–	–	–	–	–	–	–	–	–	–	–	–	0.61 (0.78)	−0.9	2.12

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