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Tackling wicked problems in agriculture with mission-oriented and transformative innovation policy?

A systematic review and cross-country comparison

by

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Abstract

Using a systematic literature review and cross-country comparison, this thesis investigates the application of mission-driven and transformational innovation policy to address intractable challenges in agriculture. In the domain of agriculture, the theoretical framework encompasses the establishment of innovation policy, wicked problems, and problem-solution space. The thesis assesses the limitations of agricultural innovation policy while confronting wicked problems and explores innovation policy approach and stylised pathways in the agricultural context. The cross-country study focuses on the agricultural policy systems of Germany and Japan and their tactics for tackling intractable problems, contrasting these systems with eleven high-level policies. The research found that there is no one-size-fits-all strategy for determining one pathway is superior than another, and that the effectiveness of the policy approach is dependent on a number of criteria. The study adds to the field by shedding light on the creation of creative policies that can be used to guide future research in this area.

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Introduction

In the recent decade, innovation policy has undergone a normative turn, reflected by the purpose shift in science, technology and innovation (STI) from fostering economic growth to addressing today's global societal challenges, including environmental threats, social demographic, health and wellbeing concerns, as well as the difficulties of generating sustainable and inclusive economic growth (Mazzucato, 2018). These challenges are considered as 'wicked problems' which are deeply rooted in our current societal structures (Wanzenböck et al., 2020) and there is a greater realization that fundamental and sustained reform across society is required to address them (OECD, 2015).

Practices of STI policy have shown that traditional innovation policies and their objectives, tools, and governance structures are insufficient and inadequate for tackling heterogeneous elements of wicked problems (Head, 2018). A next generation has emerged navigating the problem-solution space (Wanzenböck et al., 2020) which notably comprises 'transformative innovation policy' (TIP) and 'mission-oriented innovation policy' (MIP). These are not new concepts but should take into account multiple dimensions of wicked challenges (complexity, uncertainty and value divergence) (Head, 2008) to propose alternative solutions for current crises.

The concept 'transformative innovation policy' (TIP) has arisen in some domains as the new paradigm for innovation policy understanding, and is positioned as a progression from the conventional linear R&D innovation approach (Weber & Rohracher, 2012; Schot & Steinmueller, 2018). The expansion of the policy agenda is one paradigmatic change pertaining to TIP. Rather than simply pursuing the objective of growing the economy, TIP considers not only the rate and magnitude of innovation in social and environmental goals, but also its direction and related normative issues. For some policymakers and policy researchers, this manifests in a call for more mission-oriented policies (MIP), with the goal of progressively transitioning away from the dominating neutral framework policies of the past 30 years (Smits et al., 2010). As acknowledged in the literature on socio-technical transitions, mission-oriented and transformative innovation policy therefore requires fundamental social changes, necessitating not just technology but also institutional and behavioral change (Geels, 2004; Alkemade et al., 2011).

In this context, both scholars and policy makers frequently disregard the complexity and diversity of wicked problems by presenting a 'one-size-fit-all' approach for mission-oriented and transformative innovation policy, with presumptive problem classifications and an overemphasis on technical innovation (Schlaile et al., 2017). This perception of one-size-fit-all design is not maximizing its potential to provide policymakers with useful directionality and/or rationales or cannot consider different geographical and institutional circumstances, or multi-level structures. Mission-oriented and transformative innovation policy as it is now constituted may turn out to be far less successful contributing to addressing wicked problems than many anticipate. As a consequence, the design perspective needs to be more comprehensive which may not provide optimal solutions, but they may at least assist in identifying and avoiding undesirable possibilities such as 'arbitrary', ad hoc, and fraudulent alternatives (Linder and Peters, 1991, p. 149).

It is essential to evaluate the constraints of present agricultural innovation policies in order to identify gaps and deficiencies in current methods to tackling wicked challenges in the agriculture industry. This evaluation may indicate if innovation strategies are suited to address complex, interrelated challenges requiring transformational answers. When recognizing these constraints, policymakers may better comprehend the obstacles to successful policy implementation and propose improvement opportunities.

The problem-solution space idea proposed by Wanzenböck et al. (2020) is a valuable framework for investigating how strategy and design approaches might support mission-oriented and transformational agricultural innovation policy. This approach helps policymakers to evaluate the complexity of wicked issues and develop strategies as well as directionalities that are socially desirable, technically possible, economically viable, and politically acceptable. By adopting this framework, policymakers may guarantee that their innovation policies are planned with a more comprehensive and holistic viewpoint, considering the many aspects of the problem-solution area.

Furthermore, by examining the actual implementation of the problem-solution space idea in the innovation policies of Germany and Japan, this thesis might provide light on the efficacy of these methods in the national context. It can demonstrate how policymakers in these nations have turned these notions into real policy actions. This thesis can assist policymakers with applicable lessons learned and best practices.

The objective can be addressed by the following research questions:

- What are the limitations of the innovation policy in the agricultural sectors in dealing with wicked problems?
- How are strategy and design approaches in problem-solution space productive for mission-oriented and transformative innovation policy in agriculture to tackle wicked problems?
- How are they reflected in the practical innovation policy in the national context of Germany and Japan?

The structure of the thesis is as follows: In chapter 1, the theoretical framework is offered, explaining the development of innovation policy, wicked problems, and problem-solution space, which are utilized to characterize the context and dynamics of agriculture's innovation policy systems. chapter 2 discusses the used methodologies. Chapter 3 evaluates the limitations of agricultural innovation policy while addressing wicked challenges, and then provides innovation policy strategy and direction in the problem-solution area. The emphasis of chapter 4 is on analyzing the set of agricultural innovation policy of Germany and Japan in problem-solution space and then presenting cross-country comparison's findings. The study concludes with some closing observations before discussing the significance of the results for theory and policy in chapter 5.

Chapter 1. Theoretical framework

1.1. Evolution of innovation policy

1.1.1. Historical background and three frames of innovation policy

Innovation policy has emerged over the last decades as a governance instrument to stimulate innovation. The relative novelty of the term 'innovation policy' does not always mean that policies impacting innovation did not exist before. Innovation is an age-old phenomenon, and innovation activity is likely to have been impacted throughout the years by a number of policies implemented under many names which could be 'science policy', 'technological policy' and more recently 'innovation policy' (Boekholt, 2010). The phenomena did not get significant attention from academics until the 1990s, when international institutions such as the OECD (along with multiple international governments) began to take notice.

The historical evolution of innovation policy can be viewed through three distinct frames according to Schot & Steinmueller (2018). Their 'framings' perspective provides a useful point of reference for chronologizing the evolving rationales related to the field of innovation policy which are still relevant in contemporary innovation policy discussions (Fagerberg, 2018; Schot and Steinmueller, 2018b).

The first frame is marked as beginning with the institutionalization of government support for science and R&D in the three decades after World War II, as outlined in the Bush report advocating for the establishment of the National Research Foundation to fund self-directed linear basic research. It is assumed that this will promote economic growth and the private production of new knowledge. The goal is to address market failures, which are defined as the inefficient allocation of resources within markets and may arise when there are too few markets, non-competitive conduct, or non-existence concerns (Boekholt, 2010). This approach to science and research policy is largely embraced in the United States and the United Kingdom, and among other things, it contributed to the development of computers, penicillin, and the atomic bomb. This early wave of innovation strategies is supply-side driven, concentrating on the R&D inputs to the economy and society while disregarding the relevance of the demand for technology and innovation and the interactions among the numerous entities participating in the whole 'knowledge chain'. Thus, it was related with linear model

thinking and concentrated, for instance, on public research funding, e.g. transferring ideas and technologies from laboratory shelves to industrial production facilities to be transformed into innovations (Boekholt, 2010, pp.355).

The second frame started in the context of the competitive spirit fostered by globalization in the 1980s and the notion of national innovation systems for the development and commercialization of knowledge. It highlights system flaws such as a lack of collaboration and coordination among the innovation system's many participants. Consequently, the STI policy of this era is centered on developing linkages, clusters, and networks, driving learning among system parts, and fostering entrepreneurship. A more dynamic and complicated model with feedback loops that affects the success of innovations has replaced the linear model (Freeman, 1987; Lundvall, 1995; Nelson, 1993; Edquist, 1997; Klein Woolthuis et al., 2005). Diverse policy actions, including those described in the preceding chapter, include interaction-promoting platforms, educational efforts for absorption capabilities, and entrepreneurial stimulation (Boekholt, 2010, p.341-342; Schot & Steinmueller, 2018). One commonality between the first and second frames is that the social and environmental aspects of innovation are not frequently the central component of the system. In this context, there is a growing understanding that cross-border policy initiatives are necessary to solve urgent societal issues (Boekholt, 2010, p.350).

The third frame with the demand-led focus for transformative changes is aligned with contemporary phenomena in which innovation policies are targeted at addressing societal concerns, such as the Sustainable Development Goals (SDGs) (UN, 2015). This emphasis distinguishes it from the two earlier frames. Policies aimed at transformation, according to Weber & Rohracher (2012), are needed to supplement the market failure and system failure rationales that underpin current innovation policies by addressing the so-called ‘transformation failures’ of directionality, policy coordination, demand-articulation, and reflexivity. This contributed to the rise of 'challenge-led' innovation policy themes such as TIP and MIP, which this thesis investigates. However, designing such innovation policies is a complex process, requiring an in-depth knowledge of the environment of innovation systems and a long-term view that is susceptible to setbacks and failures (Edler & Fagerberg, 2017). Such policies may become more politically contentious than innovation policies have been in the past,

highlighting the need for more reflexivity and competence in innovation policy making at all levels (Edler & Fagerberg, 2017). Schot & Steinmueller (2018) argue that all three frameworks are significant for policymaking, but researching transformative innovation policy possibilities should be prioritized.

1.1.2. Emergence of mission-oriented and transformative innovation policy

As a top priority on policy agenda in global discussion, innovation policy has shifted its focus from pure growth-thinking to sustainable development in order to address 'grand societal concerns' (Weber & Rohracher, 2012; Voegtlin et al., 2021). The driver of this shift can be observed in the arrival of grand challenges in multiple functional domains (e.g. energy, food, mobility etc.) are increasingly paired with and exacerbated by the structural embeddedness of socio-technical systems (Elzen et al., 2004; Grin et al., 2010).

There is a growing recognition that traditional STI policy is insufficient to address persistent grand challenges (Kuhlmann & Rip, 2014). This results in a call for a holistic, fundamental and normative turn (Daimer et al. 2012) that built a foundation for what has been labeled ‘mission-oriented innovation policy’ (MIP) and ‘transformative innovation policy’ (TIP). Regardless of their diverse emphasis, these alternative approaches or 'paradigms' share a renewed interest in directing change to allow purposive innovations (Rabadjieva & Terstriep, 2020).

Transformative innovation policy (TIP) is a concept first used by Steward (2012) and later adopted by Schot & Steinmueller (2018a, 2018b), and Diercks et al. (2019). The TIP topic is ‘seen as layered upon, but not fully replacing, the earlier policy paradigms of science and technology policy and innovation systems policy’ (Diercks et al., 2019, 890). Schot et al. (2018) recognized that TIP is a factor in overcoming the implementation failure of ambitious, challenge-driven policy goals. TIP can serve this role because it provides an integrated and systems-based approach that tackles the Sustainable Development Goals' underlying links and trade-offs (SDGs, set out in the United Nations 2030). It does not regard the SDGs as separate objectives to be completed using a checklist. Schot & Steinmueller (2018) claim that the absence of a technique for socially choosing different development routes, however, points to a failure in policy directionality.

The concept ‘mission-oriented innovation policy’ (MIP) originates from policies of public procurement for innovation (PPI) as a demand-side mechanism in the mitigation of grand challenges (Edquist & Zabala-Iturriagagoitia, 2012). Mazzucato (2016, 2018) is generally credited with popularizing the subject and directing the change in mindset away from technical achievements of type 1 missions of Science & Technology (R&D) policies in the 1940’s (Robinson & Mazzucato, 2019) to 'wicked challenges,' as well as inventing essential MIP concepts of new market development and directionality (Mazzucato, 2018). Taking into account the wickedness[1] of the underlying challenge and the active role of policy in ensuring coordinated action and legitimacy of both problems and innovative solutions across multiple actors, Wanzenböck et al. (2020) define MIP as an orienting policy that begins with the societal problem and focuses on the formulation and implementation of a goal-oriented strategy.

Mission-oriented and transformational innovation policies, in this context, can be regarded as a new age of innovation policy that legitimizes government intervention targeted at altering the directionality of innovation systems toward solving social issues (Boon & Edler, 2018; Kattel & Mazzucato, 2018; Wesseling & Edquist, 2018; Wanzenböck et al., 2019). Particularly, this new generation policy requires fundamental societal reforms, including not only technological but also institutional and behavioral changes (Geels, 2004; Smith & Kern, 2009; Alkemade et al., 2011). In other words, policymakers need to address not just how to get there (which policies to implement), but also basic problems of directionality (what future do we want), legitimacy (why do we want this future, who determines it), and responsibility (transformation by and for whom) (Uyarra et al., 2019, p.2362; Schlaile et al., 2017).

1.2. Wicked problems in agriculture

1.2.1. The concept of wicked problems

During the 1970s, various disciplines saw the emergence of analyses that called attention to the importance of complex policy issues and the unanticipated implications of policy action in areas of risk and uncertainty. These studies revealed widespread discontent with rational-technical methods to decision making, planning, and execution (Head & Alford, 2013). Rittel & Webber (1973, p. 160) pioneers in defining that most major public policy problems are 'wicked' that are inherently resistant to a clear

[1] The wicked problem will be discussed in detail in a subsequent chapter.

definition and an agreed-upon solution. They explain that ‘a great many barriers keep us from perfecting such a planning/governing system: theory is inadequate for decent forecasting; our intelligence is insufficient to our tasks; plurality of objectives held by pluralities of politics makes it impossible to pursue unitary aims; and so on’. These researchers underlined that owing to the absence of a precise definition and the perspectives of all relevant parties during the formulation and solution of the issue, it is challenging to adopt a scientific logical approach in the case of such difficulties.

Rittel and Webber identified ten key features of wicked problems:

1. There is no clear articulation of a wicked issue.

2. Wicked issues have no ‘stopping rule’ (i.e., no definite solution).

3. The solutions are neither true nor false, but rather good or bad.

4. There is neither an instant nor a final test for a solution to a wicked issue.

5. Each (attempted) solution to a wicked problem is a ‘one-shot operation’; the outcomes cannot be easily reversed, and there is no opportunity for trial-and-error learning.

6. Wicked issues do not have an enumerable (or exhaustively specified) collection of feasible solutions, nor a well-defined set of procedures that may be integrated into the plan.

7. Every wicked problem is fundamentally unique.

8. Every wickeds problem might be seen as a symptom of another one.

9. Numerous explanations exist for the presence of a wicked problem

10. The planner has no ‘right to be wrong’ (i.e., the public does not tolerate failed trials).

In summary, societal challenges are ‘wicked’ in the sense that they are difficult, multi-dimensional, systemic, interconnected. Some problems that fit with the definition of wicked problems are climate change, inequality, disruptive migration, political instability, and disease. In the scope of thesis research, I can observe examples of wicked challenges in agri-food sustainability, natural resource limitations and biodiversity loss, enduring poverty in peripheral regions, the expanding obesity epidemic, the use of biotechnology in food and agriculture, and strategies for feeding the next generation while using less resources (BMEL, 2022b; Peters & Pierre, 2014).

Many policy challenges are viewed as wicked problems not because they contain malevolent intent, but because different stakeholders' definitions of the problem and its possible resolution pathway(s) differ. As a result, the processes and outcomes of addressing the original problem may have vicious consequences for some, open up new problems for others that were previously unanticipated, and even lock the system into sub-optimal functioning (Roberts, 2017). Therefore, there are no templates to follow in how to tackle them or no 'one-fit-for-all' approach that disregards the degree of 'wickedness' (Wanzenböck et al., 2020).

1.2.2. Specific characteristics of wicked problems in agricultural sector

As other grand global challenges, many existing problems in the agricultural field are often portrayed as wicked because they are very complicated and resistant to conventional methods of resolution. Wicked problems involve cause-effect relationships, making them difficult to define or address without provoking controversies among stakeholders, and necessitating collaborative action among societal groups with strongly held, contradictory opinions and values (Conklin, 2006; Roberts, 2017; Dentoni et al., 2012; McCALL & Burge, 2016). To obtain better understanding of the wicked nature of problems in this field, scholars typically acknowledged three characteristics of wicked problems in the public policy literature: complexity, uncertainty and value divergence (Head 2008; Alford & Head 2017; Newman & Head 2017).

First, complexity is pointed in the context of collaboration between organizations and multi-level administration (Head & Alford, 2013; Carley & Christie, 2017). This 'problem of many hands' (Thompson, 1980) arises when several actors, policy domains, and governance levels are required to collaborate (Head 2008; Van de Poel et al., 2012). One OECD document characterized trade liberalization in agriculture as wicked primarily because it involved a number of actors and took a long time to resolve (Batie & Schweickhardt, 2010).

Second, uncertainty is viewed as fragmentation and gaps in imperfect information, such as about the risks or harms of action and inaction, the precise link between the causes, effects, and side-effects of a situation, and the limitation of knowledge or evidence among various stakeholders (Van Bueren et al. 2003; Newman & Head 2017). This can be understood that a provisional resolution relies on the direction of approach for discovering the resolution, resulting in the emergence of new interconnected issues that

must be controlled (Rittel & Webber, 1973). In the current agricultural context, studies on the use of foresight information in farming remain relatively scarce, and farmers face a difficult position in the market as they are usually caught between stronger players (Micheels & Gow, 2012), despite the fact that farmers face challenges in many forms, such as 'changes in natural, technological, economic, political, and social environments' (Malcolm, 2011).

Third, contestation refers to multiple interests and values of stakeholders. The existence of competing claims, values, and framings, as well as the inherent conflicts of interest that emerge from social pluralism and stakeholder diversity (Hoppe 2011; Alford & Head 2017), are all considered as root causes of divergence. For example, extensification as a solution to agricultural pollution and biodiversity loss will create new issues with agricultural production, trade balance, agricultural incomes, and subsidy budgets. If these four issues are resolved via simple intensification, the environmental impacts will be far worse. Sustainable intensification (Godfray & Garnett, 2014), which combines the features of extensification and intensification, will increase complexity and regulatory load to show sustainability. Excluding this sustainability rule would leave the definition of the bargaining process up to the food system's stakeholders, resulting in the perpetuation and escalation of argumentative loops between competing frames (Candel et al., 2014).

As such, 'wicked problems' refer to issues which are highly complex, have innumerable and undefined causes, and are difficult to understand and frame. They result in outcomes that are either uncertain or unknowable, and often create controversies among stakeholders and require collective action among societal groups with strongly held, conflicting beliefs and values (Dentoni et al., 2012; McCALL & Burge, 2016) throughout the agri-food system and beyond. Thus, wicked problems cannot be resolved through finding 'right answers' or 'solutions' (Conklin, 2006; Roberts, 2017), but rather, they must be managed.

1.3. The problem-solution space

In an effort to operationalize a mission-oriented perspective on innovation and addressing societal challenges, Wanzenböck et al. (2020) outlined a problem-solution space: divergence on both the problem and solutions is characterized as 'disorientation,' whereas convergence on both the problem and solutions is characterized as 'alignment'

(Wanzenböck et al. 2020; see Table 1). In this regard, the authors emphasize the many types of interaction between difficulties and their related missions. This framework illustrates a variety of ideal constellations owing to the varying degrees of wickedness shown by both issues and solutions, by classifying them in accordance with their levels of contestation, complexity, and uncertainty.

The level of complexity in implementing MIPs may be high, particularly when coordinating policies across several scales, dimensions, policy domains, and sectors. For example, implementing sustainable agricultural techniques may include modifications to production, distribution, and marketing systems, as well as changes to current legislation and incentives. This may lead to a substantial governance effort that may be difficult to complete without efficient cooperation among many parties.

The level of uncertainty in implementing MIPs is determined by the availability of common knowledge about a specific problem or solution. This involves understanding the reasons and consequences of a certain activity. Farmers who are unfamiliar with new agricultural methods, for example, may be skeptical of their implementation. This might cast doubt on the feasibility of such solutions, undermining their validity.

The level of contestation in implementing MIPs is determined by the extent of conflicting claims, values, and conflicts of interest among various stakeholders. This might happen when there are opposing viewpoints on the feasibility of solutions or the relevance of issues. Certain stakeholders, for example, may object to the implementation of new agricultural techniques owing to perceived costs or hazards.

According to the concept, MIP is effective when issues and solutions are well-aligned, resulting in less contestation, complexity, and ambiguity. The concept of matching issues and solutions is not novel; it has been presented in various forms in the literature on innovation policy (Lieberman, 2002; Truffer et al., 2008; Felin & Zenger, 2014) Since many of the social concerns that must be addressed are complex and interrelated, the concept of matching problems and solutions is especially pertinent in the context of MIP. To accomplish this alignment, the MIP should be designed with the social and technological features of the particular purpose in mind. This implies that MIP should be adjusted to the specific problems of the situation at hand, while also taking use of current technology solutions to attain the desired results.

Table 1

Problem-solution space to contextualize missions. Establishing alignment on a wicked societal problem is the outcome of widespread identification of a problem (column headings) and consensus on its solutions (row headings).

	Diverging views on the problem	Converging views on the problem
Diverging views on the solution	Disorientation	Problem in search of a solution
Converging views on the solution	Solution in search of problem	Alignment

Chapter 2. Methodology

2.1. Systematic literature review

The thesis provides a systematic literature review (SLR) to select a relevant number of articles to support the theoretical foundation of the TIP and MIP topics regarding their design thinking and strategies for dealing with wicked problems, as well as an analysis of the practice of this topic in the agricultural field within a particular national context.

A SLR is a systematic review of academic research in a certain topic area, employing a structured, reproducible scientific approach (Tranfield et al., 2003). Hence, this systematic method to assess academic literature has significant benefits and is gaining popularity in the social sciences, since a systematic approach boosts the credibility of the performed study and, subsequently, the validity of assertions being made (Gough et al. 2012). This SLR follows the guidelines of Petticrew & Roberts (2006) and includes both scientific and gray literature published from 2000 to 2022.

2.2. Country selection

The nations considered for the cross-country comparison of the thesis are Germany and Japan. With modern technology, creative techniques, and complex supply networks, they are widely recognized as pioneers in agriculture and innovation, whose policies and practices often present as models for other countries to follow.

Both nations confront various wicked problems in their agricultural sectors such as climate change, water shortage and soil degradation. Yet, Germany and Japan have taken diverse approaches to addressing these obstacles, which may provide insights for cross-national policy transfer. By examining these two nations, I may obtain insight into the efficacy of various methods to solving wicked problems in agriculture and how these approaches can be categorized according to problem-solution space paths.

In addition, the cultural and institutional backgrounds of these nations may influence the implementation and consequences of agricultural innovation initiatives, giving a rich environment for examination.

2.3. Relevant assessment

2.3.1. Scientific literature criteria

There was another round of reading and evaluating whole articles based on the original set of inclusion and exclusion criteria.

Inclusion criteria

The paper had to (1) address or attempt to conceptualize 'transformative innovation policy' and/or 'mission-oriented innovation policy', (2) discuss the innovation policy in agriculture and (3) be written in English

Exclusion criteria

The paper (1) merely pointed to 'transformative innovation policy' and/or 'mission-oriented innovation policy' in passing or (2) provided no insights on innovation policy or (3) analyze innovation policy in other fields rather than agriculture or (4) not analyze innovation policy in selected countries of the thesis (Germany and Japan).

2.3.2. Policy evaluation criteria

This evaluation of policies was based on precise preliminary criteria:

(1) Be high-level policy and law in the national context

(2) Enacted since 2015 to guarantee that the foresight actions of various actors happened in a comparable post-Paris Agreement scenario and reflect the current situation of the actor presenting the vision;

(3) Relevance to the wicked problem: be directly related to addressing the wicked problem at hand, and there should be evidence to support its effectiveness in addressing the problem;

(4) Innovative approach: incorporate a new and innovative approach that has the potential to address the wicked problem in a transformative way;

(5) Stakeholder involvement: involve a broad range of stakeholders, probably including farmers, industry, academia, and government, to ensure that the problem is effectively addressed;

(6) Feasibility: be practical in regards to implementation, funding, and political support.

2.4. Process of publication collection

The procedure for data collection was represented schematically in Figure 1. First of all, an initial assessment of the literature was proposed from the glance at papers in Google

Scholar and Scopus to develop search terms. By placing the search terms (‘agriculture’ OR ‘agricultural’ OR ‘mission-oriented’ OR ‘transformative’ AND ‘innovation policy’), the included scientific literature was identified via the document search box in the database Scopus. The system displayed 327 related documents when entering this string. Subtracting from the abstracts, keywords and title identifies which papers are relevant with the thesis topic and are included in the final review list. To dig deeper in the thesis topic, I used the second string of search terms, particularly (‘agricultural policy’ AND ‘wicked problem*’), which resulted 11 related-documents. Continuing to apply the second terms in Google Scholar search to broaden sources in another database.

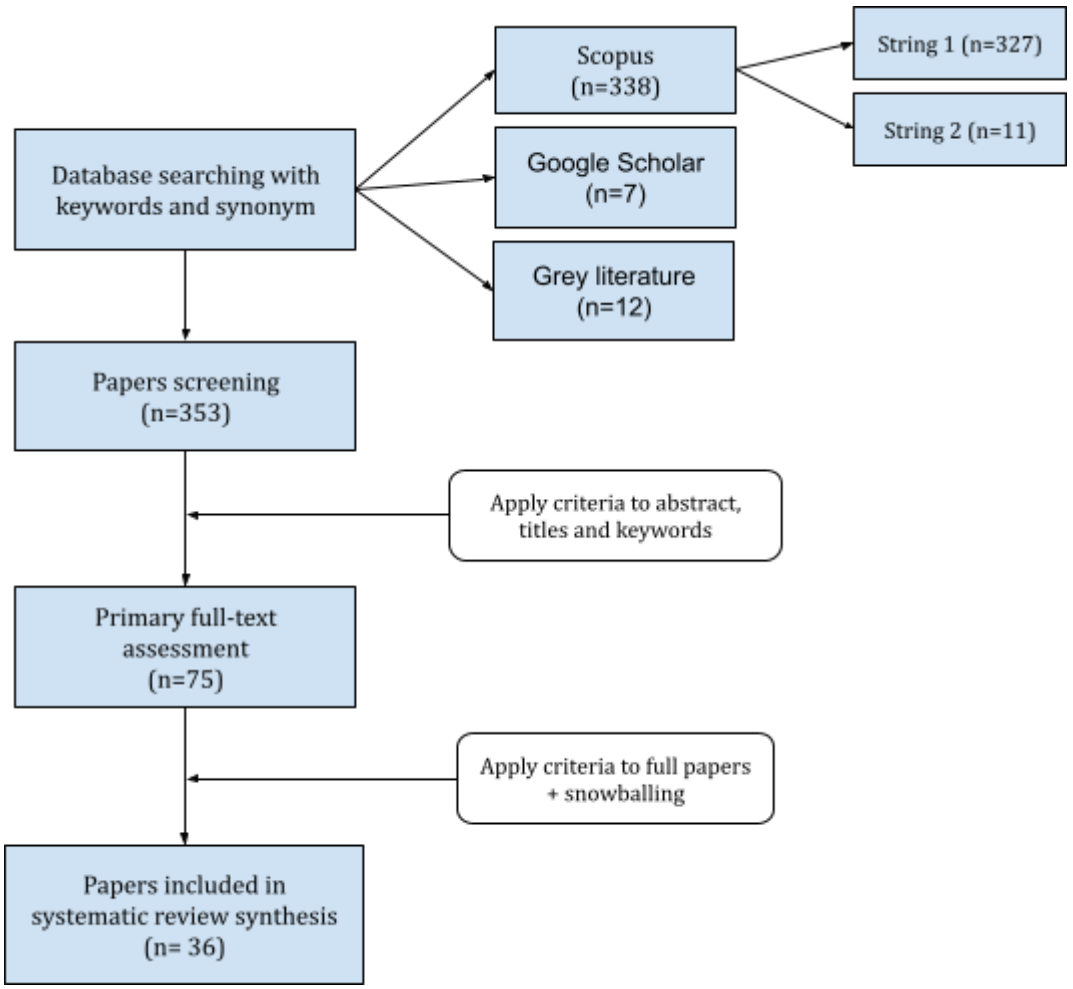
The search strategy for the gray literature was conducted via the search engine Google Scholar and the websites of three related organizations in the agricultural sector. The chosen organizations included the Organisation for Economic Co-operation and Development (OECD), the Ministry of Agriculture, Forestry and Fisheries of Japan (MAFF), the German Federal Ministry of Food and Agriculture (BMEL). These organizations were selected based on a Google Scholar search using the search terms 'agricultural innovation policy Japan' and 'agricultural innovation policy Germany', as well as OECD agricultural research pertaining to these two nations.

The process of excluding scientific material began with a screening of the titles and abstracts of identified publications. Similarly, reading the 'Google' title of the link and the brief description was conducted during the exclusion procedure for gray literature. When the conditions were met, academic papers were considered to have relevance. Both broad reflections on transformative and mission-oriented innovation policy, and specific reflections on agriculture policy coping with wicked problems in examined countries, were included. Articles and materials based on theory or concepts were also taken into account.

The final collection consisted of 15 scientific articles. I identified 2 more articles through snowballing. In conclusion, this procedure yielded 36 distinct papers (see Appendix for a summary), including 7 Google Scholar results and 12 international organization documents.

Figure 1

Publication selection process



2.5. Publication analysis

The first phase of the examination of the chosen publications was to determine the constraints and frameworks of TIP and MIP in agriculture while addressing wicked situations. Via a table, we illustrate each characteristic of wicked problems that impact agricultural policy. Next, I adopted the paradigm of transformational and mission-oriented innovation policy in the problem-solution space from Wanzenbock et al. (2020). I used their definitions of each quadrant and route to determine whether a given article referenced a compatible component. Specifically, I examined whether the article concentrated on a particular quadrant or pathway, i.e., explored it in depth, or only alluded to it. In chapter 3, I mostly included articles that focused on the corresponding component, while articles that addressed portions in passing were only included if they added further significant points to the discussion. The primary findings

of this analysis was the identification of a number of major policy making difficulties in each policy-solution space pathway.

In chapter 4, I investigate these directions in the national context of agriculture policy in Germany and Japan. First, I selected all scientific and gray literature that proposed agricultural innovation policies addressing a particular wicked issue, and then I determined whether the discovered policies could be illustrated into problem-solution space pathways through the evaluation process. The policies will be analyzed after the collection of data on the specified policies in Germany and Japan. This technique entails comparing and contrasting the policies, recognizing the strengths and limitations of each indicated route, and evaluating their possible influence on resolving the complex issue.

Once the policies were reviewed, I may provide suggestions on how they might be changed to handle the intractable issue more effectively. These proposals may propose new policy measures, advise modifications to current policies, or indicate research and partnership opportunities. By providing these suggestions, we can guarantee that the policies in Germany and Japan are better suited to solve the complex situation and that stakeholders are more involved in policy making.

Chapter 3. Conceptualization of mission-oriented and transformative innovation policy through problem-solution space in agricultural sector

3.1. Limitations of agricultural policy in tackling wicked problems

Table 2

Properties of wicked problems affecting agriculture policies. Extracted from Peters & Pierre (2014), Candel et al., (2015), Kuhmonen (2018).

Properties of wicked problems	Theme	Identified challenges in agricultural policies	Example
Complexity	Pitfall of oversimplification	Framing of the policy issue	Food policy encompasses more than just production; it also addresses food safety, distribution, allocation, and consumption.
		Limiting the robust stakeholder perspectives	Relying solely on Commission documents in the European Union can create bias and partiality in understanding the rich issues surrounding the common agricultural policy if member states, the European Parliament, civic society organizations, and third country stakeholders are not actively involved.

Uncertainty	Narrow focus	Lacking preparation for unforeseen consequences	Interfering with nature through introduction of new species leads to their rapid multiplication and spread due to lack of natural predators.
		Failing to anticipate new problem	While external forces and internal concerns fluctuate over time, the sequence of European agri-food issues, such as food shortages and agricultural output, seems to be relatively resilient.
Contestation	Fragmentation and lack of coordination	Conflicting between stakeholders	The European Union's Common Agricultural Policy offers enormous assistance to farmers, yet these subsidies boost food costs throughout Europe.
		Competing between agricultural interests and environmental goals	High-volume agriculture generally employs various chemical fertilizers, which eventually leach into water systems, causing algal blooms and dissolved oxygen depletion as the algae die.

3.1.1. Pitfall of oversimplification

When agricultural policy is oversimplified by the use of a one-size-fits-all technique that relies on presumptive issue definitions or an excessive reliance on technical innovation, it is less able to manage wicked problems (Wanzenböck et al., 2020). This oversimplification may be caused by two factors: how the policy problem is framed and how the diverse stakeholder opinions are limited. When dealing with wicked problems, the phrasing of the policy problem is crucial. By describing the problem too specifically, policymakers run the risk of ignoring important factors that contribute to it (Candel et al., 2015) . If the single or primary goal of agricultural policy is to boost output, this might lead to a disregard for social justice issues or environmental concerns. For instance, food policy addresses problems relating to food safety, distribution, allocation, and consumption in addition to the production of food (Peters & Pierre, 2014) This framing may result in the development of policies that only target the surface-level causes of the issue rather than its root causes, and they may also fall short of fully recognizing the complexity of the situation. The necessity for intelligent and inclusive farm policy methods is supported by recent research (Molas-Gallart et al., 2021; Parks, 2022; Casula, 2022) Oversimplification also runs the danger of limiting the many viewpoints of stakeholders. Stakeholders are essential in comprehending the complexity of the issue and offering solutions that are suited for the situation. Include different stakeholder opinions in the policymaking process to avoid oversimplification. Limiting stakeholder perspectives often results in a top-down approach to policymaking. For instance, relying solely on documents created by the Commission can result in bias and partiality if the member states, the European Parliament, civic society organizations, and third country stakeholders are not actively involved in understanding the complex issues surrounding the common agricultural policy in the European Union. This leads to an oversimplified depiction of the policy issue that may not accurately represent the needs and viewpoints of all relevant stakeholders. Agricultural policy-making must take a comprehensive approach that takes into account the many facets of wicked dilemmas in order to avoid oversimplification. This entails considering various stakeholder viewpoints and acknowledging how linked environmental, social, and economic aspects are. This strategy is shown by the European Union's Common Agricultural Policy, which aims to balance economic, social, and environmental goals. .

3.1.2. Narrow focus

Policymakers have a difficult challenge due to the intricacy of these issues since they must balance several, often conflicting agendas. Because of the wickedness of these issues, it is difficult to come up with solutions, and agriculture policy may be inhibited by a narrow focus on immediate goals or an inability to foresee future issues. The inability to forecast new problems and a lack of readiness for unexpected results are two variables that contribute to this shortcoming.

Agriculture policy often employs new species, innovations, or methods to address problems (Moritz et al., 2022). Yet, these policies could have unintended consequences that policymakers would not predict. For instance, the lack of natural predators may enable a novel species introduced to control pests to quickly reproduce and spread. In a similar vein, certain pesticides may harm non-target species or breed pests that are resistant to them (Peters & Pierre, 2014).

If these unforeseen consequences aren't planned for, agricultural techniques may be less effective in addressing wicked problems. Policymakers must adopt a careful approach that considers the potential risks and unpredictable nature of policies before they are implemented in order to overcome this constraint. This method calls for gathering and analyzing information on the potential impacts of initiatives, corresponding with relevant parties, and creating backup plans to deal with unexpected results.

A difficulty for agricultural policy may be a narrow focus on certain challenges, which might leave them unprepared to address emerging issues as they appear. For instance, the development of agri-food crises in Europe, such as food shortages and agricultural productivity, appears to be relatively constant despite the fact that both internal and external causes are vulnerable to change over time (Candel et al., 2015). Yet, policies that are largely aimed at resolving current issues may not be equipped to deal with emerging issues, such as excessive meat consumption or the effects of climate change on agricultural output (Moritz et al., 2022).

Policymakers must constantly monitor and analyze the situation in order to overcome this constraint. They must also create flexible policies that can be altered in response to changing circumstances.

3.1.3. Fragmentation and lack of coordination

The competing interests of several stakeholders provide a considerable challenge for policymakers in the agriculture industry. For instance, the European Union's Common Agricultural Policy (CAP) offers substantial financial assistance to farmers. Yet, this support may also result in a surge in food prices throughout Europe (Candel et al., 2015). Due to this, there is a conflict of interest between the interests of consumers—who will pay more for food—and those of farmers—who benefit from the subsidies. Similar to this, policies that promote the growth of agricultural land may clash with those of environmental organizations, who can argue that such expansion is detrimental to biodiversity and natural ecosystems. When agricultural land is prioritized above the expansion of other kinds of land, this conflict may arise.

The existence of opposing agricultural and environmental objectives is a fundamental barrier that policymakers in the agriculture industry must overcome. For instance, as pointed out by Peters & Pierre (2014), high-volume agriculture often relies heavily on chemical fertilizers, which are known to have a number of negative consequences on the local ecology. These fertilizers may infiltrate into water systems, where they might encourage the formation of algal blooms and, when the algae die off, reduce the quantity of oxygen in the water. Aquatic habitats might be harmed, and there would be less easily accessible clean water for people to utilize. Policymakers must take into account the needs of the agriculture industry while also promoting ecologically friendly land management practices and maintaining the environment as a whole.

The fragmentation and lack of coordination that exist across the several programs makes it considerably harder for agriculture policy to close the value gap created by wicked problems. The absence of a unified framework for policy creation and execution that can direct policy development and implementation across many sectors and levels of government is referred to as a lack of coordination (Kirschke et al., 2019). Fragmentation refers to the existence of multiple policy initiatives that may not be well-coordinated or integrated, whereas a lack of coordination refers to the absence of such a framework altogether. This lack of coordination may result in policies that overlap or clash, which might decrease the effectiveness of agricultural programs and make it more difficult for policymakers to address the problems currently facing the industry.

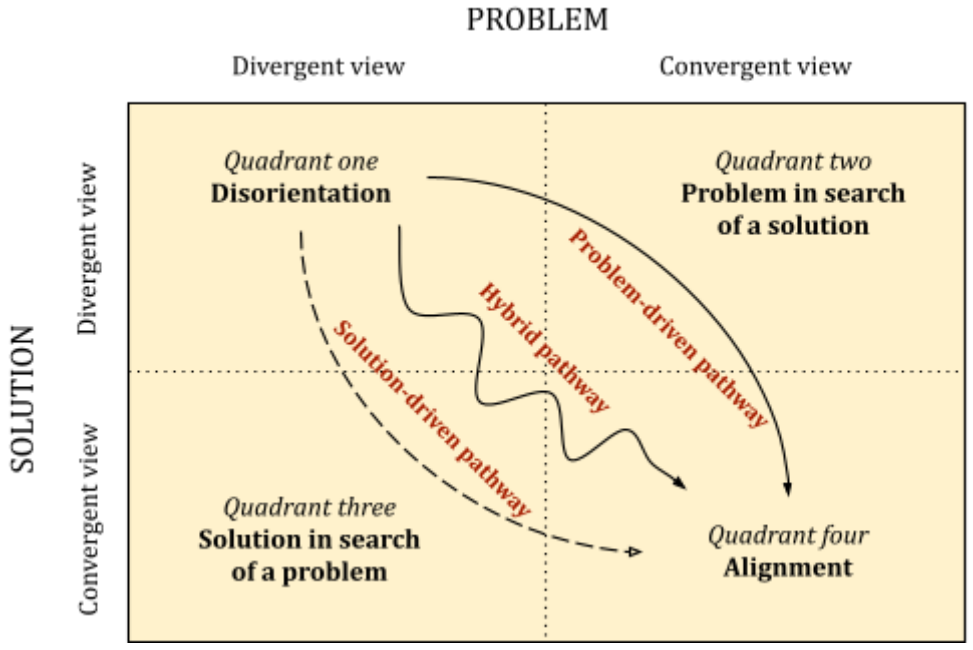
3.2. Strategy for tackling wicked problems - The problem-solution space

Limitations in agricultural policy require a holistic strategy that takes into account both the nature of a problem and the proper response. I hereby study agricultural challenges using four quadrants of the problem-solution space (see Figure 2).

Unlike the other previously stated typologies, the problem-solution space of Wanzenböck et al (2020) takes a dynamic rather than a static viewpoint (Wittmann et al., 2020). That said, constellations may alter over the course of time, for example, as a result of public debate or new technological developments that bring more stakeholder into consensus on the problem/solution.

Figure 2

Problem-solution matrix providing a schematic illustration of alignment strategies. Reproduced from Wanzenböck et al. (2020).



3.2.1. Quadrant one: Disorientation (divergence on both problem and solution)

Wanzenbock et al. (2020) defined 'quadrant one: disorientation' as a problem-solution constellation characterized by a 'very wicked' scenario in which neither an agreement on the issue description nor a clear, practical, or implementable solution idea has evolved (Termeer et al., 2013). This situation may be seen in the context of sustainable agriculture, where varied players' distinct history and skills, individual interests, views, and viewpoints on what a desirable future state could be, all have a big influence. For

example, in the knowledge-based bio-economy narrative, alternative visions, diagnoses, and treatments from opposing groups evolved, including contrasting descriptions of Europe's social challenges, such as constraints on natural resources and more 'sustainable' methods to employ them (Levidow et al., 2012). This circumstance makes developing a widely agreed understanding of the society dilemma and identifying the best means to tackle it difficult. Divergent issues and solutions emerge in the lack of a broadly accepted framing of the social issue in terms of the real difficulties and the best remedy.

To solve such a complicated scenario, scientific information regarding the problem's origins and impacts is critical for learning and better understanding the problem (Wanzenbock et al., 2020). Yet, in the context of societal challenges, policymaking is seldom based only on objectivity and technical facts, but rather demands a compromise between conflicting social ideals (Parkhurst, 2017). Social learning, collaborative visioning, and participatory governance and research methodologies are critical in this environment for promoting collaboration among varied actors, despite their disparate viewpoints and histories. These processes enable the construction of common knowledge, which entails increasing awareness of diverse framings and explanations of a problem, embracing these variances, and developing shared expectations for convergence (Wanzenbock et al., 2020).

The more open and inclusive these learning processes are, not just for policy players but also for societal actors (experts and non-experts such as citizens, companies, civic society, and interest groups), the more legitimate issue framing and problem-solving become (Wesseling & Edquist, 2018; Boon & Edler, 2018). To address difficult challenges like sustainable agriculture, new institutional structures are needed to provide a venue for discussion, allow for conflict and negotiation, and encourage the building of a shared understanding.

3.2.2. Quadrant two: Problems in search of solutions (convergence on problem, disagreement on solutions)

The second quadrant created by Wanzenbock et al. (2020) is distinguished by a dominant characterisation of a generally acknowledged societal concern for which different treatments are being pursued. Strategies for effecting change or resolving the issue are unclear, confusing, or controversial in this situation. Indeed, most Asian nations

strive to meet contemporary difficulties by gradually changing their present policy and governance methods (Karo, 2018).

When a convergent knowledge of an issue emerges, setting goals and objectives may be a policy method for overcoming coordination and directionality inadequacies, pooling expertise, and accelerating progress in resolving the problem (Weber & Rohrarcher 2012). The development of visible and understandable research and innovation missions is a valuable instrument for targeted transformation. Missions of research and innovation are transformative goals that aim to address a specific social issue by organizing and coordinating the efforts of numerous stakeholders from diverse sectors and disciplines. Such objectives provide a clear focus and direction for research and innovation activities, and they may stimulate new forms of collaboration and learning (Mazzucato, 2018). According to Karo (2018), chronic societal problems and transformational transformations driven by non-economic interests may need more radical policy reforms than technocratic tactics can give. Such changes may need to be justified for non-rational and non-economic reasons, which may affect the governance structures that evolve in this context.

But, at this level, the question of how innovation could help to goal achievement remains open and unclear, demanding inquiry and experimenting with various solutions. Missions in research and innovation should be flexible and adaptable, allowing for experimentation with a wide range of methodologies and solutions and promoting learning from both successes and failures (Mazzucato 2018). To guarantee that the mission is responsive to societal needs and values, effective research and innovation missions should be co-created with a varied range of stakeholders, including policymakers, academics, industry representatives, civil society organizations, and individuals (Termeer et al., 2013).

3.2.3. Quadrant three: Solutions in search of problems (convergence on solution, disagreement on problems)

In the third quadrant, a solution or innovation has developed, but its application to a specific situation is ill-defined, normatively loaded, or confronts public opposition. This quadrant, labeled 'Solutions in quest of problems,' presents a situation in which an innovation seems to be useful, but it is unclear how it addresses a specific societal issue (Wanzenbock et al., 2020). Cellular agriculture is an example of a complex problem that

exists in this area (Moritz et al., 2022). On the one hand, it provides a possible answer to the well-known problem of unsustainable and environmentally damaging animal agriculture. On the other hand, the use of cellular agriculture raises worries about the loss of farmers' means of subsistence as well as the consequences on biodiversity and ecosystems.

In such cases, policy must focus on balancing expectations and assessing the validity of the invention. Significant reflexivity is necessary to evaluate the claims of the breakthrough and future application possibilities (Weber & Rohracher, 2012; Termeer et al., 2013). To prevent tunnel vision, reflexivity refers to a critical review of the underlying assumptions and ideals of a specific innovation or policy, taking into consideration its potential ramifications and unintended effects. Termeer et al., 2013; Kleinman, 2010).

Without such reflexivity, strategies focusing on a single innovation risk becoming unpopular due to public misperception about its real contribution to fixing a societal issue (Termeer et al., 2013). Public opposition may be produced by a lack of understanding of the need for change, widespread social behaviors, or a lack of legitimacy (Wanzenbock et al., 2020). In addition, low social acceptability may offer incumbents with an opportunity to frame challenges in their own interests (Frenken, 2017).

Raising public awareness and engagement in the innovation process is critical for overcoming these barriers (Moritz et al., 2022). Participatory research and governance initiatives incorporating many stakeholders, such as civil society and interest groups, have the potential to increase public understanding and trust (Cagnin et al., 2012; Weber, 2006). Co-creation strategies, which incorporate collaboration among stakeholders in the design and implementation of innovations, may increase the legitimacy and relevance of the invention to social needs (Edwards et al., 2013).

3.2.4. Quadrant four: Alignment (convergence on problems and solutions)

The fourth quadrant denotes a situation in which societal challenges are fully understood and broadly acknowledged, and viewpoints on solutions have converged. (Wanzenbock and colleagues, 2020) This quadrant is defined by the necessity for

policies that prioritize targeted innovation production and dissemination, as well as the inclusion of new social behaviors.

According to Geels (2004), established items that have benefited from decades of gradual improvement may stymie public adoption of new ideas. Measures that foster market development and the dissemination of new technologies are essential in this environment. Similarly, according to Boon and Edler (2018), a lack of demand to scale up and use the idea on a wide scale may stifle the dissemination of new technology.

Systemic innovation policies may be critical for the diffusion of innovations in quadrant four. Public procurement, legislation and standards, as well as help for entrepreneurial and innovation ecosystems, are examples of such policies (Edquist, 2011; Borrás & Edquist, 2013). Moreover, innovation policies may strive to establish favorable conditions for invention diffusion via international cooperation and information exchange (Hassan et al., 2021).

In quadrant four, the alignment between problem understanding and solution perception may also aid in the greater societal absorption of specific types of conduct (Wanzenbock et al., 2020). This may be done by enacting legislation that promote the use of environmentally friendly activities and technologies, such as sustainable agriculture methods and renewable energy sources (Boon and Edler, 2018).

3.3. Directionality of innovation policy through problem-solution space

The problem-solution space framework created by Wanzenbock et al. (2020) is a valuable tool for studying agricultural concerns and developing appropriate strategies to address them. In this viewpoint, the ultimate objective of any policy plan is to reach the lower-right quadrant of the issue-solution space, where both the problem and the solution are aligned. Here, policies are most effective and have the highest probability of success.

3.3.1. Problem-driven pathway

Designing innovation policies using a problem-driven approach (curved arrow in Figure 2) is suitable for dealing with difficult situations. Policymakers must first have a thorough understanding of the problem, including its many dimensions, causes, and consequences. This needs collaboration across a diverse range of interested parties, meaning that actor consortia should be public-private (Kuhlmann & Rip, 2018; Karo,

2018), including those directly affected by the problem as well as those with expertise in relevant sectors. Finding the values, beliefs, interests, and assumptions that impact the different opinions and narratives about an issue, according to Voß and Bornemann (2011, p.156), is a key aspect of the problem framing and visioning process. The creation of a common vision guarantees that the policy is recognized and supported by a broader constituency. Creating and maintaining relationships with a large range of stakeholders may be time-consuming and resource-intensive.

Policymakers may experiment with alternative approaches to the problem after a common aim has been stated (Karo, 2018; Moritz et al., 2022). Technological, institutional, and societal innovations that address the underlying causes of the issue might all contribute to a solution. To be effective, these solutions must be scalable and durable, as well as take into account the complex web of interactions that comprise the problem. The policy must be reviewed and analyzed on a regular basis so that its effectiveness may be assessed and amended as needed.

In order to accommodate changing circumstances and new information, the problem-led approach significantly depends on reflexive governance and social learning. This may be challenging for policymakers who are hesitant to break from current policy frameworks (Karo, 2018). As a result, it asks for the government's revitalization ability to unblock unproductive patterns in current procedures (Termeer et al., 2013), as well as frequent reviews to measure the effectiveness of policies and make required modifications. According to Ison et al. (2015, p.221), social learning comprises 'iterative and participatory procedures of framing, observing, reflecting, evaluating, and altering to promote desired outcomes.' Moreover, the success of a problem-led route approach requires systems thinking, stakeholder participation, and strategic foresight ability, since addressing challenging issues often necessitates persistent labor over a long period of time. This may be challenging in a political system because short-term goals and election cycles may predominate (Karo, 2018). Borjeson et al. (2006) underline the need of using foresight approaches to examine possible future scenarios and identify emerging difficulties that may require governmental action.

3.3.2. Solution-driven pathway

In transformational and mission-oriented innovation strategies, the solution-driven pathway (broken arrow in Figure 2) is characterized by a bottom-up or solution-push

approach that emphasizes the production of single breakthroughs to solve societal challenges (Wanzenboeck, 2020). This approach is consistent with policies that justify funding for basic research by stressing science's ability to alleviate societal problems (Dosi et al., 2006; Mazzucato, 2018).

The emphasis on social problem descriptions and trade-offs between societal values may be underrepresented in a solution-led approach (Wanzenboeck, 2020). Researchers, business, and other stakeholders with strategic interests may strive to influence the formulation of social issues that the suggested solution may help solve. If the effectiveness and societal consequences of the solution are not fully understood, this pathway risks encountering societal barriers along the way, ranging from a lack of public awareness and problem legitimacy to uncertainty about the solution's impact and a lack of willingness to implement the solution on a large scale (Wanzenboeck, 2020; Peters & Pierre, 2014).

These policies are aimed at achieving specific social objectives, such as transitioning to a low-carbon economy, reducing inequality, and improving health outcomes. In order to uncover and solve complex societal issues, this technique emphasizes co-creation and collaboration among stakeholders such as academics, policymakers, and citizens. Mission-driven innovation policies strive to foster a shared understanding of societal issues and potential solutions, as well as cross-sector cooperation in the creation and implementation of these solutions (Mazzucato, 2018).

Moreover, transformational innovation methods focus on radical innovations that have the potential to disrupt present socioeconomic systems and alleviate systemic concerns (Bergek et al., 2015). These policies are meant to encourage the development of new technologies, business models, and institutions that question and replace existing socio-economic norms. The goal of transformational innovation policies is to encourage the creation of alternative socioeconomic systems that promote long-term and equitable growth (Bergek et al., 2015).

In agriculture, the solution-driven approach may lead to the development of innovative agricultural technology that addresses specific issues such as climate change, food security, and sustainable farming practices. Mission-driven and transformational innovation policies may help ensure that these solutions are linked to wider societal

goals and values, are generated via stakeholder collaboration, and have the capacity to shift the agricultural sector toward sustainability and inclusivity (Moritz et al., 2022).

3.3.3. Hybrid pathway

The hybrid policy pathway follows a co-evolutionary logic that entails bargaining, balancing interests, and conducting small-scale experiments to learn about results, potential effect, and adoption. The hybrid pathway's co-evolutionary logic necessitates a high degree of cooperation and coordination among many players, including policymakers, researchers, and stakeholders. According to Berkhout et al. (2010), co-evolutionary processes entail the reciprocal adaptation and learning of diverse actors, which necessitates the formation of trust and shared objectives.

This strategy is well-suited for ill-defined social issues with no known solution. For example, dealing with urgent social challenges, sometimes known as 'super-wicked problems' (Levin et al., 2012), may be best tackled via a co-evolutionary strategy in the implementation of mission-driven innovation strategies. Such policies need a collaborative and participatory approach that strikes a balance between the state's top-down directive role and the preservation of regions for more bottom-up experimental research (Karo, 2018). Conflicting ideals and points of view are often resolved by focusing on technical arguments and relying on scientific evidence and expertise (Candel et al., 2015). This might be a deliberate and intentional move to make it easier to get aligned opinion notwithstanding framing differences.

As a consequence, innovation policies will no longer be limited to governments, but will be an essential component of the functioning of knowledge and innovation systems, which are experiencing profound transitions that involve new funders and performers. The concept of 'creative corporatism' may inspire future innovation strategies in which governments (and/or allied international alliances) play a major role in creating greater, more diverse 'varieties of cooperation' in affluent capitalist economies (Kuhlmann & Rip, 2018).

The hybrid pathway is a viable strategy for tackling complex agricultural challenges that need transformational and mission-driven innovation approaches. Policymakers may experiment with various ideas while better understanding the issue and its consequences by using an iterative approach to policy making. Politicians must be able to negotiate the policy environment's intricacies and foresee possible roadblocks

(Kuhlmann & Rip, 2018). Policy entrepreneurs, as Howlett and Rayner (2013) remark, are crucial players in this process because they can identify policy windows and rally support for innovative policy proposals. Moreover, it is critical to emphasize the government's commitment to constantly reflect on the nature of the Grand Challenges and the responsibilities of various parties (as well as to maintain a link with democratic decision-making) (Kuhlmann & Rip, 2018).

Pursuing a hybrid route that aims for a complete grasp of the issue and its solutions risks being caught in an unguided policy approach with no realistic objectives or a clear solution path. Setbacks are more likely to occur from both sides, with the inhibited definition of the 'real' issue or the irrational selection of the 'best' solution causing major delays for a plan that was originally based on high expectations. An iterative process of trying with new ideas, on the other hand, provides a lot of learning potential if well-managed. In other words, the hybrid approach is not without danger, especially when policy aims are based on incorrect assumptions or the solution has unanticipated side consequences. Policymakers must be careful to balance the need for experimentation and learning with the need for clear goals and a realistic solution path, as well as a continuous commitment to communication and cooperation among multi-stakeholders, which includes not only policymakers but also NGOs, civil society organizations, universities, and, in some farmer-related issues, farmers (Dentoni et al., 2012; Wanzenboeck, 2020). In a nutshell, this may include establishing clear aims and priorities, developing effective governance structures, and improving stakeholders' skills and abilities (Peters & Pierre, 2014). As a result, hybrid innovation routes may use the benefits of both solution-led and problem-led methodologies while reducing their limits.

Chapter 4. (Agricultural) innovation policy in a national context

4.1. Innovation policy in German agriculture

4.1.1. The innovation policy transition in German agriculture

Overview of German agriculture

Germany has a strong agricultural sector despite having a high population density, cultivating half of its land and generating items worth more than 50 billion Euros annually in over 275,400 agricultural enterprises (BMEL, 2020a; *FiBL & IFOAM EU, 2016*). Moreover, it is the third-largest importer and exporter of agricultural products in the world, with about a third of its total production going to export (BMEL, 2020a). With 50% of cropland being grassland and using arable land for livestock feed in order to provide food for more than 200 million farm animals, Germany is one of the four largest agricultural sectors in the EU. Main agricultural production products for human use comprise bread grains, potatoes, sugar beet, oilseeds, and fruits and vegetables. In addition, areas of grassland and farmland are used to cultivate bioenergy and bioresources (BMELa, 2020).

In spite of this impressive achievement, Germany intensively encounters global wicked problems due to agri-food systems' contribution, accounting for a large share of the total agricultural emissions of the EU (FiBL & IFOAM EU, 2016; German Environment Agency, 2018). Agriculture in Germany accounts for 12.5% of the nation's total Scope 1 greenhouse gas (GHG) emissions (FiBL & IFOAM EU, 2016). In this circumstance, farmers currently are facing a perfect storm of challenges: rising costs of land and agricultural inputs, rising consumer demands for healthier, less expensive food, and a greater likelihood of catastrophic weather events such as droughts and floods (OECDa, 2020; FiBL & IFOAM EU, 2016).

Social disputes and demonstrations also reflect the magnitude and complexity of the difficulties and the range of opinions, interests, demands, and aspirations. This spurred the Federal Government to form the Commission on the Future of Agriculture (Zukunftskommission Landwirtschaft, or ZKL) in July 2020, whose responsibility is to establish the future vision in German agriculture (Commission on the Future of Agriculture, 2021).

Structure and objectives of the German agricultural policy

Germany has been implementing transformative and mission-oriented innovation policies in agriculture to address the challenges related to biodiversity, climate protection, and ecosystem restoration (German Environment Agency, 2018). This movement has been influenced by a variety of factors, including shifting societal expectations around food and agriculture, rising concerns about environmental sustainability, and the need to adapt to new technology and economic realities (Commission on the Future of Agriculture, 2021).

In recent years, following the spirit of the CAP, the German government has launched several initiatives to promote transformative and mission-oriented innovation in agriculture in favor of the SDGs of 2015 and the targets of the Paris Climate Agreement (German Council for Sustainable Development, 2022; Commission on the Future of Agriculture, 2021). One of these initiatives is the 'National Bioeconomy Policy Strategy' which aims to develop a sustainable and resource-efficient system that uses renewable resources and reduces waste (BMBF & BMEL, 2022a) and strengthen the role of Germany as a bioeconomy leader. With a goal of 30% organic farming by 2030 (BMEL, 2022b) and the restriction of pesticides to the stringent minimum (FiBL & IFOAM EU, 2016), German agriculture is oriented toward sustainable and organic farming, with the need to find solutions and maintain swift decision-making emphasized. In the meanwhile, authorities are putting restrictions on GHG emissions and mandating land use adjustments. (FiBL & IFOAM EU, 2016).

In Germany, the Bundesländer (Federal States) manage the regional implementation of cross-compliance regulations, with local authorities or Chambers of Agriculture ('Landwirtschaftskammer'), which have traditionally provided public extension and advisory services to farmers, in charge of carrying out controls (Tangermann & von Cramon-Taubadel, 2013). However, state action concerning the agriculture and food system, including its interdependencies with climate, environmental, biodiversity and animal welfare policy, is characterized to a problematic extent by the lack of an integrative guiding vision and a consistent national legal framework (Commission on the Future of Agriculture, 2021). This function is frequently met instead by executive-level policies which have all charted the symbolized directionality (German Council for Sustainable Development, 2022) such as The UN Sustainable Development Goals, the Paris Agreement, the EU Green Deal, and, on a national level, the German Climate Change

Act and the Sustainability Plan. Even before the Covid-19 outbreak and the Ukrainian conflict, many of these sustainability goals lacked any obvious trend indicating that they would be attained. Even though some scientific discoveries have been accessible for decades, there remain significant implementation gaps (German Council for Sustainable Development, 2022; Commission on the Future of Agriculture, 2021). As a result, internal contradictions and a lack of coordination between the relevant policy areas, for example in the relationship between funding and regulatory law, are thus accompanied by enforcement deficiencies and missed targets. This applies both to the economic viability of farming and to environmental sustainability goals (Commission on the Future of Agriculture, 2021).

Future prospects for the innovation policy in German agriculture

Germany's agriculture transition policy is an ongoing process, and there are still challenges to be addressed. On the one hand, environmental sustainability and economic viability for farmers must be balanced (Commission on the Future of Agriculture , 2021). On the other hand, the agricultural industry is under increasing pressure to adopt new technology and innovations to boost efficiency and resilience (Kurth et al., 2023).

To accomplish a successful transformation, broad acceptability is essential, even among those immediately impacted. This can be achieved through the establishment of platforms for dialogue and exchange of ideas, the creation of networks and partnerships, and the organization of training and education programs for farmers and other stakeholders (OECD, 2022b). A greater public awareness and engagement in a shared goal on the importance of sustainable and regenerative agriculture are required to ensure broad engagement in policy making and identification of priorities. In addition, the transformation on farmers' mindsets can be achieved through targeted financial support and funding, including regional programs and monetary incentives for farmers to transition to regenerative agriculture (Kurth et al., 2023).

The transformation of agri-environment-climate policy ought to figure into a plan to reorient the CAP (WBAE, 2020). This approach needs a progressive modification to the policymaking process that considers the correlation between a particular challenge and a potential response. In order for farmers to make the necessary investments, the approach comprises setting acceptable timeframes, creating predictable conditions, and assuring planned dependability (Commission on the Future of Agriculture, 2021). Only

then can corporations and research institutions invest in the development of future-proof new processes, technologies, products, and variants. This will result in beneficial changes to contractual agreements, negotiation frameworks, and nutritional choices (Kurth et al., 2023). In addition, policymakers should combine their complete policy toolset (including law, agricultural administration, and financial assistance) and coordinate their policies with other policy areas (such as commerce, consumers, construction, and education) (OECD, 2022b). According to the Commission on the Future of Agriculture's (2021) advice, they should transition from indicator-based input management to process and result management and place special emphasis on regional cooperation and targeted trials.

4.1.2. The German agri-food policy in the problem-solution space

The German agri-food system was selected for the thesis since half of Germany's land area is devoted to agriculture and the nation has a high meat consumption rate (Moritz et al., 2022). To promote sustainable and resilient agriculture, a systemic transformation process is required, and organic farming has the ability to act as a major pillar of this change.

Analysis of Germany's agri-food system's high-level policies can shed light on the country's strategy to tackle numerous difficulties and concerns in this industry. The table 3 provides a summary of numerous policies, including their objectives and focus areas. By evaluating these policies, it is possible to obtain a greater appreciation for Germany's problem-oriented approach to tackling agri-food system difficulties.

Table 3

The agri-food policies in Germany

Proposed Policy	**Goal**	**Target Problem**
Agricultural Systems of the Future (BMBF & BMEL, 2022)	Improving the adaptability, resource efficiency, and sustainability of agricultural production.	Biodiversity conservation, climate change, farmer livelihoods
Federal Water Act	Managing water use and	Water pollution and

(OECD, 2020a).	controlling water quality	water-related risks such as drought, flood
Plan for the Future of Organic Farming (BMEL, 2022b)	Promoting organic farming	Nutrient circularity and soil pollution, biodiversity conservation
Peat Use Reduction Strategy (BMEL, 2022a)	Reducing the consumption of peat and developing the alternatives	GHG emissions
2035 Arable Farming Strategy (BMEL, 2019)	Suggesting possibilities and methods that sustainable agriculture, i.e., environmentally friendly, commercially feasible, and socially oriented.	Environmental issues, biodiversity conservation, climate change, agriculture-society relationship, farmer livelihoods
National Programme on Sustainable Consumption (BMUB, 2016)	Seeking different consumption patterns and enhance sustainable alternatives without eliminating customers' choice freedom	Human health, biodiversity conservation,climate change, environmental issues

- *The Agricultural Systems of the Future* is a BMBF financing project including 8 initiatives that focuses on innovative concepts and advanced agricultural technology. This effort focuses on alternative production methods, the creation of modular, highly regulated and closed cultivation and production systems, the development of unusual producing organisms and the development of better working conditions for farmers. It suggests solving the difficulties confronting global agricultural and food systems. The initiative attempts to solve the target issues of biodiversity protection, climate change, and farmer livelihoods by enhancing agricultural production's flexibility, resource efficiency, and

sustainability. To attain these aims, the policy recommends alternative production techniques and sophisticated agricultural technologies that are scalable and sustainable and take into account the complicated web of interdependencies that comprise the problem.

- Water management is an additional crucial part of German agricultural and food policy. *The Federal Water Act*, implemented in 2010, controls the quality and properties-based management of surface and groundwater bodies. The purpose of the legislation is to regulate human interventions in water bodies and manage water quality and usage. To address water-related hazards like drought and flooding, ten River Basin Management Plans with institutional frameworks and stakeholder engagement have been developed. The act establishes laws for the management of surface and groundwater bodies, including stakeholder engagement in decision-making processes, emphasizing the significance of collaboration across a broad spectrum of interested parties
- Initiated in 2015, *the Plan for the Future of Organic Farming* offers 24 suggestions to enhance the amount of land employed for organic farming, aiming to account for 30% of German agricultural land. The plan's principal purpose is to provide an appropriate policy framework for the different economic players and provide insight into the transition between organic and conventional production systems. The initiative intends to solve nutrient circularity and soil contamination concerns.
- *The Peat Use Reduction Plan* presented by the BMEL seeks to reduce peat usage in horticulture while having minimal detrimental effect on the industry and for encouraging the use of commonly used alternatives to peat such as green compost, wood fibers, composted bark, and coconut products The objective of the policy is to minimize greenhouse gas emissions and promote sustainable gardening techniques.
- Adopted by the BMEL in 2019, *the 2035 Arable Farming Strategy* intends to help farmers with the execution of existing legislation and the progress of agricultural practice by targeted finance, research, and the transfer of best practices. Focusing on environmental challenges, biodiversity protection, climate change,

agriculture-society connections, and farmer livelihoods, the plan outlines viable options and techniques for achieving sustainable agriculture.

- Lastly, the BMEL's *National Programme on Sustainable Consumption* addresses a variety of consumer domains, including transportation, the household, the workplace, and leisure time. Consumers may directly impact sustainable development, notably in nutrition, and local and global politics. The initiative seeks to promote alternate consumption habits and sustainable alternatives without restricting consumer choice. The curriculum emphasizes human health, biodiversity protection, climate change, and environmental concerns.

Each of the aforementioned policies has a well-defined objective problem and proposes specific solutions; hence, they are problem-oriented. The regulations are focused toward improving the sustainability of agriculture, promoting environmentally friendly practices, and addressing issues related to water pollution and peat consumption.

External variables such as global economic and political trends, technical advancements, and environmental shocks contribute to uncertainty and contestation in the German agri-food policy system. Several variables may affect the efficiency of existing policy systems. The policy responses to these difficulties are contested and ambiguous because they entail trade-offs between diverse aims and may have unforeseen consequences. In recent years, environmental preservation and agricultural interests in Germany come into conflict, creating a public debate on regulation. Germany is seen as one of the largest farmer protests in decades. Small-scale farmers opposed tougher environmental regulations, which put them under enormous economic strain (Schaub, 2021). The stated objective of the Strategy for the Future of Organic Farming reveals an additional issue with the German agriculture policy. Critics consider the ambitious plan to increase the proportion of organic farms to 30 % by 2030 to be illusory due to social and political obstacles such as changing consumer preferences, the slow progress in converting cultivation areas to organic production, and the lack of political support (Pieper, 2023).

In order to ensure its efficacy and make any necessary changes, the policies also promote stakeholder involvement and review. This indicates a problem-oriented strategy, as opposed to a solution-oriented or hybrid approach, with a focus on finding and fixing specific difficulties. In addition to being problem-focused, these policies emphasize the need for teamwork and stakeholder engagement while confronting

challenging circumstances. The policies recognize the need for public-private partnerships and include a wide range of stakeholders, including those directly impacted by the crisis and those with expertise in related fields. This approach acknowledges the complexity and interconnectedness of the issues, which needs a complete understanding and the engagement of several stakeholders in policy creation and execution.

In addition, the policies suggest several technical, institutional, and social improvements. This technique recognizes that complex problems need a multifaceted approach that takes into consideration the situation's underlying causes and consequences. The laws also emphasize the need of scalability and sustainability in solutions, recognizing the need to consider long-term consequences and outcomes.

Nevertheless, effort, collaboration, and adaptability are necessary for the execution of these norms and the attainment of their intended outcomes. The policies emphasize the necessity for continuous inspection and reflection to guarantee their performance, as well as the fact that they may be updated as necessary. This necessitates a commitment to reflexive governance and social learning, as well as strategies for foresight in order to anticipate and address emerging challenges.

In general, these policies demonstrate a problem-driven approach to policymaking that tries to resolve the complex challenges facing the German agricultural and food system. While they provide exciting solutions, their success will be dependent on consistent work and collaboration from a wide range of stakeholders, as well as a commitment to periodic evaluation and revision.

4.2. Innovation policy in Japanese agriculture

4.2.1. The innovation policy transition in Japanese agriculture

Overview of Japanese agriculture

Japan is one of the world's top economies despite its tiny size and high population density. Agriculture accounts for 10% of GDP when all food-related enterprises are included, although using just 12% of the land, more than half of which is rice paddy fields (OECD, 2021a).

Yet, Japan's agricultural employment has dropped by more than half since 1980 to 2 million in 2019, accelerating in the recent decade (OECD, 2021a; MAFF, 2020a; OECD, 2019b). Japanese agriculture has several challenges, including diminishing acreage, output decrease, food security difficulties, and food self-sufficiency reduction (Chandra, 2020). 'Innovation 25,' Prime Minister Abe's 2007 vision plan, highlighted Japan's biggest challenges: aging and population loss, globalization, and environmental dangers (Karo, 2018; Zhenmian et al., 2013). Japanese agriculture also escalates a technological and automation revolution since 50% of farmers are over 60 (Chandra, 2020).

To fulfill global demand for food, feed, fuel, and fiber, agricultural production must increase (OECD, 2019b). Japan is well-positioned to build a more technologically intensive agriculture locally and perhaps extend its production networks for high-value agro-food products regionally and worldwide as agriculture becomes more data-intensive (OECD, 2019b). For more than two decades, Japan has advocated sustainable farming as an agricultural solution to environmental issues (Zhenmian et al., 2013). Japan improves its environmental performance and prepares for increasingly frequent natural catastrophes owing to climate change (OECD, 2019b), addressing biodiversity loss, land degradation, ecosystem pollution and health consequences, and delivering on the Sustainable Development Goals. Many forms of sustainable agriculture, such as organic farming and eco-friendly agriculture with less use of pesticides and fertilizers, were used (Zhenmian et al., 2013). This also leads to the realization that when it comes to agriculture, adaptation and mitigation cannot be separated.

Structure and objectives of the Japanese agricultural policy

In recent years, Japan's agricultural policies have experienced substantial changes, with a greater emphasis on developing resilience and sustainability in the industry following the SDGs and the goals of the Paris Climate Agreement (OECD, 2021a; (Satake & Kurai, 2021). Traditionally, these policies have concentrated on pricing and marketing control to assure cheap food prices for consumers while boosting rural agricultural revenue (OECD, 2021a). Yet, as the farming population and farmland area continue to decrease, Japan has adopted a more mission-driven and transformational approach to agricultural innovation policy (Satake & Kurai, 2021).

In Japan, the Ministry of Agriculture, Forestry, and Fisheries (MAFF) is primarily responsible for executing agricultural policy. It establishes policy, finances and directs

research, promotes markets, and participates in worldwide efforts to reduce and adapt to climate change (Satake & Kurai, 2021). One of the primary goals of Japanese agricultural policy is to improve food self-sufficiency and decrease reliance on food imports. This objective is represented in the Basic Plan for Food, Agriculture, and Rural Areas, which has been in effect since 2000 and has been revised every decade. 2015 saw the formulation of the most current plan, the 5th Basic Plan for Food, Agriculture, and Rural Regions (OECD, 2021a).

Japan's agricultural strategy aims to promote exports of agricultural and food goods in addition to increasing food self-sufficiency. In 2018, the government eliminated the government-administered rice production quota system, further liberalizing the agriculture sector of the nation (OECD, 2021a). This action was intended to increase the sector's production and competitiveness, as well as Japan's part of the worldwide market for agricultural goods.

Another important aim of Japanese agricultural policy is the promotion of environmentally friendly, environmentally sustainable farming techniques. Under the Food, Agriculture and Rural Areas Basic Act, Japan has created four fundamental concepts for its agricultural policy, including the multifunctional functions of agriculture and the development of agriculture in a sustainable manner (OECD, 2021a). The Basic Plan for Agriculture, Forestry, and Fisheries Research also establishes the direction of public agricultural R&D in Japan over a ten-year period, emphasizing research that strives to tackle challenges encountered by farmers, including climate change-related issues (OECD, 2019b). These steps demonstrate Japan's continuous commitment to developing sustainable farming practices and minimizing agriculture's environmental effect.

Notwithstanding these efforts, the Japanese agricultural industry continues to face obstacles, including high land prices, labor shortages, and the need to balance opposing demands for production and sustainability. Agriculture in Japan has plummeted by more than 25%, and the number of farms and farm employees has decreased by more than 50% during the last several decades (OECD, 2021a), prompting a reassessment of agricultural policy. To overcome these difficulties, the government must continue to foster innovation, invest in research and development, and collaborate with agricultural value chain players (OECD, 2021a).

Future prospects for the innovation policy in Japanese agriculture

Japan's agriculture sector is undergoing a transformation towards a more sustainable, resilient, and mission-oriented innovation policy that not only prioritizes the sector's competitiveness but also considers the needs of rural communities and environmental sustainability. Enhancing the environmental efficiency of agriculture and enhancing its readiness for increasingly frequent natural catastrophes as a result of climate change are essential for guaranteeing the sustainable expansion of Japanese agriculture. Converting to a bottom-up policy-making process that prioritizes farmers' interests and involves several stakeholders such as government, academics, and the commercial sector should be promoted for sustainable agricultural extension (Zhenmian et al., 2013).

Unfortunately, minimal progress has been made in minimizing the environmental impact of agriculture (OECD, 2019b). Japan should build an integrated agri-environmental policy framework that commits all producers to improving their environmental performance. Where applicable, agricultural policy initiatives should enforce penalties for non-performance and offer consistent incentives for adopting sustainable production techniques. Japan's agricultural innovation program has a bright future as the government works to restructure its agricultural industry to meet the challenges of the twenty-first century. Nonetheless, continuing investment and ongoing attempts to solve structural and environmental concerns will be required to preserve Japanese agriculture's sustainability and competitiveness. To attract a younger and more educated population to agricultural production, the aim of government initiatives to expand sustainable farming should be to increase farmers' environmental awareness (Zhenmian et al., 2013).

4.2.2. The Japanese agri-food policy in the problem-solution space

Beginning in the twenty-first century, Japan has modified its agriculture policy and introduced market-oriented agricultural sector strategies. The strategy for reforming the food and agriculture industry seeks to enhance its long-term growth and competitiveness while preserving natural resources and the rural environment (OECD, 2015). There is substantial space for agriculture to enhance its environmental performance. Many environmental programs have been launched, but agricultural policy programs should offer constant incentives for the use of sustainable production methods (OECD, 2021).

Table 4 presents high-level policies that address common wicked problems that the sector is now facing. These challenges include environmental concerns, labor shortages, the preservation of biodiversity, the protection of farmer livelihoods, and climate change.

Table 4

The agri-food policies in Japan

Proposed policy	Goal	Target problem
Smart Agriculture Comprehensive Policy Package (Matsumoto, 2021)	Promoting the creation and use of new technologies.	Environmental issues, labor shortage
Sustainability Consortium for Agriculture, Forestry, Fisheries and Food (MAFF, 2020c)	Enhancing production and consumption sustainability to reach the SDGs by 2030	Environmental issues, biodiversity conservation
Direct payments for environmentally friendly agriculture (MAFF, 2020b)	Changing from conventional to sustainable rice farming	Environmental issues, biodiversity conservation
Strategy for Sustainable Food Systems - MeaDRI (MAFF, 2021)	Increasing the productive potential and sustainability of agricultural, forestry, fishery, and food sectors by innovation	GHG emissions, farmer livelihood, climate change
New Basic Policy on the Promotion of Organic Farming (MAFF, 2019)	Contributing to the SDGs, ensuring production and supply match demand, and boosting exports	Environmental issues, biodiversity conservation

- The MAFF announced *the Smart Agriculture Comprehensive Policy Package* in 2020. The strategy includes methods to achieve smart agriculture and to have data-driven agriculture practiced by the majority of Japan's major agricultural producers by 2025. This entails increasing the development and deployment of developing technologies, as well as resolving environmental concerns and labor shortages. Environmental concerns and labor shortages are addressed by this strategy. Farmers may improve their production processes, minimize waste, and boost output by embracing data-driven agriculture, resulting in more sustainable agricultural practices.
- *The Sustainability Consortium for Agriculture, Forestry, Fisheries, and Food* is a consortium of enterprises and organizations involved in sustainable production and consumption measures with the goal of attaining the SDGs by 2030. This strategy tackles the target problem of environmental concerns and protection of biodiversity. By fostering value visualization and environmentally aware consumption, the consortium fosters the adoption of more sustainable practices in the agri-food business, resulting in a more sustainable and biodiversity-friendly supply chain.
- MAFF's *Direct Payments for Environmentally Friendly Agriculture* program incentivizes farmers to limit their use of chemical fertilizers and pesticides and to embrace agricultural methods that help to mitigate global warming and maintain biodiversity. This strategy tackles the issue of transitioning from conventional to environmentally friendly rice farming, which contributes to environmental concerns and biodiversity protection.
- The MAFF formulated *the Strategy for Sustainable Food Systems - MeaDRI* in May 2021 in an effort to promote green agricultural policies by decarbonizing support measures for agriculture, forestry, and fisheries, introducing cross-compliance subsidies, and promoting Environmental, Social, and Governance investment. The medium-long range plan sets various KPIs to reach by 2050, such as a 50% decrease in the risk-weighted use of chemical pesticides, a 30% reduction in the use of chemical fertilizers, and a 1Mha increase in organic farming. The objective of the policy is to increase the productive potential and sustainability of

agriculture, forestry, fisheries, and food sectors while addressing greenhouse gas emissions, farmer livelihood, and climate change.

- *The New Basic Policy on the Promotion of Organic Farming* intends to support the growth of organic agriculture in Japan. Focusing on environmental issues and biodiversity conservation, this policy contributes to achieving the SDGs and establishing production and supply that meet demand and promote the expansion of exports. By promoting organic farming, the policy encourages more sustainable and biodiversity-friendly farming practices, resulting in a more sustainable supply chain.

The strategies presented for Japan's agri-food industry appear to be comparable with the hybrid approach, since they entail negotiation, cooperation, and experimentation to solve difficult challenges. Japan employs a variety of techniques to promote sustainable agriculture, such as the adoption of developing technology, the promotion of environmentally friendly agricultural practices, and the establishment of sustainable food systems. Within the hybrid structure, it permits more cooperation and coordination among many stakeholders, such as government agencies, research institutions, non-profit organizations, and private businesses. This collaboration leads to the promotion of the development of science and technology data-sharing platforms that combine weather, agricultural land, map, production prediction, soil, and other statistical data in order to provide sufficient data availability for farmers and expand business opportunities.

The strategy to encourage 'smart agriculture' via the use of new technologies such as AI and IoT, for example, is a joint effort involving industry, government, and academia. Farmers are motivated to adopt data-driven agriculture by means of the Smart Agriculture Comprehensive Policy Package. This results in agricultural techniques that are more sustainable and ecologically beneficial.

The agri-food policy framework enables the design of comprehensive policies that address several concerns concurrently. The Strategy for Sustainable Food Systems - MeaDRI, for example, intends to boost the productive capacity and sustainability of agriculture, forestry, fisheries, and food sectors while addressing greenhouse gas emissions, farmer livelihood, and climate change. This comprehensive strategy ensures that Japan's agri-food sector's policies effectively handle its complex concerns.

Meanwhile, the Japanese government promotes the involvement of farmers in technological research and development (Zhenmian et al., 2013). This guarantees that the innovations created are practical from both a scientific and commercial standpoint, and that farmers accept them. Communicating in farmers' languages, increasing farmers' skills, and providing need-based financial assistance are all necessary to encourage farmers to embrace climate-smart technologies/practices.

In addition, engagement with stakeholders, such as policymakers, the commercial sector, farmers, and international and foreign research institutions, is encouraged, resulting in efficient and effective scaling up and dissemination of climate-smart technology. This partnership guarantees that policies are successfully implemented and have the greatest possible impact. This strategy allows the mutual adaptation and education of many players, which necessitates the building of mutual consensus and shared objectives.

Overall, the policies discussed for the agri-food industry in Japan exhibit a co-evolutionary logic, which entails balancing competing interests and conducting experiments to learn about results, potential effect, and adoption potential. This method is well-suited for solving complex challenges that need transformational and mission-oriented innovation initiatives.

These policies confront issues associated with the incorporation of developing technology, the balance of sustainability and farmer livelihoods, and the fulfillment of the rising demand for organic goods while guaranteeing sustainable production techniques. The aging society and labor shortage is a huge challenge for Japan in farming technologies (Yamada, 2011; Zhenmian et al., 2013). The execution of Japanese agricultural policy can be sluggish and bureaucratic, since several levels of government are engaged in decision-making (Mulgan et al., 2013). This can make it difficult for farmers in acquiring timely access to support and resources, resulting in frustration and missed opportunities. Effectively addressing these difficulties would need thoughtful deliberation and cooperation across a variety of parties.

The agri-food policy framework in Japan provides for more policymaking flexibility (Japan International Cooperation Agency (JICA), 2011; Yoshida & Yagi, 2021), allowing for continual learning, feedback, and iteration of policies. This method allows policymakers to integrate fresh information and alter their policies depending on their efficacy and changing conditions. Collaboration and coordination between stakeholders,

promotion of technologies in agriculture practices, formulation of comprehensive policies, and farmer participation in research and development all contribute to the effectiveness of Japan's agri-food policies in addressing the sector's wicked problems.

4.3. Comparison of agricultural innovation policies between Germany and Japan

The commonalities between German and Japanese agri-food policies in addressing wicked problems include an emphasis on sustainability and the need for stakeholder interaction, including those with competence in relevant sectors and those directly affected by the crisis. Germany and Japan are aggressively investigating innovative approaches and technologies to enhance the sustainability and productivity of their agri-food systems. Japan, for instance, has promoted 'smart agriculture,' while Germany has explored precision agriculture and alternate protein sources. Adoption of new technologies may also create concerns over their effects on social and environmental sustainability and its consequences for various stakeholder groups.

Nevertheless, their policy frameworks vary in their problem-solution space with Germany's being more problem-oriented and Japan's being more hybrid in character.

Policy framework approach

The German agri-food policy focuses on recognizing particular social concerns and creating solutions to meet them, such as the need to transition to more ecologically friendly and sustainable methods. The problem-driven approach may also result in a lack of strategic direction and coordination, as well as ambitions that exceed the country's present capabilities. The German emphasis on tackling current issues may come at the price of strategic planning and a long-term perspective.

In contrast, the Japanese approach to agri-food policy is more hybrid, combining top-down legislation with bottom-up implementation and stakeholder involvement to provide solutions that are more inclusive and context-specific. The hybrid strategy may also result in bureaucratic inefficiency and change resistance. According to critics, Japan's policy making process may be lengthy and complicated, making it difficult to respond to quickly changing conditions.

Context-specific matters

The agricultural and food systems of Germany and Japan are distinct, and their individual policy frameworks are customized to handle the unique difficulties and

possibilities presented by their various environments. For instance, Germany has numerous small-scale farmers who may be more susceptible to economic shocks, but Japan has a fast aging population and a significant demand for organic food. Hence, policy measures that are beneficial in one environment may not be effective in another one.

Trade-offs and contested solutions

Both the German and Japanese agri-food policy systems stress the importance of stakeholder participation and cooperation, recognizing that complex issues need multiple solutions that take into consideration the unique viewpoints and interests of many stakeholders. Yet, this also implies that policy solutions may need trade-offs between various aims and be disputed by various parties. Small-scale farmers in Germany, for instance, have protested against stricter environmental restrictions, but in Japan, there may be difficulties between developing sustainable agriculture and guaranteeing farmer livelihoods. For politicians in both nations, balancing opposing interests and reaching agreement among stakeholders is a crucial problem.

Flexibility and constant improvement

Both policies exhibit a commitment to constant inspection and reflection to ensure their performance, as well as the ability to be revised as required. This requires a commitment to reflexive governance, social learning, and foresight tactics in order to foresee and respond to developing difficulties. It also involves continual involvement with stakeholders to ensure that policy solutions are effective, equitable, and enduring.

The Japanese policy framework allows for more policymaking flexibility, allowing for continuous learning, feedback, and iteration, while German policies stress the need for stakeholder participation and greater flexibility to assure their effectiveness and enhance modifications.

Policy implementation

The implementation of agri-food policy differs greatly between Germany and Japan. In Germany, the federal government has a significant role in formulating agri-food policy, although the execution of these policies can vary depending on the priorities and resources of individual states. This decentralized system might result in more

context-specific solutions, but it can also result in inconsistent policy execution. This can cause disparities in policy implementation throughout the nation.

Conversely, the Japanese government has a more centralized control over policy implementation, which can lead to more policy implementation consistency across the nation. In Japan, however, the participation of local stakeholders in policy formulation and execution is equally essential. The government often depends on local groups, like agricultural cooperatives, to assist with local policy implementation. This strategy may guarantee that policies are customized to the requirements of local populations, but it can also result in bureaucratic inefficiency and resistance to change.

In conclusion, Germany and Japan both acknowledge the necessity of tackling wicked problems in the agriculture sector and devise distinct strategies to accomplish so. Comparing the German and Japanese agri-food policy frameworks illustrates the significance of context-specific policymaking, stakeholder involvement, and ongoing learning and development in addressing the complex difficulties confronting the agricultural and food systems of various nations. It also emphasizes the necessity for policymakers to strike a balance between competing interests and create consensus among stakeholders, all while adjusting to shifting situations and local settings. Regarding agricultural policy frameworks, there is no complete consensus about the optimal approach. Japan's hybrid approach may be more aligned with the problem-solution space's ultimate goals, but this does not necessarily imply that it is superior to Germany's approach. Their policy frameworks are tailored to address the unique challenges and opportunities presented by their respective environments, and the effectiveness of their policies may be dependent on their ability to address the specific problems and prospects of each country's agricultural and food systems, which may differ significantly.

Chapter 5. Discussion

5.1. Implications and suggestions for further research

Implications for policy makers

One of the most huge implications is the identification of policy innovation potential, challenges, and best practices. By a comprehensive assessment and cross-country comparison, the thesis emphasizes the need of addressing wicked problems in agriculture, as well as the importance of mission-oriented and transformational innovation strategies. This would provide crucial information to politicians, researchers, and academics interested in agriculture, sustainability, and innovation policies.

The comparison of agricultural innovation strategies in Germany and Japan emphasizes the significance of context-specific policy solutions that balance the requirements and interests of many stakeholders. Policymakers must identify the particular difficulties and possibilities given by their country's agricultural and food systems, and then modify their policies to meet those needs.

There is no one-size-fits-all response regarding which pathway outweighs another. Each approach in the problem-solving space has advantages and drawbacks, and the most successful strategy is decided by each nation's unique circumstances and goals. It is critical to locate a particular issue in this problem-solution space when building a transformational and mission-oriented innovation strategy so that the wickedness of problems can be appraised and policy initiatives may be focused towards objectives that have broad institutional and public support. As a result, the effectiveness of the policy approach is dictated by a variety of criteria, including the severity of the agricultural sector's difficulties, stakeholder involvement, the degree of government participation and assistance, and the ability to balance economic and environmental concerns.

To achieve inclusiveness and context-specific solutions, policy creation and implementation should promote stakeholder engagement and cooperation. The participation of numerous stakeholders with diverse views and interests may result in more effective policy decisions that balance competing interests and prioritize trade-offs. As a result, policymakers should seek consensus among stakeholders and consider their perspectives in order to design policies that are acceptable to everyone. Policymakers may use reflexive governance, social learning, and foresight strategies to

predict and react to new difficulties, resulting in policies that can be constantly improved and altered as needed. Policy solutions must be customized to each country's agricultural and food systems' particular problems and possibilities. Third, centralized control can guarantee consistency in policy implementation while also allowing for the development of context-specific solutions in collaboration with local stakeholders. Overall, these principles help guide policymakers in designing effective and sustainable agricultural policies that solve the agri-food sector's terrible difficulties.

Yet, the theory would be a good benchmark for lawmakers in other countries attempting to reform farm policy. The cross-country comparison between Germany and Japan would assist in finding areas where one country may learn from the other, as well as the manner in which different policy approaches create different outcomes. This would allow policymakers to adapt and implement policies that are most effective in their own contexts, based on the specific challenges confronting their agricultural sector, the level of government intervention and support, and the ability to strike a balance between economic and environmental concerns.

Finally, the thesis would contribute to the greater debate over agriculture's role in sustainable development and the need for new policies to achieve this. This would be of interest not just to politicians, but also to academics and researchers engaged in agriculture, sustainability, and innovation policy. This thesis would highlight the potential for more ambitious and methodical agricultural policy tools, which might lead to a more sustainable and resilient agricultural industry.

Implications for further research

The thesis focused only on qualitative data, future research should include quantitative data to give a more thorough knowledge of mission-oriented and transformational agricultural innovation methods. Large datasets might be analyzed to find patterns and trends in policy implementation and results.

Moreover, while the thesis acknowledged that different stakeholders may have different perspectives on the problem and potential solutions, it did not go into detail about the role of stakeholder engagement in developing and implementing mission-oriented innovation policies. Future study should look at how stakeholder involvement can be used to create more effective policies that meet the needs and interests of various groups.

Another suggestion is that there is a need to explore the applicability of mission-oriented innovation strategies in emerging countries as well as how such policies can be tailored to suit the particular issues that developing-country agri-food systems are facing.

There are some possible research questions at a starting point for future research: How can mission-oriented agricultural innovation policies be developed to solve the wicked problems confronting developing-country agriculture? What are the contextual elements that impact policy creation and implementation in different nations, and how can these aspects be accounted for in agricultural policy comparative studies? How can TIP and MIP strategies be incorporated into current agricultural policies and efforts in order to enhance long-term agricultural development?

5.2. Limitations

Limitations of the thesis design

The method of content analyses adopted in this paper is the qualitative method. These datasets are not statistically representative, but they do give a thorough knowledge of the many forms of TIP and MIP, as well as agriculture-related literature, that are primarily used for agricultural sustainability. The systematic review method is based on the selection of relevant literature based on specified search criteria, which may result in the exclusion of valuable research that did not satisfy the search keywords. It is constrained by the quality and availability of available literature. There may be gaps in the literature on mission-oriented and transformational innovation strategies in agriculture, especially in connection to wicked problems, in the case of this thesis. Also, the quality of the studies may vary, which may have an influence on the dependability of the findings. Moreover, the researcher's personal prejudices or assumptions could influence the interpretation of the literature.

Another drawback is the difficulty in recognizing and defining the limits of the problem-solution space of Wanzenböck et al., 2020. The issue-solution space is a complicated and dynamic notion, and various stakeholders may understand the problem and possible solutions differently. As a result, the study results and suggestions may be ambiguous and imprecise.

The emphasis on established theoretical frameworks may cause essential contextual aspects to be overlooked, which may have an influence on the success of policy interventions. Such theoretical frameworks may oversimplify the complexity of agriculture's wicked issues, resulting in insufficient policy responses or incomplete suggestions. Moreover, the assumptions and biases inherent in the problem-solution space may impact the selection of criteria for assessing policies.

Limitations of the cases selected

The thesis focused on the context of developed countries in the OECD, notably agricultural policy in Germany and Japan. Comparing policies and practices across nations may be instructive, but it has numerous limits. The environment, culture, and history of any nation may impact policy formation and execution, making direct comparisons impossible.

Nonetheless, the study's generalizability to other countries or places has certain limitations. The study's applicability to other parts of the world was limited due to the differences in agricultural policy and practices between Germany and Japan, as well as the difficulties they faced. Another limitation was a lack of data on transformative and mission-oriented innovation policies, which might limit the depth and breadth of the study as well as the conclusions that could be drawn. Moreover, due to the language barrier, important information in German or Japanese may be excluded from the research, resulting in a skewed image of the policy environment in these countries. Additionally, although all policies assessed in this cross-national analysis are given identical weight, it is possible that they might not have the same impact on agricultural development in Germany and Japan.

Conclusion

Numerous wicked problems such as climate change, soil degradation, and biodiversity loss confronting the agricultural industry, necessitating transformative and mission-oriented policy. The purpose of this thesis was to examine the potential of mission-oriented and transformative innovation policies in tackling wicked problems in agriculture. The thesis developed a systematic literature review and cross-country comparison to evaluate the effectiveness of innovation policies in Germany and Japan. The research questions of this thesis were as follows: observing the the limitations of the innovation policy in the agricultural sector, how are strategy and design approaches in problem-solution space are productive for mission-oriented and transformative innovation policy in agriculture to tackle wicked problems and how are they reflected in the practical innovation policy in the national context of Germany and Japan?

The thesis demonstrated that the wicked problem in the agriculture industry are characterized by complexity, uncertainty, and contestation, making it challenging to identify a single solution. The thesis found weaknesses of the innovation strategy in the agricultural sectors, including pitfall of oversimplification, narrow focus, fragmentation and lack of coordination via a systematic literature review. These restrictions have led to an insufficient response to the sector's pervasive terrible challenges.

To overcome these restrictions, the problem-solution space of Wanzenbock et al (2020) is a valuable and effective tool that takes into account the problem's context and multi-dimensions. The problem-solution area should be treated with an emphasis on co-creation, experimentation, and learning, while taking the different viewpoints and expertise of the stakeholders into consideration.

The thesis also researched the innovation policy practices of Germany and Japan and discovered that both nations have adopted mission-driven and transformational agricultural innovation programs. I compared these systems by analyzing 11 high-level policies. In spite of the fact that both nations recognize the significance of addressing wicked problems in the agriculture sector, there is no perfect unanimity over the ideal method, according to the results. The effectiveness of these policies may depend on their ability to meet the unique challenges and opportunities of each nation's agricultural and food systems, which may differ greatly.

The findings show that tackling wicked problems in agriculture requires a thorough and collaborative strategy that considers the complexity of the challenges and the variety of stakeholder views. There is no one-size-fits-all solution to wicked problems, and that any method in the field of problem-solutions has both strengths and flaws. Thus, while building a transformational and mission-driven innovation strategy, it is essential to position a particular issue in this problem-solution space so that the wickedness of problems can be evaluated and policy initiatives may be focused towards objectives with broad institutional and public support.

Future research must integrate quantitative data to provide a more complete knowledge of mission-driven and transformative agricultural innovation techniques, according to this study. Future research should also examine how stakeholder participation may be used to develop more effective policies that suit the needs and interests of diverse groups. Lastly, the thesis would add to the larger discussion on the role of agriculture in sustainable development and the need for new policies to accomplish this.

In conclusion, the thesis emphasizes the features of wicked problems in agriculture as well as the necessity for a thorough and collaborative strategy to resolve them. Transformational and mission-driven innovation policy may be a useful instrument for addressing these issues, but it must be constructed in a manner that accounts for the range of stakeholder viewpoints and the complexity of the issues. I believe that our research will lead to a better understanding of how to handle wicked challenges in agriculture and pave the path for a more successful and sustainable innovation strategy in this industry.

Appendix

Overview of articles included in the full text analysis.

Author (Year)	Title	Souce
BMEL (2019a)	2035 Arable Farming Strategy - Prospects for Productive and Diverse Crop Farming	Organization website
OECD (2020a)	Agriculture and water policies: Main characteristics and evolution from 2009 to 2019 Germany	Organization website
Wanzenböck, I., Wesseling, J., Frenken, K., Hekkert, M., & Weber, M. (2020)	A framework for mission-oriented innovation policy: Alternative pathways through the problem-solution space	Scopus
Kirschke, S., Häger, A., Kirschke, D., & Völker, J. (2019).	Agricultural nitrogen pollution of freshwater in Germany. The governance of sustaining a complex problem	Scopus
OECD (2020a)	Agriculture and water policies: Main characteristics and evolution from 2009 to 2019 Germany	Organization website
BMBF & BMEL (2022)	Bioeconomy in Germany: Opportunities for a bio-based and sustainable future	Organization website
MAFF (2020b)	Direct payments for Environmentally Friendly Agriculture	Organization website
BMEL (2022a)	Going peat-free, protecting the climate: The Peat Use Reduction Strategy of the Federal Ministry of Food and Agriculture	Organization website
Matsumoto, M. (2021)	Japan's initiatives on Smart Agriculture. Economic Research Institute for ASEAN and East Asia	Organization website
MAFF (2021)	Measures for achievement of Decarbonization and Resilience with Innovation (MeaDRI)	Organization website
Parks, D. (2022)	Directionality in transformative innovation policy: Who is giving directions?	Scopus
Levidow, L., Birch, K., & Papaioannou, T. (2012)	EU Agri-Innovation Policy: Two contending visions of the bio-economy	Scopus

Author (Year)	Title	Souce
Peters, B. G., & Pierre, J. (2014)	Food policy as a wicked problem: Contending with multiple demands and actors	Google Scholar
BMUB (2016)	National Programme on Sustainable Consumption - From Sustainable Lifestyles towards Social Change	Organization website
Termeer, C. J., Dewulf, A., Breeman, G., & Stiller, S. J. (2013)	Governance capabilities for dealing wisely with wicked problems	Scopus
Termeer, C. J., Dewulf, A., Breeman, G., & Stiller, S. J. (2013)	Governance capabilities for dealing wisely with wicked problems	Google Scholar
Casula, M. (2022)	Implementing the transformative innovation policy in the European Union: How Does Transformative Change OCCUR IN member states?	Scopus
MAFF (2019)	New Basic Policy on the Promotion of Organic Farming	Organization website
BMEL (2022b)	Organic Farming in Germany	Organization website
Dentoni, D., Hospes, O., & Ross, R. B. (2012)	Managing wicked problems in agribusiness: The role of multi-stakeholder engagements in value creation: Editor's Introduction.	Google Scholar
MAFF (2020c)	SCAFFF2030	Organization website
Karo, E. (2018)	Mission-oriented innovation policies and bureaucracies in East Asia	Scopus
Mazzucato, M. (2018)	Mission-oriented innovation policies: Challenges and opportunities	Scopus
Kattel, R., & Mazzucato, M. (2018)	Mission-oriented innovation policy and dynamic capabilities in the Public Sector	Scopus
OECD (2021)	Agricultural Policy Monitoring and evaluation 2021	Organization website

Author (Year)	Title	Souce
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