

# A Global Correlational Analysis of Bioeconomy Policy Problematizations

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## Abstract

Bioeconomy is considered as a political and societal project that aims at transforming the fossil-based to a bio-based, resource-efficient and circular economy. Bioeconomy-related policies have been published in more than 50 countries and scholars have increasingly studied bioeconomy policy from different angles, focusing particular on bioeconomy policy goals and instruments (e.g. Dietz et al. 2018). To date, however, no study has looked at bioeconomy policy problematizations, that is, how the policy's authors frame problems as discursive justification of their policy (Feindt et al. 2020), which, we argue, constitute a central quality of policy problem structuring. Relatedly, no efforts have been undertaken to understand why problematizations might differ across bioeconomy policies and countries. To address this gap, we first conduct a systematic qualitative content analysis of 78 policy documents from 50 countries to identify patterns of bioeconomy policy problematizations across the globe. In a second step, building on the new policy design perspective (Howlett 2014), we try to understand origins and associations of these patterns. To that end, we identify a range of political, environmental, and socio-economic conditions that could be linked to different thematic problematization orientations and probe their association using correlational analysis.

**Keywords:** policy problematization, bioeconomy, problem structuring

## 1. Introduction

Bioeconomy is understood as the range of economic activities based on the utilization, management and exploitation of biological processes and renewable resources for agricultural and industrial purposes (GBC, 2018). Bioeconomy constitutes an emerging political project loaded with the transformative ambition to substitute fossil fuels with renewable resources, biomaterials, bioenergy and biofuels in closed material cycles (Staffas et al., 2013; Scarlat et al., 2015; Murray et al., 2017). A rapidly growing number of national and international organizations and actors see the transformation towards a sustainable bioeconomy as an important approach to address various problems and conflicts of our time (e.g. food security, poverty, climate protection, health risks, sustainable energy supply, biodiversity conservation) (Philp, 2018, IACGB 2020). Thus, a sustainable bioeconomy is considered as an essential element of international and regional political agendas to address the EU Grand Societal Challenges, achieve the United Nations Sustainable Development Goals (SDGs), and contribute to the post-COVID-19 recovery.

While the exact meaning and scope of the bioeconomy remains unsettled (Bugge et al., 2016), its concept has become the object of political contestation (Vivien et al., 2019), and its policies have triggered discourses and entered debates on various sustainability-related issues (e.g. the food-energy dilemma, the environment-development nexus, and the society-technologization challenge). The global proliferation of bioeconomy-related policy statements is epitomized in the sprawling adoption of bioeconomy policies by about 50 countries over the last decade (Meyer, 2017; Dietz et al., 2018). While bioeconomy policy goals and instruments are increasingly discussed, disputed, and analyzed by political groups, societal actors, and scientific communities (e.g. Hausknot et al. 2017, Meyer 2017, or Dietz et al. 2018), dealing with policy problematizations has been kept on the sidelines. In particular, scholarly literature on bioeconomy policy problematizations is missing.

In general, problematization reflects the way we understand, frame, and present an issue, thereby shaping how we conceptualize its setting and deal with it to find solutions. Problematization is inherent in policy that seeks to recognize, describe, and solve policy problems (Colebatch, Hoppe, and Noordegraaf 2010). It indicates the narratives and meanings surrounding a policy, influences the selection of policy goals

and instruments, and shapes policy problem structuring understood broadly as the policy formulation of a problem situation that worries society (Turnbull 2006, 6; (Dunn 2018).

In this paper, we address the problematizations of bioeconomy policies, i.e. the thematic foci problematized in bioeconomy policy documents and used to justify policy goals and instruments to promote bioeconomy. In particular, we identify the types of bioeconomy policy problematizations, that is, which social, environmental, economic, and political concerns and issues different governments choose to highlight in bioeconomy policies, and therefore, incorporate into discourses, and translate into political action. We, finally, want to explore countries' variation in their bioeconomy problematization structures. To do so, we identify a range of potential explanatory context conditions and correlate them with policy documents' propensity to employ different types of problematizations.

In the following sections, we first describe the concept of (bioeconomy) policy problematization while putting emphasis on the link between policy problematization and politics, and present our expectations. We then explain our methodology and particularly the case selection, operationalization of problematizations, dependent and independent variables, and data analysis strategy. In the fourth section, we present our findings on the salience of problematizations in bioeconomy policies and the link between problematizations and country characteristics and assess our expectations. The concluding section discusses the findings, reflects on the limitations of our study, and presents suggestions for future research.

## **2. Concept and Theory**

### ***2.1 Conceptualizing Policy Problematization***

We refer to policy problems as concerns that call for collective deliberation (Turnbull 2005). Policies represent problems by problematizing phenomena that are associated with specific issues, challenges, conflicts, and changes or solutions (Bacchi 2012, 4). Policy problematization, then, is about creating the conditions to deal with problems by considering problem-related ideas, narratives, practices, and solutions, thereby “developing opportunities, i.e. preparing somehow the ground for solutions” (Webb 2014, 369). Fundamentally, there is no problem solving without

problem setting and “the questions we ask shape the answers we get” (Rein and Schon 1993, Turnbull 2006, 6–7).

Scholarly literature on policy problematization distinguishes between the interpretivist and the Foucauldian approach. Interpretivists define and form problems by framing issues. In the interpretive tradition, policy makers shape particular interpretations of problems that create shared understandings of problems in order to frame and justify collective action (Bacchi 2015, 5). In so doing, policy makers allow for a reformist agenda. Foucault-influenced poststructuralists, by contrast, go beyond the conceptualization of policy problematizations as problems to be solved (by policy makers). They analyze problematizations in policies in terms of scrutinizing their meanings and implications rather than dealing with how policy makers shape diverse problem interpretations to justify solution approaches and accordingly policy instruments (Bacchi 2015, 8). Thus, Foucault-influenced poststructuralists continually question political governance.

Based on Bacchi's (2015, 2) notion that researchers give problematization a meaning that fits their case under study, our policy problematization approach lies somewhere in the middle, though tilting closer towards the interpretivist approach. This means that we consider policy problematization as a combination of displaying, framing and interpreting problems that shapes and is shaped by discourses (Hoppe 2018, 5). Furthermore, we associate problem posing with problem solving; notwithstanding that solving goes along with expert knowledge while posing links concerns to public discourse and deliberation (Turnbull 2005). For the purposes of this paper, “policy problematization constitutes the [issue-based] discursive justification of a policy, articulates its ideational framework, and links the policy to broader societal discourses” (Feindt, Proestou, and Daedlow 2020, 641). Policy problematization, or in other words framing a particular policy problem, is associated with why a particular approach is justifiable to broader society as a political goal that in turn legitimizes policy solutions or instruments (Holland 2014). For example, describing concerns about environmental resources and bio-based production systems in a policy may justify the policy goal of more efficient and circular biomass use that legitimizes infrastructure policy instruments such as the promotion of biorefineries.

## ***2.2 The Politics of Policy Problematization***

Rather than reflecting outcomes of technocratic and apolitical deliberations, problematizations should be considered as political acts (Hoppe 2018, 14) resulting from political decisions (Turnbull 2006, 8). Policy problematizations demonstrate what policy makers treat and present as problems, show what kind of problems they prioritize, and reveal the government's political attitude (Bacchi 2015, 4). Policy problematizations are important because the way problems are interpreted reflects the debates and processes within the agenda setting stage.

As exemplified by Turnbull (2005), the problem of street crime can be interpreted as lack of policing that is translated by expenses for more police to patrol the streets. If, however, policy makers interpret street crime as a problem of joblessness or drug abuse, the policy response could rather focus on public spending for more training and integration programs. Conversely, climate change can be framed as an urgent problem of global warming that requires international strategy development towards ecological modernization; or as an agenda of a corrupt scientific elite that advocates global concerns rather than national values and therefore needs to be removed from the political agenda (Müller and Kruse 2021, 547–48; Lockwood 2018). As such, the framing of a problem significantly affects the solutions that can be chosen – solutions which are likely of distinct interest to different political groups.

The content and formulation of a policy problem are integral parts of how the problem is constructed that in turn is shaped by politics (e.g. interests of political groups, power constellations, and debates) (Dunn 2018). Policy problematization is a function of problem structuring, because it concerns what is included or excluded in structuring a policy problem (Hoppe 2018, 1). In other words, the issues policy makers choose to identify as worthwhile to ponder and discuss show the quality of problem structuring (Hoppe 2002, 305–6), and accordingly, the policy design ambitions. Assuming policy makers choose to highlight environmental sustainability rather than clean energy when it comes to environmental concerns, their choice might show to what extent they tend to promote a more abstract (socio)ecological or a more tangible techno-environmental orientation of policy design respectively. At the end of the day, which orientation they prefer is determined by contextual knowledge, public debates, global

discourses, and the political interests of stakeholder groups and the government they represent (Howlett and del Rio 2015).

An example showing the link between policy problematization, problem structuring and politics is the Dutch aviation case given by Hoppe (2002, 305–6). In the mid-1990s, the Dutch government invited multiple stakeholders to jointly deliberate on the future of civil aviation in its economy, specifically whether the country's largest airport should be expanded. Critically, the government framed the debate by asking "Should further growth of civil aviation be accommodated; and if so, how?", hereby already structuring the problem as a mere matter of "growth/no-growth". Nevertheless, the 80 distinct stakeholders came up with a diverse set of own frames superseding the simplistic pro-/anti-growth dichotomy, generating a more complex, innovative, and comprehensive set of issues and proposals to be considered. Eventually, however, the government chose to ignore these frames, adhere to its original simplistic dichotomous framing, and, in line with its fundamental political interest, to consequently continue the entrenched policy orthodoxy of tolerating civil aviation growth in terms of expanding the airport. The Dutch aviation example, thus, shows two things. First, policy makers may actively structure and problematize problems in a way that serve their political interests and ideally limits space for alternative, less-desired frames. Second, they can nevertheless include other – potentially oppositional – stakeholders to generate the semblance of inclusiveness and hereby legitimacy. Critically, similar dynamics are likely in the context of bioeconomy policy making.

### ***2.3 Bioeconomy Policy Problematization***

Bioeconomy policy is a nexus policy including multiple problematizations, goals, instruments, sectors and bio-based production systems. What kind of problematizations are named and prioritized in bioeconomy policy mixes goes along with how bioeconomy-related problems are structured. For instance, a salience of economic problematizations and particularly of market development and business environment may show a problem structure focusing on economy and very likely on related solutions such as direct support instruments (e.g. subsidies for producers, credit schemes).

In this paper, we ask which types of bioeconomy policy problematization are presented in bioeconomy policy documents and how country characteristics correlate with these problematization types. Bioeconomy policies reflect social, political, environmental and economic ideas, trajectories and settings, and often place special emphasis on technological development and innovation (Feindt, Proestou, and Daedlow 2020). Based on this, we distinguish between five fundamental and intuitive bioeconomy policy problematization supra-categories, namely "Economic", "Environmental", "Social", "Political", and "Research, Innovation & Technology". "Economic" refers to economic-related subcategories such as market development, business environment, biomass management and productivity. The "Environmental" supra-category includes, among others, environmental concerns about resources and bio-based production systems and references to climate change and environmental sustainability. Under "Social" we categorize the problematizations that deal, for instance, with behavioral and demographic dynamics, human health, and quality of life. The "Political" supra-category refers primarily to regulation, governance, and political competition and cooperation at international level while the "Research, Innovation & Technology" category consists mostly of issues related to biotechnology advancements, novelties, and the development of skills and knowledge.

#### ***2.4 Expected Conditions for Bioeconomy Policy Problematization Variation***

In addition to knowing the extent to which bioeconomy-related policy documents contain different types of problematizations, we also want to explore why such elements might be more present in some policies than in others. Building on the recent literature on policy design (Howlett 2014), we argue that this likely depends on the policy design space (Feindt, Proestou, and Daedlow 2020), i.e. the intent of the policy designers and a range of context conditions that affect its ability to design and implement policies (Howlett 2018; Howlett and del Rio 2015). In the following, we discuss for each supra-category what kind of conditions we expect to be associated with their frequency in a policy document.

Focusing first on the conditions we expect to affect the degree of economic problematizations, we suppose that strategies written by environmental ministries (rather than, say, ministries of industry or the economy) or governments including

environmental (e.g. “green”) parties will have *less* of a focus on economic problematizations as environmental authorities and parties will put more weight on environmental topics (Spoon and Williams 2021). Relatedly, we also think environmental topics might trump economic topics in countries with significant climate change exposure, which is why we expect to see *less* economic problematizations there. In contrast, we expect economic problematizations to be *more* relevant in low-income countries, given that economic concerns tend to be more imminent here. Furthermore, we expect that countries with higher education expenditure will focus on economic problematizations because they follow a competitiveness framing linked to education.

With regard to the problematizations of environmental concerns, we first assume that this will be more pronounced in strategies written by democratic regimes. Fundamentally, democracies allow more room for civil society organizations (CSOs) and interest group formation (Warren 2011), which has been particularly important with regard to the formation of environmental advocacy coalitions, parties, and CSOs (Buergin and Kessler 2000; Giugni and Grasso 2015; Ward 2008; Wurster 2013). Hence, we expect such concerns to be more explicitly vocalized in democratic countries’ policy documents. Moreover, and mirroring the arguments in the previous paragraph, we expect strategies to problematize environmental concerns more if written by an environmental authority and/or a government including an environmentally-oriented party. Indeed, using expert surveys on party positions and content analysis of national party manifestos, Carter (2013) found that green parties still focus very much on environmental issues and other major parties still do not see environmental issues as a priority. That being said, his analyses show that more economically left-oriented parties give larger consideration to environmental issues than more right-oriented parties, which is why we expect to see the same in our data (see also Neumayer 2004). And, again mirroring the argument in the previous paragraph, we expect that governments facing greater climate change exposure will be more likely to problematize environmental concerns, as there is likely a greater sense of urgency and necessity to address them (Bruckner 2012; Dolan 2021). Finally, arguing along the lines of the environmental Kuznets curve, we assume wealthier societies (and their policy makers) to be more sensitive to environmental



concerns, and as such problematize them more in their policies (Destek and Sarkodie 2019).

With regard to the degree of social problematizations, we would again expect the regime type to play a role. Specifically, we assume that more democratic regimes put greater emphasis on social matters given the electoral need to focus on the wider public rather than just a small elite selectorate (Bates and Block 2013). Moreover, we expect more left-oriented governments to focus more on the problematization of social aspects as these are among their core political themes (Farstad 2017). Relatedly, we expect that countries with more populist governments - specifically those with high levels of people-centrism - to also have social concerns more at hand, thus, being more likely to problematize them in bioeconomy policies as well.

Looking at the problematization of political concerns, we would expect the level of state capacity in a country to be the largest predictor. Specifically, we would expect countries with lower state capacity to have higher shares of political problematizations, since building up governance and adequate regulation (perhaps the two biggest subcategories of the political supra-category) are of particular importance in such countries (Khan 2002; Besley and Persson 2010). Relatedly, since countries with lower levels of development tend to also have lower levels of state capacity, we would also expect correlation here, that is, countries with lower levels of development will mention political concerns more. Given that more populist regimes are also more likely to talk (critically) about political topics and shortcomings (such as the lack of bottom-up decision making) and matters of international political competition (Huber et al. 2021; Moffitt and Tormey 2014; Wirth et al. 2016), we would also believe there are more likely to problematize political topics.

The last supra-category is the "Research, Innovation & Technology" supra-category. Above all, we would expect that governments that spend a lot of their budget in this area to be more aware of it and therefore problematize it more. At the same time, we could imagine countries that do not yet do very well in this field (e.g. have fairly few patent applications per capita), see this as a problem and therefore mention it more. Lastly, recent studies have found that more populist parties and governments tend to be more mistrusting of the sciences (Huber et al. 2021; Mede and Schäfer 2020; Merkley 2020). One might therefore either expect more populist governments to

problematize such issues more (with a skeptical undertone) or less should they not want to acknowledge the topic at all.

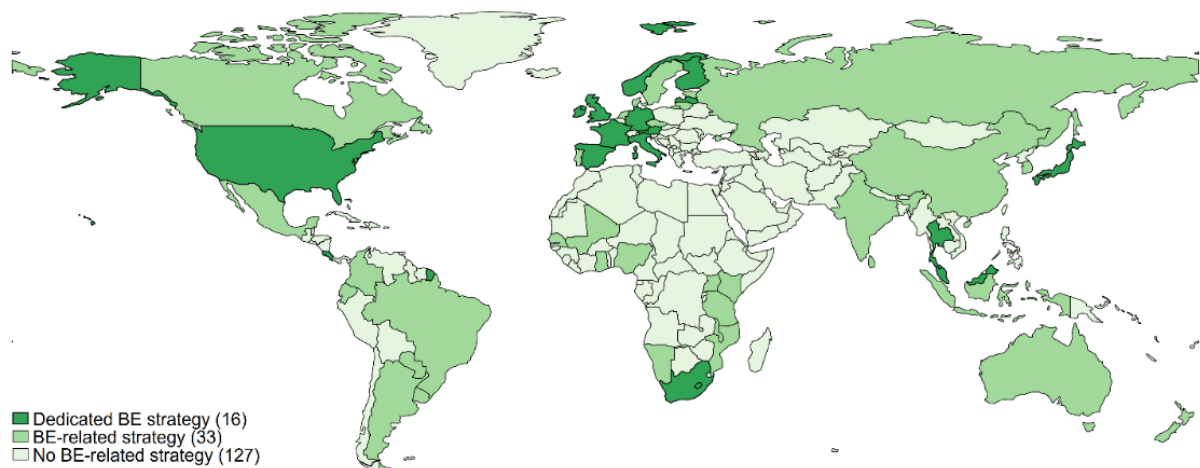
### **3. Methods and data**

To analyze and explore the character and variations of problematizations in bioeconomy-related policy documents we conduct a systematic qualitative-quantitative content analysis of 78 policy documents from 50 countries (mapped in Figure 1). Coded text-segments are aggregated to document-level problematization categories. Their patterns are mapped using different descriptive statistical illustrations and correlated with potential explanatory variables. The following section discusses the document selection criteria, specifies the construction and operationalization of our key problematization supra-categories and explanatory variables, and concludes with a presentation of our analysis strategy.

#### **3.1 Case selection**

Our aim was to analyze all documents that most directly and comprehensively capture the contemporary bioeconomy orientation in a country. Doing so required an inventory of all bioeconomy-related policy documents. Relying on lists compiled by the 2018 and 2020 Global Bioeconomy Reports (IACGB 2020; Dietz et al. 2018), and our own research, we identified a total of 288 potentially relevant bioeconomy or bioeconomy-related policy documents. Since most of these documents did not represent the most direct or recent characterization of contemporary bioeconomy policy in a country, we further reduced this list in two steps. First, 16 countries have published holistic bioeconomy strategies, that is, strategies that are dedicated to promoting the bioeconomy explicitly in its entirety. In these cases, we exclusively analyzed a country's most recent holistic bioeconomy strategy, since it represents the most direct, encompassing, and effective depiction of a country's prevailing bioeconomic vision. Second, for countries that did not publish holistic bioeconomy strategies, all relevant bioeconomy-related documents entered our analysis. We considered documents to be bioeconomy related if their focus relates directly to at least one of the main areas of the bioeconomy, i.e. biotechnology, biomass, biofuels, biorefineries, bioindustries, bioenergy, the blue economy, or circular economies. If a country had several strategies per area (e.g. two biofuel strategies), only the most

recent was selected. While all related to the bioeconomy, these same-country documents are substantially distinct and typically promulgated in different years by different agencies and governments. Figures depicting the frequency of documents by document type and year of publication can be found in Appendix 1 and 2.



**Figure 1.** Geographical coverage of coded bio-related documents

### **3.2 Operationalization of Problematization and Dependent Variables**

The aim of our analysis was to create variables that capture the types and extent of problematizations in bioeconomy policy documents. This was done in several steps. First, conventional content analysis was employed to the entire text corpus to inductively compile a comprehensive list of potentially relevant codes. Apart from topics referring directly to problematizations – i.e. the strategies’ problem-focused justifications of why the respective strategy or a bioeconomy transformation more generally was necessary – our project was also interested in bioeconomy policy documents’ goals, instruments, and scope.

These initial codes were then categorized and combined into a structured coding scheme. Critically, 227 distinct topics related to problematizations were identified and categorized into the five distinct supra-categories "Economic", "Environmental", "Social", "Political", and "Research, Innovation & Technology". Each of these supra-categories was further disaggregated into up to fifteen distinct subcategories, detailed in the next section. It should be noted that in rare instances, codes and subcategories could be assigned to more than one supra-category. The subcategory “employment”,

for example, was assigned to both the “Economic” and “Social” supra-category. Using this scheme, we then systematically coded all documents using the qualitative content analysis software MAXQDA over the course of six months.

In a third step, we aggregated the information from the content analysis to create two distinct types of variables. First, variables that depict a document’s text share (in per cent) focusing on problematizations vis-à-vis a document’s entire coded text area (that was not only coded as problematization but with our goal, instrument, or scope condition codes). These variables help to analyze to what extent problematizations in general play a role in bioeconomy-related policy documents. Second, we created variables that depict which percentage of a document’s text coded as problematization-oriented is coded with our specific problematization codes, subcategories, or supra-categories. These help us to assess the substantial focus of problematizations in bioeconomy-related policy documents and also serve as dependent variables in our correlational analysis. Note that because the same text segment can be coded with different codes belonging to different subcategories and supra-categories and because some codes are assigned to distinct supra-categories, the combined percentage of such variables will typically go beyond one hundred per cent.

Appendix 3 provides summary statistics for all variables used in the analysis. Appendix 4 shows the values for our problematization variables for all 78 policy documents.

### **3.3 Independent variables**

To conduct an exploratory analysis of which factors might shape the type of problematizations, we integrate independent variable data from several major databases. To operationalize the degree of *Democratization* in a country, we employ the Polity2 combined score (Marshall, Gurr, and Jaggers 2019) which measures the regime type or level of democracy from a scale from -10 (most autocratic) to 10 (most democratic). Thus, higher values indicate more democracy.

Second, and third, we try to capture the extent to which environmentally-oriented authorities or parties were involved in the policy process in two ways. *Environmental author type* codes the degree to which more environmentally-oriented authorities

were involved in authoring a policy. The variable is self-coded as '4' if an environmental authority was involved in authoring the policy; as '3' if the policy was authored by the whole government (assuming that an environmental ministry would have some say in this); '2' if an agricultural or innovation related ministry wrote the policy; and finally, '1', when a ministry of economics or industry authored the policy. And *Environmental governing party* is a dichotomous variable that captures whether (1) environmental issues are among the three issues most relevant issues for a governing party's effort to gain and keep voters (coded "1") – or not (coded "0"). It was generated through a combination of the VDEM V-Party Dataset (Lindberg Staffan I. et al. 2022) variables v2pasalie\_12 ("1") and v2pagovsup ("0" or "1").

Using the VDEM V-Party Dataset we created two additional variables. *HoG left-right orientation* measures the Head of Government's (HoG) party's overall ideological stance on economic issues from a range of "0" (far-left) to "6" ("far-right"). Higher values indicate more economic right stances of the ruling party. And *HoG people-centrism* measures the HOG's party's "people-centrism", which captures the extent to which it glorifies the ordinary people and identifies itself as part of them, ranging from "0" (it never does this) to "4" (it always does this). Higher values indicate higher levels of, what we interpret as, "populism".

Sixth, the Notre Dame Global Adaptation Initiative's (2021) *Climate change exposure* index further measures the degree to which a system is exposed to significant climate change from a biophysical perspective, independent of socio-economic context. Higher values indicate higher exposure.

Widely used as a proxy for development more generally and social development more specifically, we employ the World Development Indicators database's (World Bank 2021c) *Infant mortality rate*. Here higher values indicate greater infant mortality and thus lower levels of development. To reduce the likelihood of outliers and assure greater normality of the distribution, the variable was log-transformed.

Eighth, we make use of Hanson and Sigman's (2021) capacity score to measure a country's state capacity. It captures states' relative abilities to extract revenue, protect themselves against external threats, maintain internal order, and administer as well

as provide the basic infrastructure necessary to sustain economic activity. It is scaled from -2.31 to 2.96, where higher values indicate greater levels of state capacity.

Lastly, as potential explanators for research problematizations we include two variables. First, *Patents per capita* measures the number of patent applications by a nation's residents filed through the Patent Cooperation Treaty procedure or with a national patent office divided by the population number (and log-transformed to reduce data skewness). Finally, *Education expenditure* measures a government's total expenditure on education as per cent of government expenditure. The underlying patent, population, and education expenditure data was also derived from the World Development Indicators database (World Bank 2021c).<sup>1</sup> To increase the data coverage for better comparability, missing values for both variables were linearly inter- and extrapolated.

### **3.4 Data analysis strategy**

To assess the degree to which different topical categories of problematizations and problematizations more generally are represented within bioeconomy-related documents, we make use of simple descriptive statistics of our dependent variables, mostly depicted below in bar charts. To explore whether the discussed conditions help to explain variation in problematization categories across documents, we revert to calculating classical Pearson product-moment correlation coefficients (or simply Pearson correlations) as our sample size is too small for regression analysis. For Pearson correlation coefficients to be meaningful, the correlated variables must be measured at the continuous level (which is the case for almost all our variables),<sup>2</sup> correlations need to be linear, potential influential outliers should be examined (and prevented in certain cases by log-transforming the data). The latter two criteria were checked using scatter plots of all dependent and independent variable combinations

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<sup>1</sup> To increase the data coverage for better comparability, missing values Patents p.c. (log) and Education expenditure– were linearly inter- and extrapolated.

<sup>2</sup> Environmental author type and Environmental governing party are ordinal variables. We cross-checked our results with more appropriate Point Biserial correlations, which generate the same results.

(see Online Appendix 5). All plots appear to show linear relations and no major influential outliers.<sup>3</sup>

Nevertheless, we want to state clearly that these correlations can only serve as preliminary explorative and visually more efficient descriptive statistics of potential associations between our variables of interest. The inability to address potential omitted variable bias or reversed causality forbids any strong claims of associational validity, let alone, causality. As such, all findings produced here should be consumed with care and be seen as the beginning to more in-depth qualitative or quantitative data collection and analysis.

#### **4. Analysis and findings**

In this section, we assess the problematization-related content of bioeconomy policies based on two distinct rounds of analysis. In the first round, we employ simple descriptive statistics to assess and illustrate the relative frequency and variation of problematization-related codes in bioeconomy policies. In the second, we aim to explore underlying associations of this variation and explain the correlation between country context conditions and problematizations according to our expectations using correlational analysis.

##### ***4.1 Descriptive statistical identification of problematization frequency and variation***

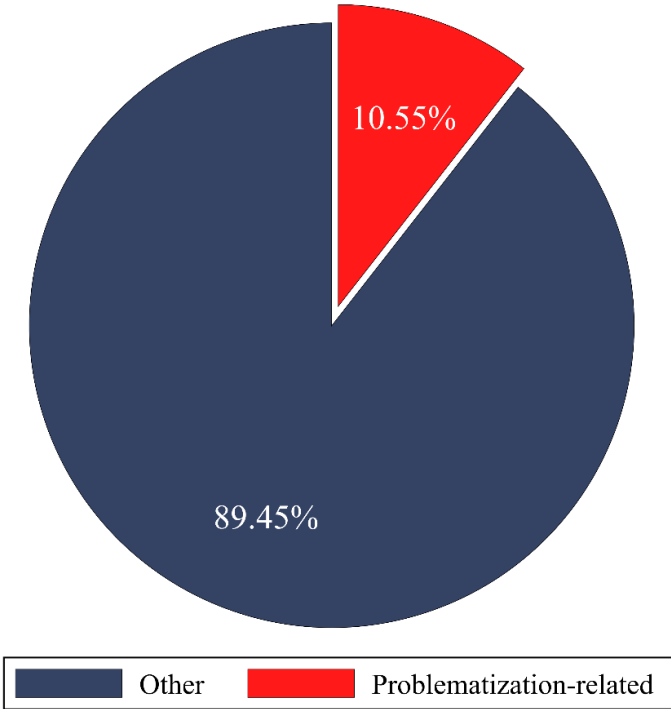
The first question we address is to what degree our text corpus incorporates problematization-oriented codes in general, and specifically, different problematization supra-categories. Figure 2 illustrates the main patterns by describing the text share of problematizations in bioeconomy-related policy documents and Figure 3 shows the share of supra-categories in the text share of problematizations. Several findings emerge.

First, problematization-related codes only represent roughly one-tenth of all identified codes. In particular, problematization-related codes overall can be found in 10,55 per cent of our text corpus while the remaining 89,45 per cent addresses other policy

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<sup>3</sup> Data files and logs will be made available for replication upon publication.

elements e.g. policy goals and policy instruments. There is no percentage standard or typical share of problematization observed or recommended in policy documents. While not particularly large (in comparison, the average space given to the discussion of a strategy's main goals takes up 38% of relevant text), this is still a substantial share. However, one could argue that given the importance of problem structuring for setting goals and solving problems, our finding implies that problematization does not play a major role in bioeconomy policy making.

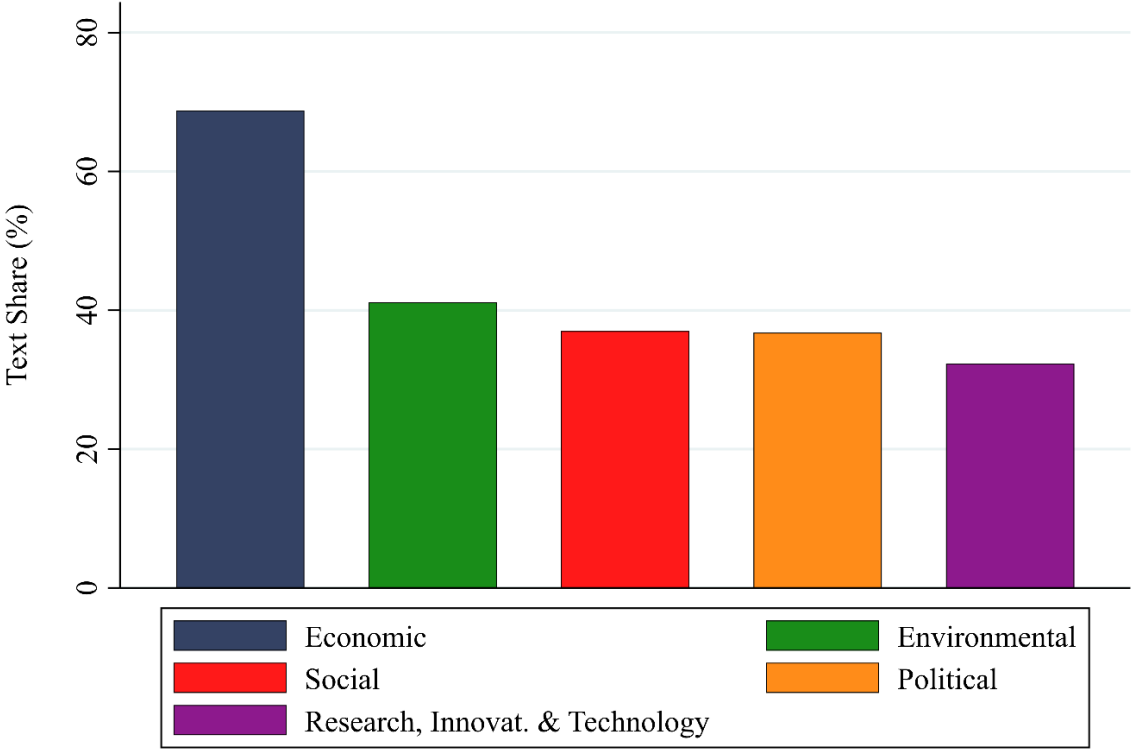


**Figure 2.** Text Share of Problematizations in bioeconomy-related documents (in %)

A second major finding is that the problematization topical categories (supra-categories) do not differ strongly in their respective prevalence with the exception of the supra-category "Economic". Most notably, the supra-categories "Environmental", "Social", "Political", and "Research, Innovation & Technology" were found in less than 41 per cent, 38 per cent, less than 38 per cent, and 36 per cent respectively of the text share of problematizations. In stark contrast, with nearly 70 per cent, the share of the supra-category "Economic" was very high. This is in line with previous descriptions of bioeconomy discourses as being highly economical, focused primarily on promoting the bioeconomy as a means to promoting economic development rather than truly fostering countries sustainability (Hausknot et al. 2017; Vivien et al. 2019).

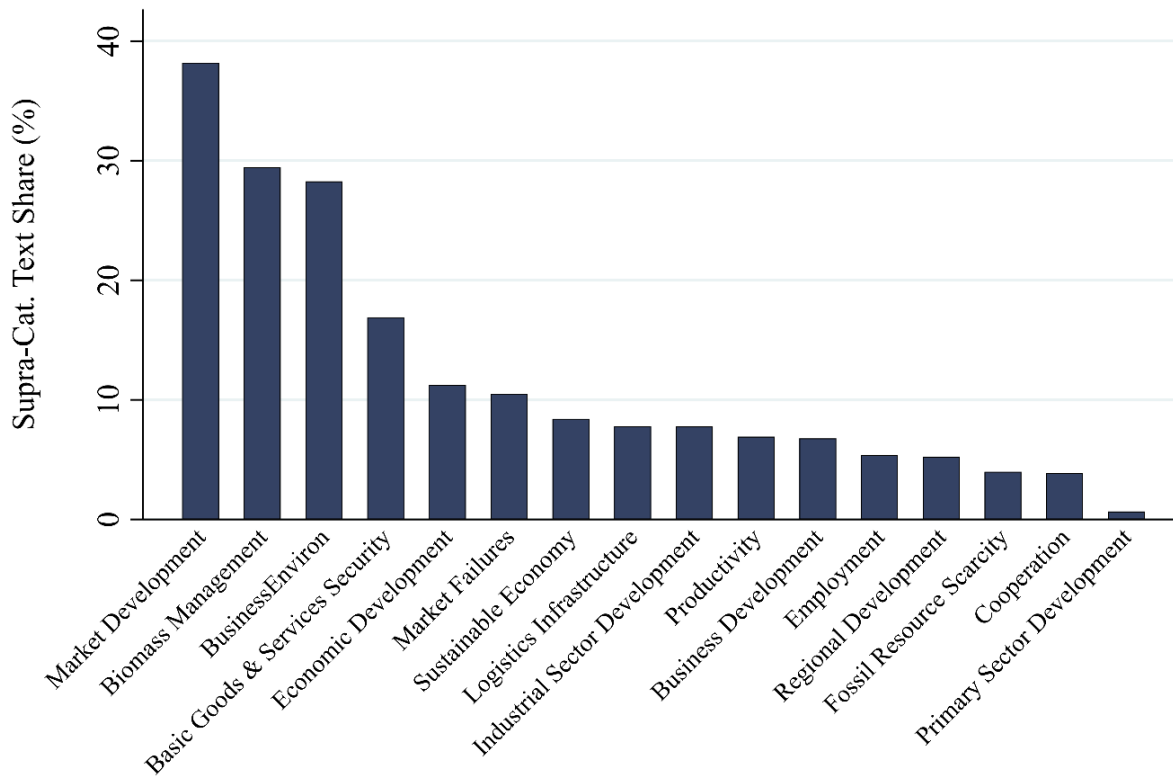


In particular, in the majority of bioeconomy strategies bioeconomy represents a vehicle for increasing economic output and continuing capitalist growth in order to deal with resource scarcity (Hausknost et al. 2017, 6).



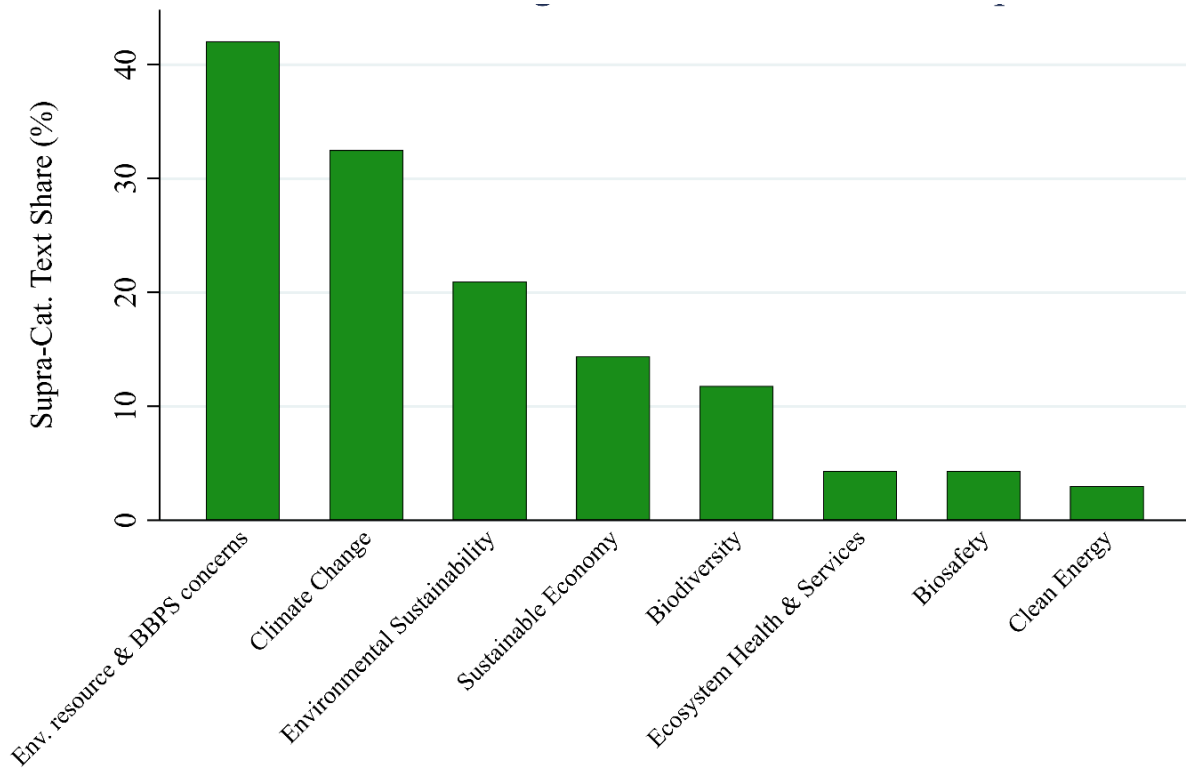
**Figure 3.** Share of Supra-Categories in Problematization Text Share (%)

Figures 4, 5, 6, 7, and 8 further depict which percentage of a document’s text coded as problematization-oriented is coded with our distinct subcategories (after disaggregating the supra-categories into their respective subcategories). First, within the "Economic" supra-category represented by 16 codes (or subcategories) (Figure 4), “Market Development”, “Biomass Management” and “Business Environment” appear to be essential with the share of “Market Development” reaching nearly 40 per cent. This is in line with the hitherto dominant narrative of a biomass-based bioeconomy for energy production and development of biomass markets (Vivien et al. 2019) as well as the recent discussion about biomass alternatives for biorefining.



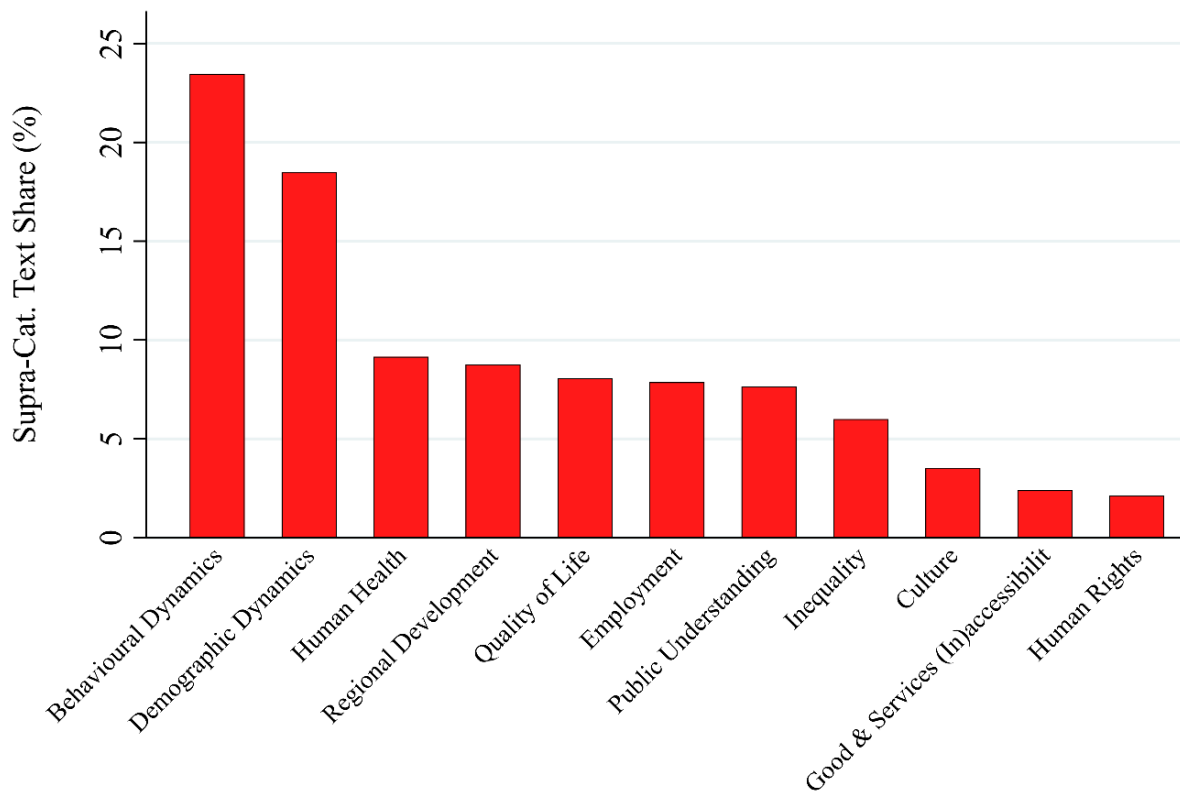
**Figure 4.** Share of Sub-Categories in the 'Economic' Supra-Category

Second, among the eight environmental subcategories (Figure 5), “Environmental Resource & Bio-based Production System Concerns” constitute the most prevalent subcategory with a share of more than 40 per cent while “Climate Change” and “Environmental Sustainability” have a relatively high though less significant share of roughly 30 per cent and 20 per cent respectively. This is in line with the argument that the bioeconomy transition targets the grand challenge of climate change (Bugge, Hansen, and Klitkou 2016), although concerns about environmental resources and production systems are not substantially addressed within the discourse.



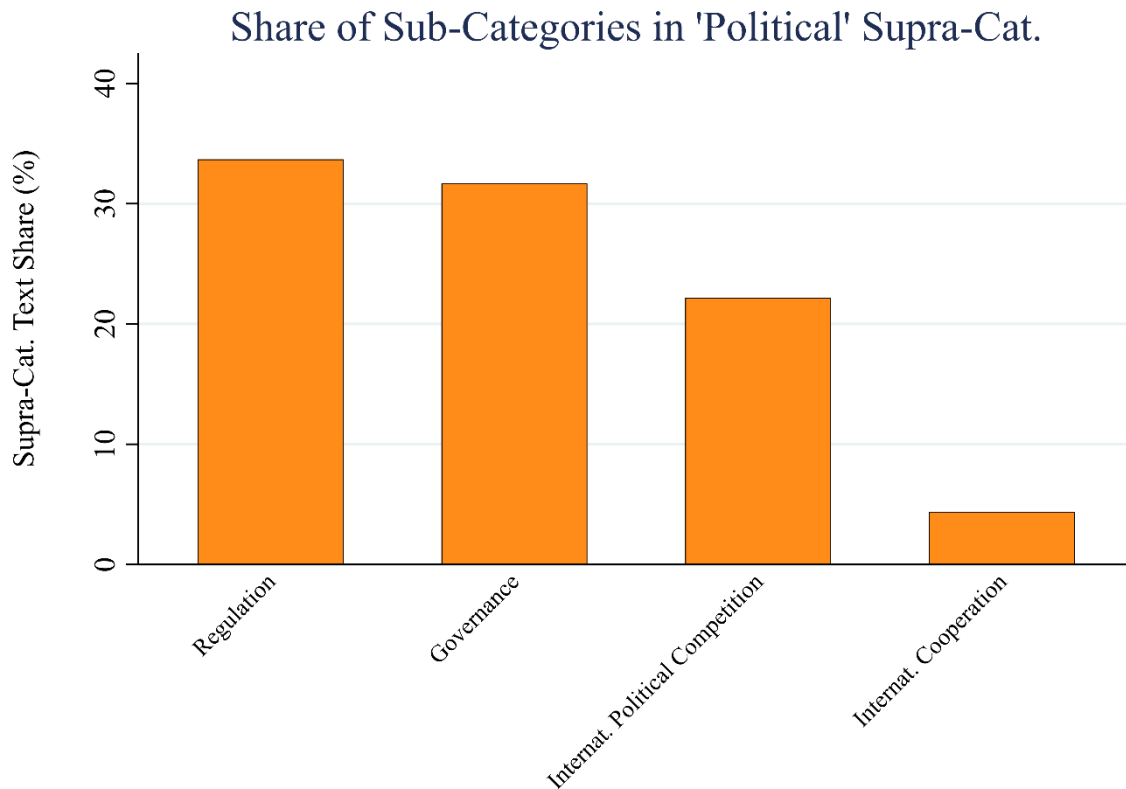
**Figure 5.** Share of Sub-Categories in the 'Environmental' Supra-Category

Third, “Behavioral Dynamics” and “Demographic Dynamics” are the most important social topics as shown in Figure 6 that illustrates the “Social” supra-category represented by 11 codes. This is only partly in line with the literature that addresses mainly human health, nutrition, and rural development when it comes to social considerations that, however, are generally missing in the bioeconomy discourse (D’Amato et al. 2017).



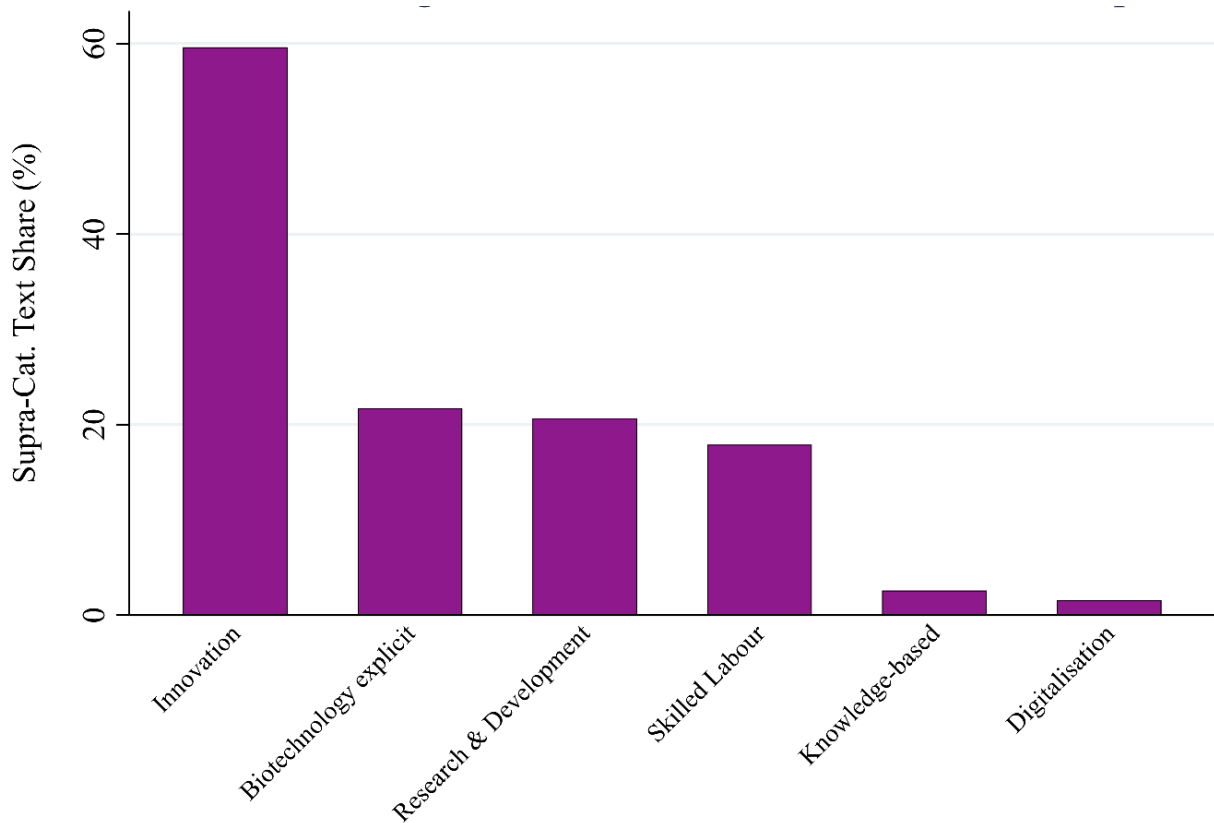
**Figure 6.** Share of Sub-Categories in the 'Social' Supra-Category

Fourth, among the political subcategories “Governance”, “Regulation”, “International Political Competition”, and “International Cooperation” (Figure 7), “Regulation” and “Governance” were found to be most relevant, covering nearly 34 per cent and 32 per cent of the “Political” supra-category text share. The key concern policymakers have with the issue-topic of regulation is that bioeconomy adequate regulation is often still missing. Relatedly, the particular governance concern appears to be the difficulty and lack of attempts to coordinate different authorities and portfolios working in the different bioeconomy related policy fields (see also Töller et al. 2021). Policymakers also appear to worry about a lack of adequate institutions and a general strategic capacity to promote the bioeconomy and the new demands it generates.



**Figure 7.** Share of Sub-Categories in the 'Political' Supra-Category

Lastly, with regard to the "Research, Innovation & Technology" supra-category illustrated in Figure 8, "Innovation" appears to be the most essential subcategory by a large margin reaching almost 60 per cent. "Biotechnology explicit", "Research & Development" and "Skilled Labor" have less significant shares of roughly 20 per cent respectively while the "Knowledge-based" and "Digitalization" subcategories are barely represented. This finding resonates with previous findings in the bioeconomy literature that research and development are key concerns of both the larger "Biotechnology" as well as the "Bioresource" visions which characterize the dominant bioeconomy discourse (D'Amato et al. 2017; Vivien et al. 2019).



**Figure 7.** Share of Sub-Categories in the "Research, Innovation & Technology" Supra-Category

#### **4.2 Exploratory correlational analysis of problematization variation**

The previous descriptive analysis has demonstrated that different types of problematizations are given different degrees of attention in bioeconomy-related policies. What is more, as depicted in Figure 8 below, the prevalence of distinct problematization types varies strongly. Specifically, as shown using the two most prevalent categories, economic and environmental, documents tend to range across the possible space of problematization frequency. In this section, we aim to uncover underlying associations of this variation, that is, try to explore why some documents might problematize certain topics more than others. To do so, we discuss the correlation between country context conditions and problematization supra-categories according to our expectations using correlational analysis. The results are presented in Table 1 below (all expected associations, as per Section 2.4, are highlighted in bold font).

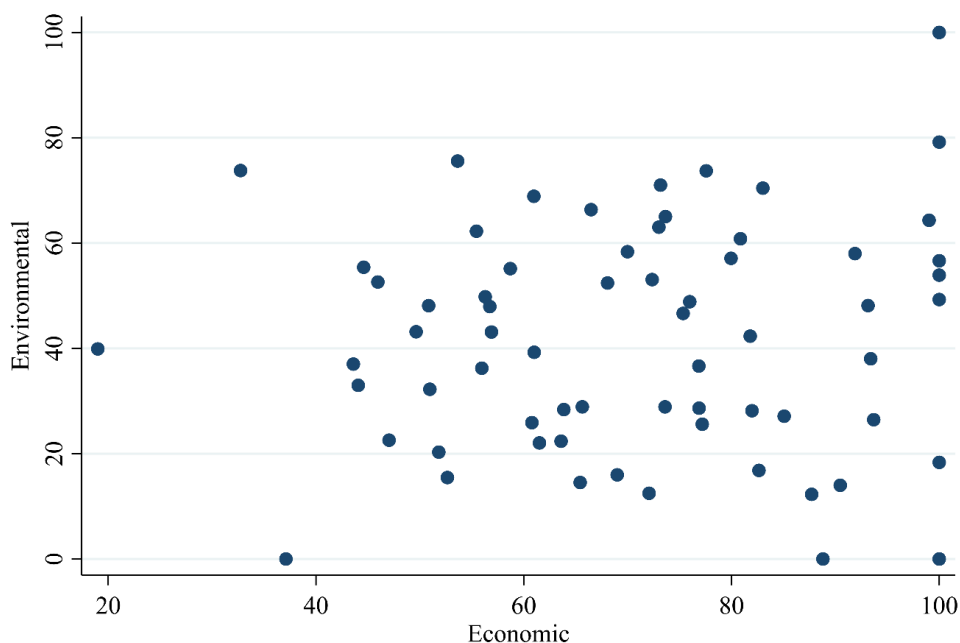


Figure X. Scatter Plot of Economic and Environmental Problematization Frequency Across Documents

When it comes to our first supra-category "Economic", none of our expectations is strongly confirmed by the data. Non-environmental ministries do not seem to focus more on economic problematizations. Yet, less green governments might deal more with economic problematizations, though this finding is not significant. Our data also fall short of our expectation that less developed countries (with higher infant mortality rates) would problematize economic topics more, given that the (expected) positive correlation is also insignificant. Similarly, the expected positive correlation between countries with less climate change exposure and economic problematizations lacks significance and as such is not confirmed. Interestingly, the only remotely relevant correlation for economic problematization appears to be the positive one with the degree of democratization. No obvious mechanism comes to mind for this association. Our initial reaction that these might be due to a spurious correlation – democracies are wealthier on average, and wealthier countries might be more likely to problematize economic issues – is thwarted by our finding that economic development does not appear to be positively associated with economic problematizations. As such, this initial exploratory correlational analysis was not able

to identify any meaningful associations between bioeconomy-related strategies and economic problematizations.

**Table 1: Correlation Results for Policy Problematization in Bioeconomy-Related Policy Documents**

	Economic	Environmental	Social	Political	Research
Democratization (Polity2)	0.22*	<b>0.25*</b>	<b>-0.16</b>	-0.41***	-0.15
Environmental author type	<b>0.08</b>	<b>-0.09</b>	-0.23*	0.05	-0.01
Environmental governing party	<b>-0.05</b>	<b>0.25**</b>	-0.08	-0.15	-0.09
Left-right orientation	<b>0.04</b>	<b>0.19</b>	<b>0.09</b>	-0.21	-0.20
People-centrism	-0.06	-0.19	<b>0.27**</b>	<b>0.27**</b>	0.22*
Climate change exposure	<b>0.09</b>	<b>-0.00</b>	0.19	0.15	0.11
Infant mortality rate (log)	<b>0.08</b>	<b>-0.09</b>	<b>0.27**</b>	<b>0.25**</b>	-0.00
State capacity	-0.02	0.12	-0.14	<b>-0.27**</b>	-0.07
Patents p.c. (log)	0.09	-0.06	-0.05	-0.23*	<b>-0.07</b>
Education expenditure	0.19	-0.19	0.11	0.11	<b>0.12</b>

\*  $p < 0.10$ , \*\*  $p < 0.05$ , \*\*\*  $p < 0.01$ . All expected associations (as per Section 2.4) are highlighted in bold font.

The findings with regard to the supra-category "Environmental" are slightly more consistent with our expectations, but they still paint a muddled picture. In detail, we find a positive and significant correlation between higher levels of democracy and environmental problematizations. This finding meets our expectation that the more democratic a country the more room exists for environmental CSOs and advocacy coalitions. Similarly, and as expected, we find that more environmentally oriented governing parties are significantly associated at the five percentage-level of significance with more environmental problematizations. However, and somewhat surprisingly, there appears to be no significant (if at all, negative) correlation between environmental authority involvement in authoring a strategy and the degree to which it problematizes environmental concerns. While left-wing parties are tentatively considered as more environmentally friendly, we find that left-wing ruling parties do not tend to problematize environmental issues more than economically right-oriented parties. One reason might be that right-oriented parties also tend to be more conservative, and in line with this, might emphasize nature conservation and cultural landscape protection (despite also being more likely to be climate change skeptics). More populist parties, however, do not show the same pattern. Our expectation that



countries with higher climate risk exposure will problematize more environmental topics is also not confirmed. In contrast, wealthier countries (with lower infant mortality rates) appear to focus more on environmental problematizations, a correlation that confirms our expectation, although at insignificant levels.

Likewise, the findings for the variable (supra-category) "Social" indicate a generally fuzzy correlational direction. In particular, the data do not confirm our expectation that democratic countries will problematize social issues more (because of their greater focus on wider public needs rather than small elites). Similarly, and unexpectedly, we did not find a positive correlation between left-wing parties and social problematizations. In contrast, more populist parties and poorer countries (with higher infant mortality rates) focus more on social issues, as expected.

Our expectations for the "Political" supra-category are mostly confirmed. Countries with lower state capacity appear to see more need for problematizing social topics as expected. The same holds true for more populist parties, probably because they focus more on state intervention in favor of the people. Less developed countries are also associated with greater political problematizations. Disaggregating a bit more this association, we infer that one reason for this finding might be that these countries see a greater need for international cooperation and institutional change. Another significant finding going beyond our expectations is that less democratic countries are associated with greater political problematization. One possible explanation for this finding might be that autocratic countries are more inclined to promote top-down governance by regulating and intervening in the economy more than more democratic governments while they might still need to cooperate at international level to attract foreign support. And more generally, political matters might be more essential for the political survival of autocracies and therefore problematized more.

With regard to our last supra-category, "Research, Innovation & Technology", the picture remains fairly murky. Counter expectation, there is no significant correlation between countries with higher patents per capita and the problematization propensity of this supra-category. In line with our expectations, countries with higher education expenditure problematize topics of research, innovation and technology more, however, not at a significant level. The only remotely significant correlation here is that more populist regimes appear to problematize this topic more. We had expected

this might be the case, because populist regimes tend to be more mistrusting of the sciences and might therefore critically problematize the topic more. Yet, during our coding exercise we found most problematizations of research, innovation, and technology to be rather science and technology friendly, therefore, making this mechanism unlikely and this finding unexpected. Yet again, this association barely scratches significance and should, thus, be interpreted with critical caution.

## **5. Conclusion**

In this paper, we studied the problematization of bioeconomy policies worldwide in light of the increasingly major role of bioeconomy as a political project and the important, however, hitherto unexplored meaning of bioeconomy policy problematization as well as its linkage to politics. Conceptually, we built on the approach of policy problematization and focused on its connection with structuring policy problems and designing policies to describe and explain the problematization orientation of bioeconomy policies. Methodologically, we first conducted a systematic qualitative-quantitative content analysis of 78 bioeconomy policy documents across the globe to assess the degree to which these documents incorporate problematization. In doing so, we distinguished between five supra-categories of problematizations ("Economic", "Environmental", "Social", "Political", and "Research, Innovation & Technology") disaggregated into up to fifteen distinct subcategories. We further employed descriptive statistical and correlational analyses to explore the character and potential determinants of problematization variation.

Our analysis generated several important findings. The descriptive analysis of problematization in bioeconomy policies shows that nearly 70 per cent of the average policy's text is coded with economically oriented problematizations, driven primarily by the "Market Development", "Biomass Management" and "Business Environment" economic subcategories. The other four categories fall significantly behind, at around 36 to 40 percent. This finding demonstrates the prevalent economy-oriented framing of bioeconomy as a whole. Moreover, we find that the extent to which certain topics are problematized varies strongly across documents. Our explorative correlational analysis provides first tentative insights as to the factors associated with the cross-case variation in problematization orientation:

First, in line with our expectations, more democratic countries and environmentally oriented governing parties are associated with a greater focus on environmental problematizations. More populist parties, poorer countries, and countries with lower state capacity appear to problematize social issues more. Less developed countries focus more on political problematizations while countries with higher education expenditure are associated with putting greater emphasis on topics of research, innovation and technology. Lastly, countries with higher education expenditure correlate with a greater frequency of economic problematizations. Second, and contrary to our anticipations, democracies do not seem to be more concerned with social and political problematizations and environmental ministries do not problematize environmental or social issues more. Similarly, countries with higher patents per capita, higher education expenditure and countries that are more advanced are not associated with a greater focus on problematizations concerning research, innovation and technology. Furthermore, environmental ministries do not seem to focus on environmental problematizations while less developed countries do not problematize economic topics more.

When structuring bioeconomy policy problems, policy makers tend to highlight economic issues related to markets, business and biomass while they refer to environmental, social, political, and research-technology-oriented issues and challenges to some extent. In light of this, bioeconomy policy seems to be designed largely in economic terms and determined by the biomass-oriented – however, recently discarded rationale of the – bioenergy boom.

Our study makes several important contributions to the study of policy problematization and problem structuring. First, it constitutes the first attempt at systematically operationalizing and quantifying problematization orientations across bioeconomy policy documents. In doing so, it helps grasp the complexity of bioeconomy policy and contributes to a better understanding of the character of problem structuring therein. Second, the explorative analysis provides first relevant insights into the factors shaping distinct problematization orientations. Nevertheless, further exploration is required to fill gaps and address additional research questions.

In particular, we see three avenues for further research. First, the exploratory analyses conducted in this study are correlational and not causal. Whereas reverse

causation is near impossible in this case, omitted variable bias is a very real concern to causal inference. Advanced regression analyses would be the ideal response to these concerns, yet, the size of the data set does not lend itself to such methods. One viable alternative is qualitative comparative analysis (QCA). Second, future in-depth analyses of specific country and policy cases can further open up the correlational black boxes and help identify or falsify potential mechanisms linking the studied factors with different problematization topics. Third, scholars could also look at related alternative outcomes. Specifically, it would be interesting to see whether and how the identified problematizations are actually addressed by the goals and instruments suggested in the policy documents.

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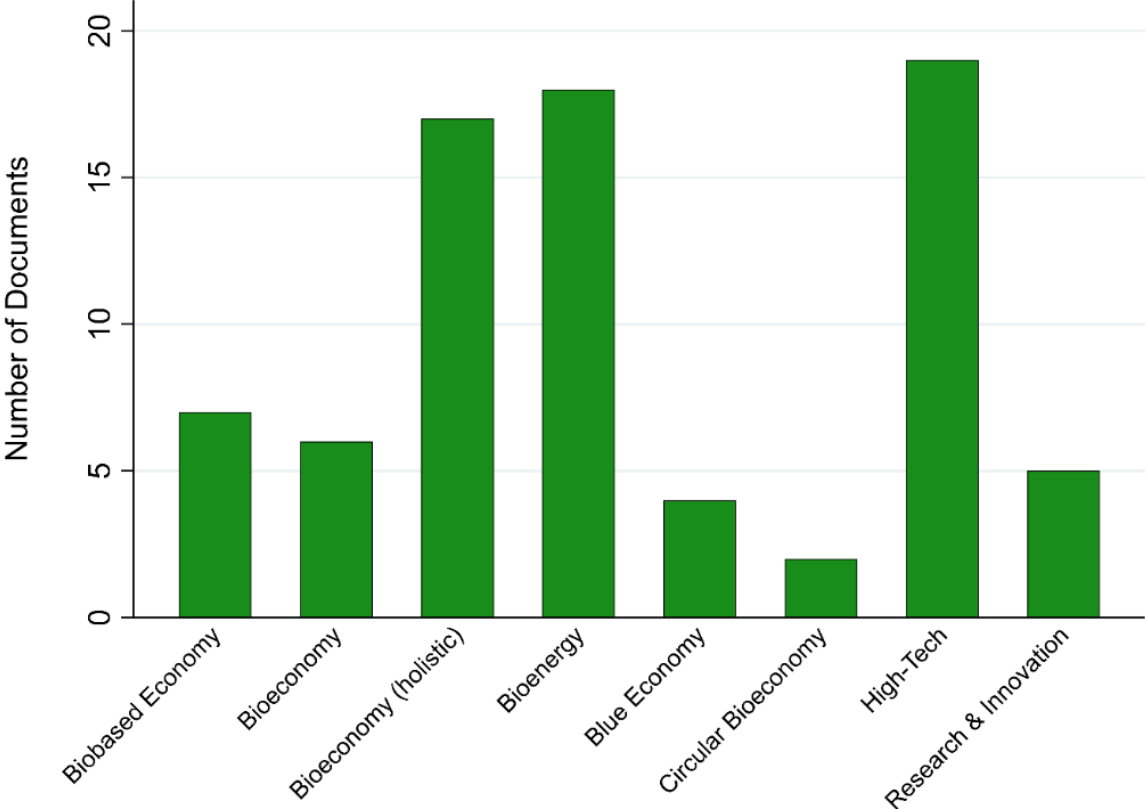
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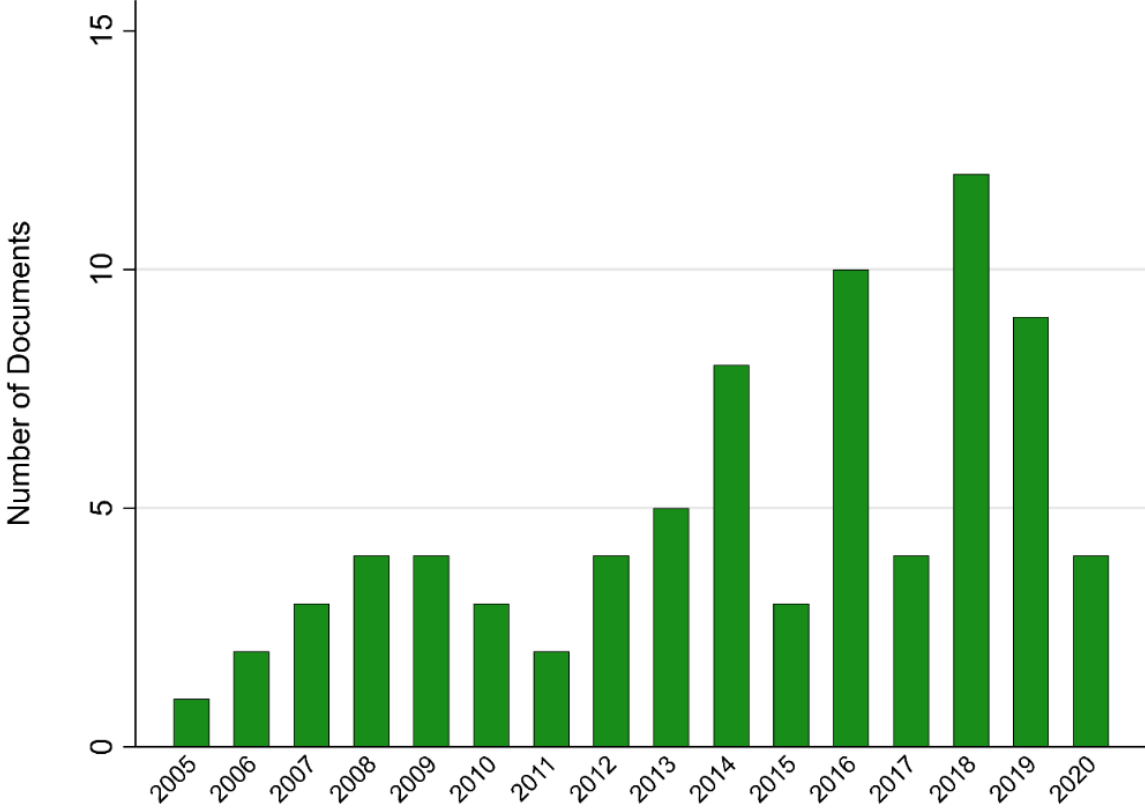
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**Appendix**

**Appendix 1: Number of documents per document type (as per GBS 2020 report perspective)**



**Appendix 2: Number of documents per year**



### **Appendix 3: Summary Statistics**

<b>VARIABLES</b>	<b>N</b>	<b>mean</b>	<b>sd</b>	<b>min</b>	<b>max</b>
Environm. author type	78	2.244	0.996	1	4
Democratization (Polity2)	65	7.092	3.844	-7	10
Environm. governing party	74	0.0541	0.228	0	1
Left-right orientation	71	0.498	1.235	-1.539	3.251
People-centrism	71	-0.138	1.322	-2.487	2.849
State capacity	78	1.165	0.855	-0.515	3.191
Climate change exposure	78	0.453	0.0554	0.273	0.572
Research, tech. & innovation	72	32.31	32.10	0	100
Economic	72	68.77	23.97	0	100
Social	72	37.00	24.26	0	100
Environmental	72	41.14	24.86	0	100
Political	72	36.76	30.02	0	100
Education expenditure	61	14.93	4.105	1.386	25.08
Infant mortality rate (log)	74	2.238	1.151	0.588	4.501
Patents p.c. (log)	72	-10.40	2.339	-15.78	-5.760

**Appendix 4: Values for our problematization variables across all policy documents.**

Country	Document Name	Year	Document Character	Economic	Environmental	Social	Political	Research
Argentina	Bioeconomía Argentina	2016	Bioeconomy	68	52	45	45	10
Australia	Opportunities for Primary Industries in The Bioenergy Sector: National Research, Development and Extension Strategy Workplan	2014	Bioenergy	78	74	19	69	36
Australia	Biotechnology and agriculture in Australia: policy snapshot	2018	High-Tech	100	100	46	0	100
Austria	Bioeconomy a strategy for Austria	2019	Bioeconomy (holistic)	73	71	23	35	11
Brazil	Estrategia Nacional de Ciencia, Tecnologia e Inovacao	2016	Research & Innovation	72	53	76	3	8
Brazil	Plano de Ação em Ciência, Tecnologia e Inovação em Bioeconomia	2018	Research & Innovation	93	38	59	5	50
Brazil	Plano Decenal de Expansão de Energia 2029	2020	Bioenergy	64	22	15	0	25
Canada	Canada's Bioeconomy Strategy	2019	Bioeconomy	82	28	13	50	32
China	13th FYP for Strategic Emerging Industries	2016	High-Tech	0	0	0	100	100
China	13th FYP on Bioindustry Development	2016	High-Tech	0	0	0	100	0
Colombia	Política par el Desarrollo Comercial de la Biotecnología a	2011	High-Tech	99	64	0	92	74

	partir del uso Sostenible de la Biodiversidad							
Colombia	Colombia Bio	2016	High-Tech	0	100	100	0	0
Colombia	Colombia Green Growth Roadmap	2018	High-Tech	81	61	34	62	18
Costa Rica	National Bioeconomy Strategy – Costa Rica 2020 – 2030	2020	Bioeconomy (holistic)	100	0	0	0	100
Czech Republic	Bioeconomy concept in the Czech Republic from the perspective of the Ministry of Agriculture 2019 – 2024	2019	Bioeconomy	61	39	33	50	46
Denmark	Plan for Growth for Water, Bio & Environmental Solutions	2013	Green Economy	88	12	76	0	50
Denmark	Denmark as growth hub for a sustainable bioeconomy	2014	Bioeconomy	69	16	27	31	49
Denmark	Strategy for Circular Economy	2018	Circular Bioeconomy	92	58	42	38	7
Ecuador	Lineamientos Para El Fomento Del Bioemprendimiento	2019	Biobased Economy					
Estonia	Development Plan on the Promotion of Biomass and Bioenergy Use for 2007–2013	2007	Bioenergy	74	29	15	9	25
Finland	The Finnish Bioeconomy Strategy	2014	Bioeconomy (holistic)	83	70	49	5	18
Finland	Competitive Advantage from Clean Food and Responsible Bioeconomy and Circular Economy	2018	Bioeconomy (holistic)	80	57	50	24	4
France	A Bioeconomy strategy for France (Goals & Action Plan)	2018	Bioeconomy (holistic)	77	37	35	40	11

Germany	Nationale Bioökonomiestrategie	2020	Bioeconomy (holistic)	73	63	55	20	12
Ghana	Ghana renewable energy master plan	2019	Bioenergy	66	29	35	36	27
India	National Biotechnology Development Strategy 2015 - 2020	2015	High-Tech	74	65	23	26	33
India	National Policy on Biofuel	2018	Bioenergy	90	14	62	42	6
Indonesia	Bioenergy Policies and Regulation in Indonesia	2014	Bioenergy	100	79	0	0	0
Indonesia	Master Strategy for Agricultural Development 2015 - 2045	2014	Biobased Economy	82	42	61	31	16
Ireland	National Policy Statement on the Bioeconomy	2018	Bioeconomy (holistic)	85	27	0	85	20
Italy	BIT II - Bioeconomy in Italy: A new bioeconomy strategy for a sustainable Italy (including Action Plan)	2019	Bioeconomy (holistic)	46	53	46	50	10
Japan	Bio Strategy Japan 2019/2020	2019	Bioeconomy (holistic)	52	20	29	20	54
Kenya	A National Biotechnology Development Policy	2006	High-Tech	57	43	50	26	99
Kenya	Strategy for Developing the Bio-diesel Industry in Kenya	2008	Bioenergy	50	43	40	55	4
Latvia	Latvian Bioeconomy Strategy 2030 (LI-BRA)	2017	Bioeconomy (holistic)	61	26	52	21	5
Lithuania	National Renewable Energy Action Plan	2010	Bioenergy	45	55	0	0	0

Lithuania	Action Plans on Biomass Energy, Biomolecular Biotechnologies and Biorefineries promotion as part of the Lithuanian Smart Specialization Program	2014	Biobased Economy	76	49	0	0	51
Malawi	Malawi Biomass Energy Strategy	2009	Bioenergy	56	50	35	36	4
Malaysia	“National Biotechnology Policy” (2005-2020)	2005	High-Tech	37	0	37	100	43
Malaysia	Malaysia’s National Blue Ocean Shift	2009	Blue Economy					
Malaysia	National Biomass Strategy 2020: New wealth creation for Malaysia’s biomass industry (Version 2.0)	2013	Biobased Economy	100	0	29	0	0
Malaysia	Bioeconomy Corporation Bioeconomy Transformation Program (BTP)  I believe there are more recent reports as well.	2015	Bioeconomy	77	29	50	93	50
Mali	Stratégie Nationale pour le Développement des Biocarburants en Mali & Loi pour l'etabilissement de l'Agence Nationale de Développement des Biocarburants	2008	Bioenergy	93	48	47	47	15
Mauritius	The Ocean Economy	2013	Blue Economy	19	40	6	16	35
Mexico	Estrategia Intersecretarial de los Bioenergéticos	2009	Bioenergy	66	66	17	18	10



Mexico	Transition Strategy to Promote the Use of Cleaner Technologies and Fuels	2020	Bioenergy	100	100	100	100	100
Mozambique	Política e Estratégia de Biocombustíveis	2009	Bioenergy	100	54	54	46	0
Mozambique	Mozambique Biomass Energy Strategy	2012	Bioenergy	70	58	54	48	2
Namibia	The National Programme on Research, Science, Technology & Innovation	2014	Research & Innovation	62	22	72	85	77
Netherlands	Strategic Biomass Vision for the Netherlands towards 2030	2016	Biobased Economy	94	26	18	25	8
Netherlands	The position of the bioeconomy in the Netherlands	2018	Bioeconomy	100	57	43	0	0
New Zealand	Primary Sector Science Roadmap - Te Ao Turoa	2017	Research & Innovation	55	62	49	29	43
Nigeria	Nigeria Biofuels policy and incentives	2007	Bioenergy	100	49	49	0	0
Nigeria	National Biotechnology Development Agency Bill	2015	High-Tech					
Norway	Familiar resources – undreamt of possibilities. Government Bioeconomy Strategy	2016	Bioeconomy (holistic)	77	26	16	32	29
Paraguay	Política y Programa Nacional de Biotecnología Agropecuaria y Forestal del Parauay (2011)	2011	High-Tech	100	18	18	35	100
Portugal	National Ocean Strategy 2013-2020	2013	Blue Economy	54	76	44	51	9

Portugal	National Plan for the Promotion of Biorefineries	2017	Bioenergy	56	36	11	17	23
Portugal	Circular Economy Action Plan	2017	Circular Bioeconomy	61	69	34	36	12
Portugal	Portuguese Bioeconomy Strategy Roadmap	2019	Blue Economy					
Russia	Comprehensive Program and Roadmap for the Development of Biotechnology in Russia by 2020	2012	High-Tech	89	0	0	57	95
Senegal	Biofuels Jatropha Program 2007-2012	2007	Bioenergy	100	0	100	100	0
Senegal	Lettre de Politique de Développement du Secteur de L'Énergie	2008	Bioenergy	83	17	45	45	0
South Africa	The Bio-economy Strategy	2013	Bioeconomy (holistic)	64	28	37	39	53
South Korea	Biovision 2016 - For Building a Healthy Life and a Prosperous Bioeconomy	2006	High-Tech					
South Korea	Biotechnology in Korea	2018	High-Tech					
Spain	The Spanish Bioeconomy Strategy 2030 Horizon	2016	Bioeconomy (holistic)	51	48	56	0	22
Sri Lanka	National Biotechnology Policy	2010	High-Tech	51	32	35	57	84
Sweden	Swedish Research and Innovation Strategy for a Bio-based Economy	2012	Research & Innovation	57	48	0	12	10
Tanzania	National Biotechnology Policy	2010	High-Tech	53	15	40	54	68
Tanzania	Biomass Energy Strategy (BEST) Tanzania	2014	Bioenergy	44	33	29	48	0

Thailand	Bio-Circular-Green Economy (BCG) in Action: The new Sustainable Growth Engine	2019	Bioeconomy (holistic)	33	74	60	5	12
Uganda	National Biotechnology and Biosafety Policy	2008	High-Tech	59	55	57	71	75
Uganda	Biomass Energy Strategy (BEST)	2018	Biobased Economy	44	37	38	50	29
United Kingdom	Growing the Bioeconomy	2018	Bioeconomy (holistic)	47	23	58	33	41
United States	Federal Activities report on the bioeconomy	2016	Bioeconomy	75	47	50	3	72
United States	Strategic plan for thriving and sustainable bioeconomy	2016	Bioeconomy (holistic)	65	15	29	14	8
Uruguay	Plan Sectorial de Biotecnología 2011-2020	2012	High-Tech	72	12	34	72	88

**Appendix 5: Scatter Plots of Bivariate Correlations between the Independent and Dependent Variables**

