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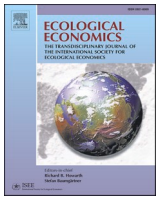

Framing effects in expert assessments of optimal GDP development

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ABSTRACT

Optimal economic development is a central topic across societies, usually giving Gross Domestic Product (GDP) growth rates a central role. This study delves into the psychological implications of different GDP development framings among academic experts. In an online experiment involving academic researchers, the present study uncovers significant variations in desired GDP developments depending on the framing of GDP growth. Prompting experts to state optimal GDP growth *rates* results in substantially larger GDP sizes compared to the desired growth *factors* over a period of 100 years. This phenomenon holds true across non-economists as well as economists. The findings underscore the importance of the psychological framing of economic growth in shaping individuals' perceptions and preferences. In addition, the research reveals disparities in the preferences for economic development, both between different academic disciplines and between the assessment of low-income and high-income countries.

1. Introduction

Gross Domestic Product (GDP) is the most commonly applied wealth indicator globally and routinely used to measure economic performance. GDP reflects the market value of all final goods and services produced in a specific time period by a country. The development of GDP has huge implications on how societies evolve and interact with nature (Eisenmenger et al., 2020; van den Bergh, 2009). Large institutions often put emphasis on growth rates, such as the projections of the European Central Bank, the OECD Weekly Tracker of Economic Activity, or the Sustainable Development Goal 8 (SDG) of the United Nations. However, the psychological consequences of GDP development framed as an annual growth rate are rarely addressed. In this study we show experimentally that the framing of GDP development affects judgments about the desired GDP growth among academic researchers.

In recent years, the focus on GDP as the primary indicator of prosperity has been increasingly criticized. Critics argue that GDP fails to account for environmental degradation, social inequality, and overall well-being (Kubiszewski et al., 2013). There is a growing interest in alternative metrics that provide a more holistic view of prosperity such as the Genuine Progress Indicator or the Sustainable Development Index (Hickel, 2020; Kalimeris et al., 2020). The limitations of GDP were a central topic at the Beyond Growth Conference, 2023 held at the European Parliament (Beyond Growth Conference, 2023). The Beyond Growth Conference brought together scholars, policymakers, and further stakeholders to explore alternatives to the GDP-centric model of economic development. Discussions at the conference emphasized the need to shift towards an economic system that prioritizes environmental health and human well-being over relentless GDP growth.

In light of GDP criticism and alternative perspectives, we present a behavioral perspective on the implications of the current mainstream GDP growth framing. Sustained GDP growth can quickly lead to an enormous GDP. SDG 8 of the United Nations aims to sustain per capita economic growth in accordance with national circumstances. For the least developed countries, the annual GDP growth is set to be at least 7%. A sustained annual GDP growth rate of 7% implies a doubling of GDP every 10.3 years. Several developed countries such as Australia, the United States, the United Kingdom, Austria or Norway reached average yearly growth rates higher than 2% from 1972 to 2022 (World Bank, 2023). Even an annual GDP growth rate of 2% leads to a doubling of the size of the economy every 36 years. The global average GDP growth rate between 1961 and 2022 has been 3.5%, which is reflected in an

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exponential, sharply rising growth curve (World Bank, 2023).

That said, economic expansion does not happen in a vacuum, but strongly affects other variables of the planet by creating pressure on the environment and other Earth systems. For example, globally, we observe a tight correlation of material use and GDP (e.g., Hickel and Kallis, 2020; Wiedmann et al., 2015). Likewise, CO_2 emissions (e.g., Chaabouni and Saidi, 2017; World Bank Open Data, 2023), energy use (e.g., Haberl et al., 2020; Ward et al., 2016), and water use (e.g., Distefano and Kelly, 2017; Duarte et al., 2014) are strongly linked to GDP. This implies that potentially biased conceptualizations of optimal GDP loom large. It is therefore paramount to understand factors associated with experts' assessment of optimal GDP, which includes psychological factors such as biases and heuristics (Tversky and Kahneman, 1974).

Past research shows that an exponential growth bias, i.e. an underestimation of the outcomes of growth rates, undermines people's ability to predict growth rate outcomes accurately (e.g., Banerjee et al., 2021; Wagenaar and Sagaria, 1975). Factors such as financial expertise, framing as financial investment scenario, a high need for cognition, short time frames, or being male have been shown to reduce the exponential growth bias (Benzion et al., 1992; Christandl and Fetchenhauer, 2009; Keren, 1983). Thus, there are various factors associated with the estimation of growth rate outcomes. The question arises whether the focus on GDP growth rates also influences experts' perception in determining desired future GDP development. Focusing on annual GDP growth rates may distract from long-term implications of exponential growth. In this context, our study investigates the psychological impact of GDP growth framing on desired GDP growth among academic researchers.

Embedded into a larger survey, our online experiment involves 1802 academic researchers. It examines their ideal economic development perceptions by framing GDP growth as either a growth rate (e.g., economy grows x% per year for the next 100 years) or a growth factor (e.g., economy is x times bigger in 100 years). Academic researchers publishing in the areas of *Economics, Econometrics and Finance* as well as *Environmental Science* were approached via email using the Scopus database of Elsevier. In this paper, we refer to the first group as *economists* and to the second group as *non-economists*. Divided into the two randomized groups RATE and FACTOR, participants were asked to express their ideal economic development by indicating GDP development for the next century either as a rate or a factor. All participants were asked to express the desired economic development for low-income as well as high-income countries.

The results show that prompting experts to state their desired growth rate leads to substantially larger GDP sizes than when prompting to state desired growth factors. This result has been found for both *economists* and *non-economists*. On average, *economists* prefer to have higher GDP growth for low-income countries than *non-economists*. With regard to the desired growth of high-income countries, no difference between *economists* and *non-economists* has been found. Both groups are in favor of higher growth rates for low-income countries than for high-income countries.

Our study contributes to the ongoing discussion on global economic development with regard to the direction of development (grow, shrink, remain) and the desired extent of economic development for low-income and high-income countries (Drews and van den Bergh, 2017). The investigation also contributes to the framing literature by showing how subtle changes in the presentation of an economic issue can influence individuals' perceptions and preferences. Finally our study contributes to decision biases of experts (e.g., Cain and Detsky, 2008; Englich et al., 2006). The fact that GDP growth framing has a significant impact on desired growth offers opportunities to critically reflect on rates as the status quo of growth framing and to consider taking a broader perspective with regard to economic development.

2. Related literature and hypotheses

2.1. The misperception of growth rates

There is ample evidence for an exponential growth bias leading to underestimations of the outcomes of growth rates. In an experiment, participants were asked to estimate the outcome of a financial investment of $100 for different interest rates and durations (Benzion et al., 1992). The participants underestimated the impact of growth rates, which led to significantly lower estimated end values compared to the true value. The extent of the miscalculation increased with a longer time span and a higher level of interest rates. In another experiment, participants were asked to extrapolate a hypothetical development of a pollution (Wagenaar and Sagaria, 1975). The majority of the participants made estimations reaching only 10% or less of the true value, leading to an immense underestimation of the true value. The exponential growth bias has also been shown for the estimation of economic growth rate outcomes: In different experiments, people had considerable difficulties to predict the outcome of economic growth rates in the long run (Christandl and Fetchenhauer, 2009).

The COVID-19 pandemic is another example where the exponential growth bias can have real consequences since the early transmission path of the disease is exponential (Zhao et al., 2020). Studies have documented an exponential growth bias for the prediction of the number of future COVID-19 cases (Banerjee et al., 2021; Banerjee and Majumdar, 2023; Lammers et al., 2020). This underestimation of growth rate outcomes exists despite the fact that there is a simple rule of thumb which helps to calculate the outcomes of growth rates. Based on fixed growth rates, the "rule of 72" offers a simple heuristic to determine how long it takes for a given GDP size to double. Dividing 72 by the annual growth rate results in the number of years it takes until GDP will duplicate itself. To give an example, for an annual growth rate of 6% it takes 12 years until the GDP size is doubled. The exponential growth bias has not only been found for numerical tasks presenting means of tables or graphs but also for non-numerical paradigms (Wagenaar and Timmers, 1979). Generally, previous studies show that people are bad at predicting exponential growth rate outcomes accurately even though there is a simple rule of thumb to predict numerical exponential growth outcomes.

Previous studies show mixed evidence about the influence of people's expertise to predict exponential growth outcomes more accurately. Participants owning monetary investments did not differ in their ability to estimate the future values of monetary investments from participants without monetary investments (Benzion et al., 2004). But it has been shown that previous experience with high inflation rates leads to more accurate estimations (Keren, 1983). Further, instructing students on the characteristics of exponential growth and informing them about people's tendency to underestimate exponential effects led to better estimations than the one's of the control group (Wagenaar and Sagaria, 1975). However, also the informed students tended to underestimate the true values in a subsequent extrapolation task (Wagenaar and Sagaria, 1975). Another study showed that advanced students of economics and business administration made better estimations than a student group of various courses of study (the majority were future teachers) (Christandl and Fetchenhauer, 2009). These results suggest that people's level of expertise may influence the accuracy of their exponential growth predictions.

Besides expertise, further factors can be associated with the accuracy of predicted exponential growth rate outcomes. Males and participants scoring high on the *need for cognition* scale made better estimates than women and participants scoring low on the *need for cognition* scale (Christandl and Fetchenhauer, 2009). Further, there is a positive association between the exponential growth bias and more optimistic economic expectations (Banerjee and Majumdar, 2023). The framing of a task as economic growth scenario can lead to less precise estimations than the framing as financial investment scenario (Christandl and

Fetchenhauer, 2009). Although exponential growth bias occurs at short time periods of five years (Wagenaar and Sagaria, 1975), the underestimations increase with the duration and with the magnitude of the interest rate (Benzion et al., 1992). Interest in economics and politics as well as financial incentives have not been shown to influence the accuracy of participants' estimations (Christandl and Fetchenhauer, 2009).

Our study aims to show the impact of GDP growth rate versus factor framing on desired future GDP development among a large international sample of academic researchers. There are three main differences to previous research investigating the exponential growth bias. First, compared to previous studies, our sample only consists of highly educated academic researchers. At least one published article as a corresponding author in one of the top 100 peer-reviewed journals in the field *Economics*, *Econometrics*, *Finance* or *Environmental Science* between 2018 and 2022 was required to be considered for the survey target population. Second, previous studies used different time periods (from $t = 0.083$ to $t = 25$) and different interacting growth rates (from 1% to 100%) to demonstrate exponential growth bias. The present study draws on a longer time period, as the context demands for this. Regarding optimal growth of economies, 100 years is a horizon over which potential negative effects may accumulate (if green growth is not realized) and which will certainly far exceed planetary boundaries. Third, compared to previous studies, participants are not asked to solve an exponential growth task but to indicate a desired growth rate or growth factor (depending on the treatment group) for the next century. Instead of focusing on the accuracy of growth rate outcome estimations, our study investigates the outcomes of two different GDP growth framings. Growth factors capture the compounding effect of growth over time, while growth rates only represent the annual change. Following previous literature, we hypothesize that participants neglect the compounding effects in the growth rate framing of GDP. More specifically, we hypothesize that when asked about growth rates versus growth factors, people will suggest higher ideal growth when asked about growth rates compared to growth factors (Hypothesis 1, pre-registered).

2.2. Economic growth preferences depending on academic discipline

The preferences regarding the magnitude of economic growth may depend on whether academic researchers belong to the group of *economists* or *non-economists*. Several studies found support that economists rather follow the basic neoclassic concept of *homo economicus*. The *homo economicus* concept assumes that human beings are rational, often self-interested, and opportunistic actors. Already a short introduction to general neoclassical economics assumptions has been shown to lead to more self-interested behavior (Ifcher and Zarghamee, 2018). Advanced economics students have been shown to behave in a more self-serving manner than economics beginners (Haucap and Müller, 2014) suggesting an influence of economic education on compliance with neoclassical concepts. In public goods, prisoner's dilemma, ultimatum, and dictator games, students of economics have displayed behavior more strongly in line with the homo economicus assumption than people without an economic background (e.g., Cadsby and Maynes, 1998; Carter and Irons, 1991; Ifcher and Zarghamee, 2018; Marwell and Ames, 1981; but see McCannon, 2014 or Yezer et al., 1996 for conflicting results). Compared to non-economic students, future economists put more emphasis on the market than on the state and indicated a higher perceived legitimacy for antisocial behaviors such as tax avoidance, throwing garbage into the street, and free-riding (Lopes et al., 2015). Taken together, this may imply that economists place more emphasis on growth compared to other social goals, show a tendency to have a stronger trust in the market, and act more according to the basic neoclassical assumptions than non-economists.

Economists have been shown to have different views regarding economic development than academic researchers from other fields. Compared to other social scientists or natural scientists, economists are rather in favor of a green growth approach, i.e., increasing GDP while decoupling it from negative environmental effects such as greenhouse gas emissions, than focusing on other well-being indicators (King et al., 2023). Scientists of environmental social sciences, natural / environmental sciences, and ecological economics indicated significantly lower favored GDP growth rates for the next decade than scientists of environmental & resource economics as well as scientists from other economic fields (excluding the areas economic growth, environment and energy) (Drews and van den Bergh, 2017). The nearest end of economic growth in rich countries is expected by ecological economists (median = 25–50 years) and environmental scientists (median = 50–100 years) whereas growth economists, environmental and resource economists, and other economists (excluding growth, environment, and energy economists) are the most convinced that eternal GDP growth is possible (Drews and van den Bergh, 2017). Even though ecological economists seem to have lower preferred growth rates than other economists, this group represents only a small proportion of economists. Thus, we hypothesize, that *economists* will suggest higher ideal growth compared to *non-economists*, in both high- and low-income countries. Further, we expect that this pattern will be present in both experimental conditions (Hypothesis 2, pre-registered).

2.3. Perceived ideal growth rate of low-income versus high-income countries

GDP growth is often seen as a solution to poverty. Based on empirical research, it has been argued that growth in low-income countries is a necessity to alleviate poverty (e.g., Garza-Rodriguez, 2018; Škare and Družeta, 2016). However, the conventional view that relentless growth is a panacea for societal ills has been challenged by Max-Neef (1995) threshold hypothesis. This hypothesis states that although the initial phase of economic growth can be accompanied by an improvement in the quality of life, there is a critical threshold beyond which further growth can lead to a decline in life quality. In line with this hypothesis, it has been proposed that developed countries should stop solely focusing on GDP growth or even downsize their economies in order to provide development space for poorer countries (Alexander, 2012; Kubiszewski et al., 2013). In a global survey with 789 climate policy researchers, 53% at least somewhat agreed with the statement that "In view of limited natural resources, rich countries may have to give up their economic growth to assure that all poor people in the world can reach a fair standard of living" (King et al., 2023). Thus, academic researchers may desire a higher growth rate for low-income than for high-income countries. We hypothesize that participants' perceived ideal growth rate is higher for low-income countries than high-income countries. Further, we expect this to be the case within both experimental conditions (Hypothesis 3, pre-registered).

3. Online experiment

3.1. Open science and ethical statement

The present work followed the following open science standards. First, the study's hypotheses were pre-registered on the platform Open Science Framework (OSF).[1] All study materials, data, and statistical code to computationally reproduce the presented results are available via the OSF.[2] Ethical approval was granted by the Faculty of Business Administration, Economics and Social Sciences of the University of Bern, with the protocol number 342022.

[1] Hypotheses 3–5 are for this paper, the others for another paper: https://osf.io/3p2dt

[2] https://osf.io/ru26y/?view_only=1b81caa719b7445e897d8c7d6a87b62e

3.2. Experimental design and procedure

Our study investigates the optimally perceived GDP development for high-income and low-income countries among academic researchers. We conducted an online experiment to examine whether the perceived ideal economic development differs depending on the GDP growth framing as a rate or as a factor. The experiment was part of a global survey investigating the perception of academic researchers towards the possibility of green growth.[3]

The experiment consists of two treatment groups called RATE and FACTOR. The treatments differ with regard to the given GDP development framing. The RATE group was asked to indicate the perceived ideal economic development as a rate, e.g., "Over the next 100 years, the economy should grow by _ % each year". In contrast, the GROWTH FACTOR group was asked to indicate a factor, i.e., "In 100 years, the economy should be _ times bigger than it is today". The study participants could in principle also indicate a negative rate (factor) or that the economy should keep the current size.

The survey consists of consent to participation, socio-demographic questions, the experiment and a final questionnaire with further questions about beliefs and attitudes. Among other things, in the first part of the survey participants were asked about their gender, age, and primary scientific field. Participants could self-assign their primary scientific field from a list.[4] Participants that have chosen the fields *Business, Management and Accounting* or *Economics, Econometrics and Finance* are considered as *economists* and all other participants as *non-economists*. In the next part of the survey, participants were asked about their ideal perceived economic development. Participants had to decide what they believe to be the best development of GDP, i.e. whether it should grow, shrink, or remain the same. Depending on the treatment, participants were asked to indicate the perceived ideal (de)growth rate or factor for the next century, for the two categories of high-income and low-income countries. At the end of the survey, political ideology was measured on a 7-point scale ranging from 1 ("completely left/liberal") to 7 ("completely right/conservative"). As a further control variable, the h-Index[5] of the academic researchers was retrieved from Scopus.

3.3. Sample characteristics

Academic researchers in the subject areas *Economics, Econometrics and Finance* as well as *Environmental Science* were targeted using the Scopus database of Elsevier. A minimum of one published article as a corresponding author in one of the top 100 peer-reviewed journals of the participants' field between 2018 and 2022 was required to be considered for the target group of the survey.[6] A personalized invitation was sent to 49,838 academic authors via email, followed by two reminders.[7] The emails were distributed in batches from February 21 to March 23, 2023.[8] The data of 2255 researchers was eligible for data analysis, since these researchers answered all experimental questions (response rate: 4.52%). Similar response rates have been reported in studies with comparable methodology (see e.g., Dablander et al., 2023). We excluded researchers from the data analysis who did not indicate their primary research field (n = 24), who provided no numerical growth rates or factors (n = 100), negative growth rates for a growing economy (n = 1), growth factors of 0 (n = 4), and who indicated surreal high growth factors or rates (growth factor ≥ 1,000,000 or annual growth rate ≥ 14.81%, respectively) (n = 65) leading to a sample of 2061 participants.[9][10][11] This sample is used for the analysis with regard to the academic researchers' preferred future direction of economic development (see section 4.4). In this sample, 853 participants have an economic background and 1208 participants have a background in other scientific fields, mostly in multidisciplinary, agricultural and biological, or environmental science (see Fig. 4 in Appendix). Compared to all invited academic authors, the study participants showed a reasonable similarity in all characteristics. However, an analysis of the continents to which they currently belong revealed that scientists from Europe were overrepresented in our survey, while scientists from Asia were underrepresented (see Fig. 5 and Table 5 in Appendix).

Since the hypotheses of the study focus on differences between participants who indicated positive growth rates / factors, we provide the sample characteristics of the 1802 subjects who indicated a numeric, positive growth rate/factor for low-income countries and/or high-income countries.[12] Table 1 provides descriptive statistics for socio-demographic variables, academic-related variables, and political ideology of the two treatment groups. The randomization between the two treatment groups was successful for all variables, meaning that no significant differences between the control variables were found.

4. Results

4.1. Effect of GDP growth framing on ideally perceived GDP

We first investigate whether GDP development framed as a rate leads to higher desired growth than when framed as a factor. Here, we solely focus on participants who have indicated positive growth numbers. Looking at high-income countries, participants in the RATE treatment indicated a median annual growth rate of 2% (mean = 2.64; SD = 1.85;

[3] See study instructions and questionnaire in supplementary document.

[4] We made a crosscheck among the participants' preferences and our initial Scopus pool showing that 36% of participants publishing in the subject area Economics, Econometrics and Finance self-assign themselves to another field than economics whereas only 1.9% of authors publishing in Environmental Science assign themselves to the field economics (see Table 6 in Appendix).

[5] The h-index is a metric to calculate the scientific output of a researcher (Hirsch, 2005). The metric is calculated based on citations of the scientist's publications.

[6] Journals were ranked using the CiteScore metric. This metric reflects the annual average number of citations to recent articles published for different academic journals. An overview of all journals can be seen in the the supplementary material. 24,838 economic experts and 112,646 environmental science experts fulfilled these requirements. Due to the imbalance between subject areas, only the top 25,000 Environmental Science experts, determined by the citation count of their articles, were selected to participate in the study.

[7] The first reminder was sent one week and the second two weeks after the initial invitation.

[8] The study responses were collected with the software Qualtrics. Participation in the survey was possible until April 4, 2023.

[9] With the exception of the exclusion criterion with the surreally high growth factors/rates, all criteria meet the necessary requirements for the hypothesis tests to be carried out. The exclusion of participants with surreally high growth factor or rates excludes only 65 participants from the analyses.

[10] For this sample, we winsorized the data: Economy sizes exceeding three standard deviations from the mean were considered as outliers. We substituted outliers with the highest value that was not an outlier.

[11] The answers of respondents who preferred either a growing or shrinking economy, but provided an ideal growth rate of 0 or factor of 1 were manually changed to "remain", as both a growth rate of 0 and factor of 1 lead to unchanged economy sizes after 100 years (n = 41).

[12] In other words, this means that we excluded participants who indicated that the economy should shrink or that the economy should neither grow nor shrink for both high- and low-income countries.

Table 1
Sample characteristics and randomization check between experimental conditions.

Variables	RATE	FACTOR	Group Comparisons
Demographics			
Gender (% male)	**75**	75	$p = 1$
Age in years	49 (11)	49 (12)	$p = 0.47$
Academic-related			
Scientific field (% economists)	44	41	$p = 0.29$
h-Index	20.38 (18.75)	21.42 (19.36)	$p = 0.34$
Political ideology			
Conservative ideology	3.12 (1.36)	3.12 (1.37)	$p = 0.92$
Observations	924	878	1802

Note. The table reports means and standard deviations for continuous variables and %age frequencies for categorical variables for both groups of the experiment. Standard deviations are given in parentheses. Female is a binary variable taking a value of 1 for individuals who identify themselves as men and 0 for women, individuals who self-describe them or prefer to not state a gender they identify with. Conservative ideology refers to a political ideology and was measured on a 7-point scale ranging from 1 ("completely left/liberal") to 7 ("completely right/conservative"). For categorical variables the results of Chi-squared test comparisons are given and for continuous variables the results of Wilcoxon-Mann-Whitney tests.

$n = 585$) for the next 100 years resulting in an economy that is 7.24 times larger than today (mean = 339.06; SD = 1739.30).[13] In the FACTOR condition, the median response resulted in an economy that is 5 times larger in 100 years (mean = 98.27; SD = 895.10; $n = 514$). Participants in the RATE condition suggested significantly higher ideal perceived growth for high-income countries than participants in the FACTOR condition ($p < 0.01$).[14] For low-income countries, the median growth rate indicated in the RATE treatment is 4% per year (mean = 4.08; SD = 2.41; $n = 910$) which leads to a median economy size that is 51 times bigger in 100 years (mean = 1098.37; SD = 3461.54). In the FACTOR condition the outcome is a median of a 6 times bigger economy size in 100 years (mean = 109.67; SD = 959.77; $n = 857$). Also for low-income countries participants suggested significantly higher ideal growth when asked about growth rates than when asked about growth factors ($p < 0.01$). The significant difference between FACTOR and RATE framing is also present in a sample including the surreal high growth factors / rates ($n = 2126$), for both high-income ($p < 0.01$; $n = 1140$) and low-income countries ($p < 0.01$; $n = 1825$). Our data thereby supports the hypothesis that participants in the RATE condition indicate larger GDP outcomes than participants in the FACTOR condition (Hypothesis 1).

Fig. 1 shows the distribution of the resulting economy sizes depending on the condition and income level of the country. The dispersion of the resulting economy sizes is much greater in the RATE condition than in the FACTOR condition. This is due to the fact that growth rates are exponential and therefore even small differences in annual growth rates lead to significantly different economy sizes after 100 years. This dispersion of economy sizes becomes bigger, the higher the growth rates get. This explains the great dispersion of values for low-income countries in the RATE group.

OLS regression models confirm the results of the hypothesis tests. There is a significant impact of the rate framing on the resulting economy sizes of high-income countries (see Table 2).[15] Specifications 2 and 3 control for further factors potentially influencing the ideal perceived economic growth. While gender, age and participants' h-index do not have a significant influence on the outcome of desired GDP growth, the academic field has. Having an academic background in economics leads to significant smaller ideal perceived economic growth. The mean economy size resulting of the growth indicated by *non-economists* (mean = 302.10) is much larger than that of *economists* (mean = 160.71). In terms of the median, however, both scientific groups have a median of 7.24. Since *non-economists* may have less knowledge about the exponential effect of growth rates, they may have underestimated growth more. For a high mean, it only takes a few people to underestimate exponential growth.[16] The interaction plot visualizes that the experimental condition had stronger effects on non-economists' growth rates than on economists (see Fig. 2).[17]

In comparison to the regression model focusing on factors influencing the economy size of high-income countries, the specifications for low-income countries show two main differences (see Table 3). First, the effect of the RATE condition on the economy size is by far stronger for low-income countries. Second, there is no significant influence of an academic background in economics on the desired growth of low-income countries. The interaction plot depicts that *economists*' and *non-economists*' growth numbers are more aligned with regard to low-income countries (see Fig. 2).

As explorative analyses, sub-groups with the same academic background were analyzed to see whether both *economists* and *non-economists* are influenced by GDP growth framing. Since *economists* might have more knowledge regarding GDP development than other academic researchers, *economists* may be less likely to be influenced by the framing of GDP development. For high-income countries, the desired extent of economic growth by *economists* leads to a significantly larger economy in 100 years in the RATE condition (median = 7.24; mean = 180.33; SD = 1193.45; $n = 324$) than in the FACTOR condition (median = 5; mean = 136.64; SD = 1085.23; $n = 264$) ($p < 0.01$). For low-income countries *economists*' optimal perceived growth rates (median = 50.50; mean = 881.80; SD = 3003.20; $n = 400$) also lead to a significantly larger economy in 100 years than the indicated growth factors (median = 10; mean = 167.20, SD = 1280.05; $n = 353$) ($p < 0.01$). Less surprisingly, also *non-economists*' growth rates lead to a significant larger economy than their indicated growth factors, for both low-income ($p < 0.01$) and

[13] Despite the exclusion of surreally high growth numbers with growth factors equal or higher than 1,000,000 or annual growth rates equal or higher than 14.8%, respectively, there are still some large values leading to a right-skewed distribution with a high mean value. The median is therefore more representative and significantly smaller than the mean.

[14] For between-subject comparisons, one-sided Wilcoxon-Mann Whitney tests were conducted.

[15] We refrain from showing regression robustness checks including participants who indicated surreally high growth rates or factors. The reason for this is that these participants' growth numbers result in enormously high economic sizes, which completely distort the results of the regression. For high-income countries there are 21 data points with economy sizes that are greater than 1e+10 in 100 years and for low-income countries 32. Due to the exclusion of surreally high growth numbers (growth factor $\geq$ 1,000,000 or annual growth rate $\geq$ 14.8%, respectively) only 65 participants are excluded and our treatment effect with the restricted sample is highly significant for all specifications ($p < 0.01$). Thus we assume that the results are robust.

[16] After winsorizing, the highest value for the economy size of high-income nations is a 10,640 larger economy size in 100 years. Of the 25 participants indicated growth values leading to this size, only 7 stem from *economists*.

[17] See regression tables including the interaction effects in Table 4 in the Appendix.

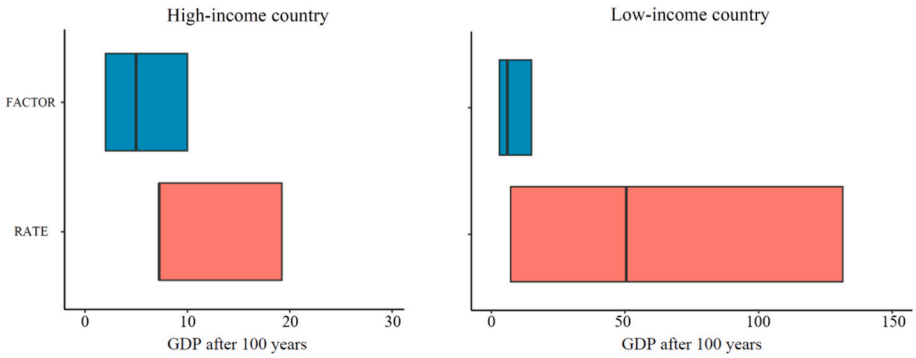

Fig. 1. Boxplots showing the distribution of the resulting relative GDP sizes based on the indicated growth factors and rates by condition (RATE or FACTOR) and income of country (high- or low-income). The baseline for the GDP size is 1. The line inside the box represents the median, while the bottom and top edges of the box represent the first and third quartiles, respectively.

Table 2
Effect of GDP growth framing on economy size of high-income country: OLS regression results.

	Economy size of high-income country (1)	Economy size of high-income country (2)	Economy size of high-income country (3)
(Intercept)	98.27 *	128.03	226.88 *
	(39.52)	(94.24)	(114.22)
RATE	240.79 **	245.43 **	247.51 **
condition	(82.11)	(87.30)	(88.01)
Male		−36.06	−0.62
		(114.66)	(114.72)
Age		29.80	52.05
		(53.64)	(65.08)
Field			−240.11 *
Economics			(104.01)
h-index			−96.93
			(50.23)
Observations	1099	1073	1073
R2	0.01	0.01	0.01

Note. The table presents ordinary least squares estimates. The dependent variable is the resulting economy size of a high-income country in 100 years. Male is a binary variable taking a value of 1 for men and 0 for women and non-binary and other individuals. Field Economics is a binary variable taking the value of 1 if the academic field is Economics, Econometrics, Finance, Business, Management, or Accounting. *, **, and *** represent significance at the 5%, 1%, and 0.1% levels, respectively.

Table 3
Effect of GDP growth framing on economy size of low-income country: OLS regression results.

	Economy size of low-income country (1)	Economy size of low-income country (2)	Economy size of low-income country (3)
(Intercept)	109.66 *** (32.80)	327.56 **	389.80 **
		(124.13)	(132.61)
RATE	988.72 ***	978.83 ***	985.25 ***
condition	(119.41)	(120.92)	(122.12)
Male		−285.71	−278.50
		(164.86)	(166.81)
Age		−10.80	−47.41
		(60.62)	(84.36)
Field			−166.98
Economics			(156.96)
h-index			38.39
			(108.31)
Observations	1767	1722	1722
R2	0.04	0.04	0.04

Note. The table presents ordinary least squares estimates. The dependent variable is the resulting economy size of a low-income country in 100 years. Male is a binary variable taking a value of 1 for men and 0 for women and non-binary and other individuals. Field Economics is a binary variable taking the value of 1 if the academic field is Economics, Econometrics, Finance, Business, Management, or Accounting. *, **, and *** represent significance at the 5%, 1%, and 0.1% levels, respectively.

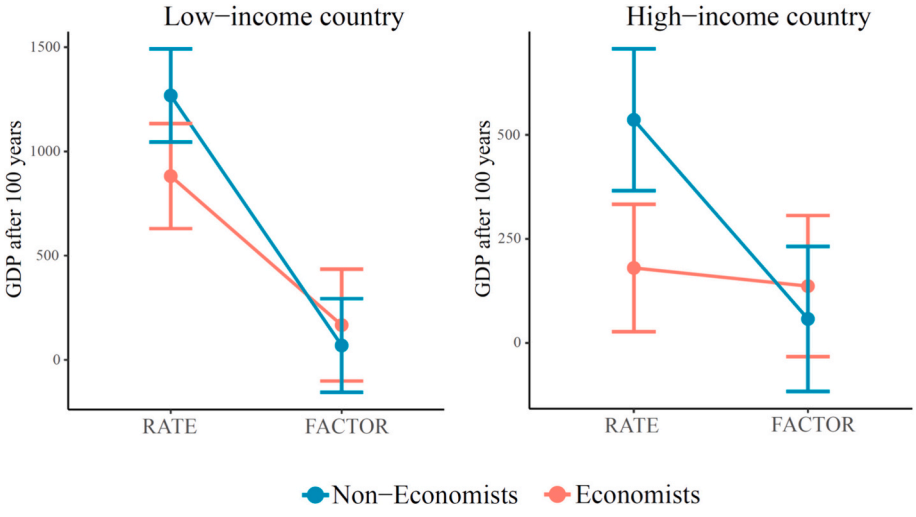

Fig. 2. Interaction effects of condition (RATE or FACTOR) and academic field (non-economists or economists) for the resulting mean economy sizes after 100 years (calculated based on the researchers' factors or rates indicated) of both high-income and low-income countries. Error bars are indicated.

high-income ($p < 0.01$) countries.[18][19]

4.2. Partially different perceived ideal GDP growth by economists and non-economists

This section focuses on potential differences between *economists* and *non-economists* regarding their ideal perceived GDP growth. The analyses focus only on survey participants who have indicated positive growth numbers. Independent of the condition, the median economy size of high-income countries resulting from the indicated growth rates and factors is 7.24 among *economists* (mean = 160.71; SD = 1145.38; n = 588) as well as among *non-economists* (mean = 302.09; SD = 1667.48; n = 511).[20] Thus, across treatments *economists* did not suggest significantly higher ideal growth compared to *non-economists* for high-income countries (p = 0.78). For low-income countries, the growth rates and factors indicated by *economists* result in a median economy size that is 19 times larger (mean = 546.8; SD = 2383.22; n = 753) and the growth rates indicated by *non-economists* result in a median economy size that is 10 times larger (mean = 672.34; SD = 2780.89; n = 1014).[21] Across treatments, *economists* suggested significantly higher ideal growth for low-income countries compared to *non-economists* ($p < 0.01$). Fig. 3 shows the resulting median economy sizes of high- and low-income countries, broken down by academic fields.

Further analyses compare the resulting economy sizes based on the answers of *economists* and *non-economists* sub-divided into the two treatment groups. For high-income countries in the RATE condition, *economists* (median economy size = 7.24; mean = 180.33; SD = 1193.45; n = 324)[22] did not suggest significantly higher ideal growth compared to *non-economists* (median economy size = 7.24; mean = 536.11; SD = 2226.02; n = 261)[23] (p = 0.990). Also in the FACTOR condition, *economists* (median = 5; mean = 136.64; SD = 1085.23; n = 264) did not suggest significantly higher ideal growth for high-income countries compared to *non-economists* (median = 5; mean = 57.76; SD = 635.25; n = 250) (p = 0.183). With regard to low-income countries in the RATE condition, *economists* suggested growth rates leading to a significantly larger median economy size (median = 50.50; mean = 881.80; SD = 3003.20; n = 400)[24] compared to *non-economists* (median = 20.62; mean = 1268.24; SD = 3776.61; n = 510)[25] ($p < 0.01$). For low-income countries in the FACTOR condition, the growth factors indicated by *economists* also led to a significantly larger economy size (median = 10; mean = 167.20; SD = 1280.05; n = 353)[26] than the growth factors indicated by *non-economists* (median = 5; mean = 69.36; SD = 645.78; n = 504)[27] ($p < 0.01$). The hypothesis (2) that *economists* suggest higher ideal growth compared to *non-economists* can only be confirmed for the desired growth for low-income countries, but not for high-income countries.[28]

4.3. Different perceived ideal GDP growth for high-income and low-income countries

In this section, the focus is on potential differences between the optimal perceived economic growth of low-income versus high-income countries. For this within-subject analysis, only participants who indicated a positive growth rate or factor for both low- and high-income countries are considered (n = 1064). Across both treatments, the optimal perceived economy size of high-income countries is three times (= median) bigger in 100 years (mean = 152.56; SD = 1162.88). For low-income countries, the ideal perceived economic growth is a ten times (=median) larger economy size in 100 years (mean = 607.03; SD = 2594.64). Across all participants who indicated a positive growth rate or factor for low-income and high-income countries, the perceived ideal GDP growth is significantly higher for low-income countries than for high-income countries ($p < 0.01$).[29] Also when looking at the RATE ($p < 0.01$) and FACTOR ($p < 0.01$) condition groups separately, within both groups the resulting economy size is larger for low-income than for high-income countries. Thus, hypothesis 3 can be confirmed.[30]

4.4. Preferences about the direction of economic development

Besides the extent of economic growth, we also measured preferences about the direction of development, i.e. whether the economy size should shrink, remain the same, or increase over the next 100 years. For high-income countries, 16.7% of participants indicated that the size of the economy should ideally decrease, 53.3% that it should increase, and 30% that it should remain in a steady state. For low-income countries, 3.2% of participants indicated that the size of the economy should ideally decrease, 85.7% that it should increase, and 11.1% that it should remain in a steady state. Taken together, 85.7% of participants are in favor of an increasing economy over the next 100 years for low-income countries and 53.3% for high-income countries.

We find significant differences when comparing the ideal perceived direction of economic development between *economists* and *non-economists*. For high-income countries, 10.4% of *economists* are in favor of a decreasing, 68.9% of an increasing, and 20.6% of a steady state economy. 21.2% of *non-economists* prefer a decreasing, 42.3% an increasing, and 36.5% a steady state economy for high-income countries. There is a significant difference between *economists*' and *non-economists*' perception of ideal direction of economic development for high-income countries ($p < 0.01$; Pearson's Chi-squared test) that has also been confirmed for all pairwise tests.[31] With regard to low-income countries, 2.6% of *economists* prefer a decreasing, 88.3% an increasing, and 9.1% a

[18] The median economy size of low-income countries in the FACTOR condition among *non-economists* is 5 (mean = 69.36; SD = 645.78; n = 504) and in the RATE condition 20.62 (mean = 1268.24; SD = 3776.61; n = 510). For high-income countries, the indicated factors among *non-economists* leads to a median economy size of 5 (mean = 57.76; SD = 635.25; n = 250) and the growth rates to a median economy size of 7.24 (mean = 536.11; SD = 2226.02; n = 261).

[19] Within the group of *economists* as well as *non-economists*, the significant difference between FACTOR and RATE framing is also present in a sample including the surreal high growth factors / rates, for both high-income and low-income countries (p-values of all four pairwise tests <0.01).

[20] A 7.24 times bigger economy in 100 years corresponds to an annual growth rate of 2%.

[21] A 19 times bigger economy corresponds to an annual growth rate of 4% and a 10 times bigger economy to an annual growth rate of 3% over the next 100 years.

[22] Corresponds to a median growth rate of 2% per year (mean = 2.42; SD = 1.55).

[23] Corresponds to a median growth rate of 2% per year (mean = 2.92; SD = 2.12).

[24] Corresponds to a median growth rate of 4% per year (mean = 4.27; SD = 2.19).

[25] Corresponds to a median growth rate of 3% per year (mean = 3.93; SD = 2.56).

[26] Converted into a growth rate, the median economy size after 100 years corresponds to a median growth rate of 2.34% per year.

[27] Converted into a growth rate, the median economy size after 100 years corresponds to a median growth rate of 1.62% per year.

[28] The p-values obtained from significance tests including the participants who indicated surreal high growth factors / rates confirm this conclusion.

[29] For all within-subject comparisons Wilcoxon signed rank tests were performed.

[30] The p-values obtained from significance tests including the participants who indicated surreal high growth factors / rates confirm this conclusion.

[31] The p-value has been adjusted due to multiple testing. Since the pairwise Chi-square tests are performed for the three directions of economic development for high and low-income countries, the p-value is divided by 6. Thus, the adjusted p-value is 0.00833 (0.05/6).

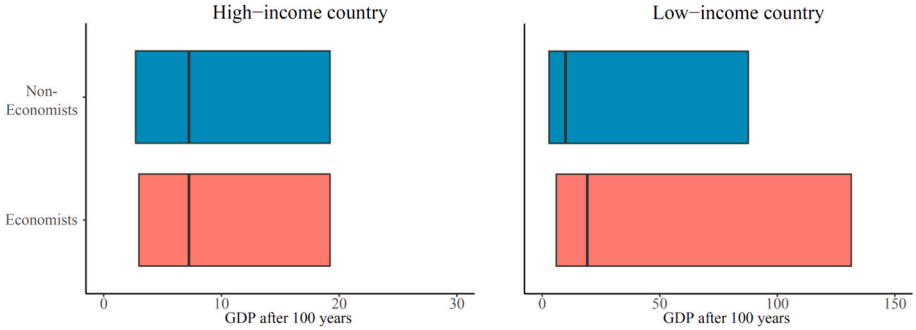

Fig. 3. Boxplots showing the distribution of the resulting relative GDP sizes of high- and low-income countries across experimental conditions, broken down by the responses of the two academic fields. The relative GDP sizes are calculated based on the indicated growth factors and rates. The baseline GDP size is 1. The line inside the box represents the median, while the bottom and top edges of the box represent the first and third quartiles, respectively.

steady economy. Similarly, also a majority of *non-economists* are in favor of an increasing economy size (83.9%) and only a few prefer a decreasing (3.6%) or steady (12.5%) economy size of low-income countries. There is an overall significant difference between the two fields' perceptions of optimal direction of economic development of low-income countries ($p < 0.05$; Pearson's Chi-squared test), and also the pairwise tests for the fractions for an increasing and stable economy size yield a significant difference based on the adjusted p-value.

5. Discussion and conclusion

We investigate the ideal perceived GDP development among *economists* and *non-economists* by framing GDP development either as an annual rate (i.e., x% annual growth over the next 100 years) or as a factor (i.e., x times bigger GDP in 100 years). The results of the experiment show that a rate framing leads to a significantly larger economy than GDP factor framing. Both economic and non-economic academic researchers indicated growth rates that lead to significantly larger economy sizes than when suggesting growth factors.

Underestimating exponential growth as well as an anchoring bias are potential reasons why GDP development framed as rate leads to higher desired growth than GDP development framed as factor. An annual growth rate of 2% may sound like a small rate but leads to a 7.24 times larger economy in 100 years. Therefore, the exponential effect of annual growth rates may be underestimated even among academic researchers (see e.g., Christandl and Fetchenhauer, 2009; Wagenaar and Sagaria, 1975). This notion is supported by the finding that the effect of the rate framing on the economy size is stronger for low-income countries where significantly higher desired growth has been indicated than for high-income countries. When asked about annual rates, individuals may also anchor their estimates to historical or target growth rates of countries that they are familiar with (Campbell and Sharpe, 2009; Tversky and Kahneman, 1974). Individuals may use historical or target growth rates as reference points for their growth rate suggestions. In contrast, when asked about growth factors, the absence of specific reference points may reduce the influence of anchoring, leading to more tempered or cautious ideal growth suggestions.

Preferences for continued economic growth seem to be higher in our study than in previous research. For high-income countries, 16.7% of our participants perceive a decreasing economy as ideal, 53.3% an increasing size, and 30% a steady state. Similar research investigating GDP development opinions among academic researchers categorized only 27% of participants holding a general green growth position (King et al., 2023) and 22.3% supporting a green growth approach of high-income countries for the current decade (Koskimäki, 2023). In contrast to our study, both of these studies have samples solely consisting of researchers actively publishing on sustainable development. These experts might be more aware of the trade-offs between mitigating environmental pressures and increasing GDP than our study sample. Further, by indicating the level of agreement with different growth-versus-environment statements (e.g., "Economic growth is necessary to finance environmental protection"), the academic researchers in the study of King et al. (2023) were forced to think about environmental aspects in relation to the economic development. Similarly, Koskimäki (2023) asked participants to choose one of four different future pathways, all of which included different developments of GDP, societal well-being, and environmental impact. The different samples and measurements might explain, why in our study participants are more in favor of an increasing GDP.

A limitation of the study is that we do not distinguish between different fields within *economics* and the group of *non-economists* in our analyses. It has been shown that within the broad field of economics different opinions with regard to economic growth exist (Drews and van den Bergh, 2017). For example, environmental & resource economists have been shown to be more in favor of GDP growth than ecological economists. Since ecological economists are a minority among economists, we assume that our study results mainly represent the opinion of mainstream neoclassical economists. The focus of our study is to provide a behavioral perspective on ecological economics that may have significant practical implications on economic development goals and in consequence on the ecological sustainability of the economy. Nevertheless, future studies could investigate whether similar GDP growth framing effects also exist within different sub-groups of economics, such as in the fields of ecological economics or growth theory.

In our study, participants were asked to indicate the optimal direction and extent of economic development over the next 100 years. It can be criticized that 100 years is too long of a period to make an accurate assessment of economic development. However, previous studies already widely demonstrated biases for shorter time periods (from $t = 0.083$ to $t = 25$). Also, we argue that exactly this lack and disability of long-term considerations with regard to GDP development is a major issue. Focusing only on growth rates for the next year or decade may undermine the ability to reflect about the major impact of long-term economic growth. Our study clearly shows that among academic researchers a focus on annual rates leads to significantly higher desired economic growth compared to a focus on factors. This result suggests an underestimation of GDP growth rate outcomes among academic researchers.

Since there is a relationship between exceeding planetary boundaries and economic growth, a critical reflection about the direction and extent of economic development is necessary. Annual target GDP growth rates may be internalized by different institutions without being questioned with regard to their concrete purpose or potential long-term implications. Our research suggests that preferences with regard to annual growth rates are rather based on heuristics than on a thorough analysis of optimal economic development.

Being aware that even small annual growth rates have a large long-term impact on the size of an economy might raise awareness to consider

alternative post-growth perspectives in the discourse on sustainable economic development strategies. Increasing understanding of exponential growth among academic researchers and policy makers dealing with economic growth issues may be a fruitful way forward. Being aware of the exponential development of GDP growth and its framing implications may foster discussions about more nuanced approaches to economic development that are less based on heuristics. Alongside considerations of planetary boundaries and human well-being, economists and policymakers are urged to factor in the framing used to discuss economic growth or degrowth pathways. Ultimately, this holistic perspective may advocate for sustainable economic development goals centered on indicators beyond mere GDP growth.

CRediT authorship contribution statement

Manuel Suter: Writing – review & editing, Writing – original draft, Visualization, Software, Project administration, Formal analysis, Data curation, Conceptualization. **Noel Strahm:** Writing – review & editing, Visualization, Software, Methodology, Formal analysis, Data curation, Conceptualization. **Till Bundeli:** Writing – review & editing, Data curation, Conceptualization. **Kaja Kaessner:** Writing – review & editing, Data curation, Conceptualization. **Viktoria Cologna:** Writing – review & editing, Methodology, Conceptualization. **Sebastian Berger:** Writing – review & editing, Supervision, Project administration, Methodology, Conceptualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

We have shared the link to our data/code in the manuscript.

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Appendix A. Additional Analyses

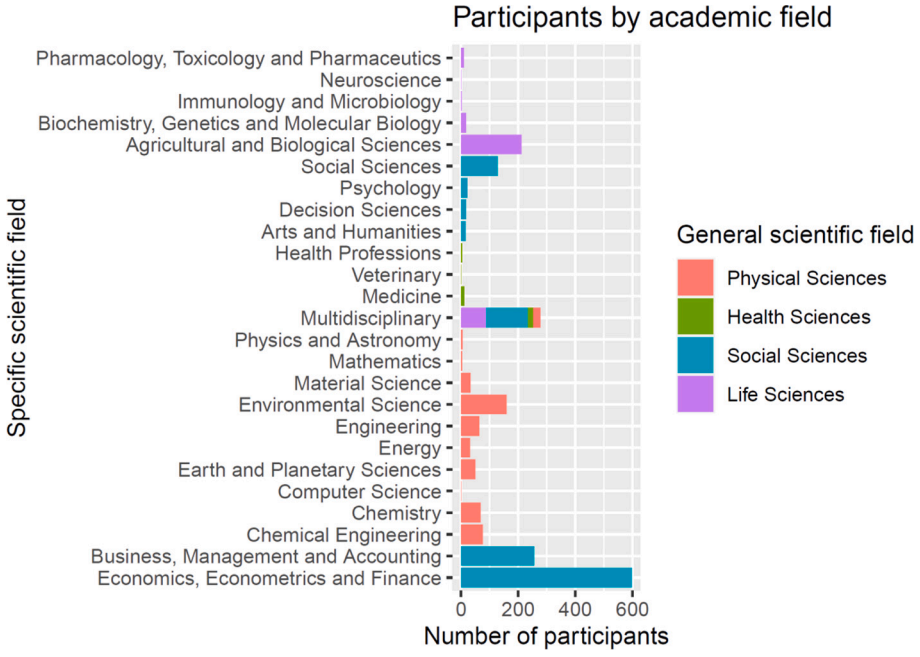

Fig. 4. Number of participants by academic field ($n = 2061$).

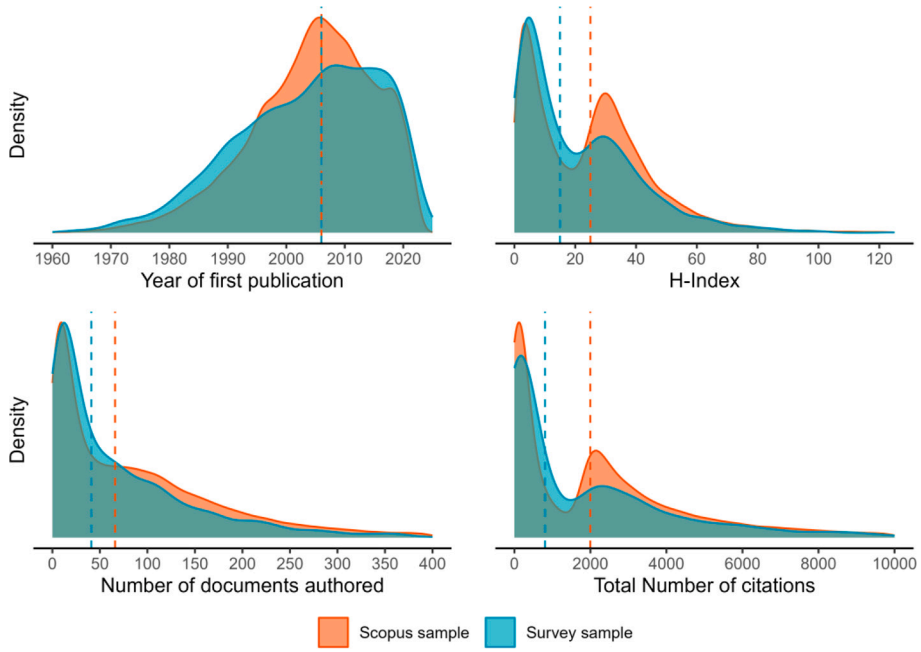

Fig. 5. Comparison of survey participants (survey sample, $n = 2061$) with the Scopus survey population invited (Scopus sample, $n = 49{,}838$). The dashed lines indicate the median values of the respective distributions.

Table 4
Comparison of survey participants (survey sample, $n = 2061$) with the Scopus survey population invited (Scopus sample, $n = 49{,}838$). Gender was self-reported in the survey sample and estimated in the Scopus sample based on the author's first name using the Gender API algorithm (see Santamaría and Mihaljević, 2018). The other variables were obtained from Scopus.

Characteristic	Total sample ($n = 49{,}838$)	Survey ($n = 2061$)
H-Index	25 (20.15)	15 (19.10)
Number of articles	66 (124.84)	41 (95.31)
Total number of citations	1997 (4851.10)	806 (4271.58)
Year of first publication	2006 (10.61)	2006 (12.01)
Affiliation's continent		
Asia	19,017 (38%)	195 (9.5%)
Europe	15,825 (32%)	1127 (55%)
North America	11,090 (22%)	493 (24%)
Oceania	2167 (4.4%)	113 (5.5%)
South America	957 (1.9%)	88 (4.3%)
Africa	588 (1.2%)	34 (1.7%)
Gender		
Female	13,018 (28%)	505 (25%)
Male	33,811 (72%)	1496 (74%)
Other	21 (<0.1%)	18 (0.9%)

Note. The table reports medians and standard deviations for continuous and percentage frequencies for categorical variables. Standard deviations are given in parentheses.

Table 5
Effect of GDP growth framing and interaction on economy sizes: OLS regression results.

	Economy size of high-income country	Economy size of low-income country
(Intercept)	57.76	69.36
RATE condition	478.35 ***	1198.88 ***
Field economics	78.88	97.84
RATE condition × Field economics	−434.66 **	−484.29
Observations	1099	1767
R^2 / R^2 adjusted	0.016 / 0.013	0.039 / 0.038

Note. The table presents ordinary least squares estimates. The dependent variable are the resulting economy sizes of a low- and high-income country in 100 years. Field Economics is a binary variable taking the value of 1 if the academic field is

Economics, Econometrics, Finance, Business, Management, or Accounting. *, **, and *** represent significance at the 5%, 1%, and 0.1% levels, respectively.

Table 6
Crosscheck among participants' preferences for their primary scientific field and the initial Scopus pool.

	Publishing author in:		
	Economics, Econometrics and Finance	Environmental Science	Total
Self-assigned as:			
Economist	839 (64%)	14 (2%)	853 (41%)
Non-Economist	472 (36%)	736 (98%)	1208 (59%)
Total	1311 (100%)	750 (100%)	2061 (100%)

Appendix B. Supplementary data

Supplementary data to this article including study instructions and questionnaire as well as the list of journals considered for the study target group can be found online at https://doi.org/10.1016/j.ecolecon.2024.108240.

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