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ARTICLE

Measuring farmer time preferences: A systematic literature review for Europe and North America

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Abstract

We present the first systematic review of the literature on farmer time preference measurements across Europe and North America. We synthesize methodological developments, summarize the empirical findings, and discuss challenges and potential areas for further research. The average reported discount rate of the farmers in Europe and North America is 23% per annum. Farmer time preferences are, however, highly heterogeneous within and across studies. Moreover, we identify methodological challenges and knowledge gaps to be addressed in future research. We draw conclusions for policymakers and researchers.

KEYWORDS

agricultural investment, discounting, Europe, farmers, North America, time preferences

JEL CLASSIFICATION

D25, D15, D22, Q12

1 | INTRODUCTION

A characterizing feature of agricultural production is long delay between investments and potential returns (e.g., Sunding & Zilberman, 2001). For example, many benefits resulting from the adoption of new and more sustainable farming practices only materialize fully over longer time horizons (Mao et al., 2021, Wuepper, 2020).

Farmers' time preferences are often key to explain observed investment behaviors and thus of key relevance for agricultural policy, public extension services, as well as for up- and downstream industries. Policies supporting adoption of innovations and sustainable farming practices can often be made more efficient by taking into account farmers' preferences (Wuepper et al., 2023). We currently, however, lack a systematic overview of farmer time preferences.

This paper presents the first systematic review of the literature on farmer time preferences across Europe and North America. We address three questions: First, what do we know about the time preferences of farmers in this part of the world? Second, what do we know about best practices and empirical issues regarding the elicitation of these farmers' time preferences, including the effects of different methodological choices? Third, what are open areas for future research?

Previous studies aiming to synthesize knowledge across time preferences were especially focused on methodological choices and their impact (e.g., Cheung, 2016, Cohen et al., 2020, Matousek et al., 2022, Sprenger, 2015) and general discussions of time discounting and time preferences (Frederick et al., 2002). Complementary to our work, Iyer et al. (2020) synthesized knowledge of European farmers' risk preferences using a systematic review. Also complementary, Matousek et al. (2022) have recently meta-analyzed individual discount rates in the general population globally. We here contribute by providing the first systematic review of farmer time preferences in Europe and North America, which has been missing to date. Our geographic focus has three reasons. First, even though there are obvious differences, farmers in both regions face similar policy goals and incentive schemes from policies (Baylis et al., 2008, 2022, Dessart et al., 2019).[1] Second, socioeconomic conditions (e.g., income, education) matter for time preferences (Falk et al., 2018, Haushofer & Fehr, 2014), so we have aimed here to focus on a somewhat comparable world region in terms of socioeconomic conditions. Third, voluntary agri-environmental schemes are a key element in agricultural policies in Europe and North America and our review aims to provide relevant information for such programs. For example, Schaub et al. (2023) show that more impatient farmers have a lower willingness to take up more inflexible agri-environmental schemes (e.g., regarding contract length and contract restrictions) and we here provide systematic evidence how impatient farmers actually are. Fourth, we also capture which methods are commonly used, results in terms of farmer time preferences, and empirical associations between elicitation choices and findings.

We identified 12 published articles reporting farmer time preferences in Europe and North America. We find a substantial heterogeneity in elicited time preferences and underlying methodological approaches, such as the range of choices in experimental elicitations. However, all methodological and sample effects aside, there are empirical regularities in the published literature that are a reliable foundation for future research and policies. First of all, farmers in Europe and North America discount the future strongly, that is, on average by 23% per annum. Second, there is large variation between and especially within countries. In Germany, the lowest elicited discount rate was 4% (Philipp Steinhorst & Bahrs, 2014) and the highest was 30% (Gruener, 2021). In France, the lowest elicited discount rate was 14% (Bocquého et al., 2013), and the highest was 27% (Bougherara et al., 2021). The largest discount rate was found in the USA, with 45.5% (Kovacs & Snell, 2021).

The remainder of this paper is structured as follows. In Section 2, we describe the background on time preferences and time preference elicitation. Then, we describe our empirical approach and data (Section 3). This is followed by our results (Section 4), a discussion and conclusion (Section 5).

2 | BACKGROUND

In this section, we briefly introduce the most common modeling frameworks (Section 2.1) and empirical approaches (Section 2.2). We also refer to further literature, as we can only scratch the surface here, especially in Section 2.2.

[1]Baylis et al. (2008) also discuss differences between agri-environmental programs between Europe and North America.

2.1 | Economic theory on time preferences

Farmer time preferences represent their current valuation of receiving a benefit or paying a cost at a later point in time. This can be expressed using a discount function. The stronger the farmer's time preference (higher discount rate), the more impatient is the farmer, that is, the smaller is her valuation of future benefits and costs. The simplest kind of discounting is exponential discounting, which assumes that farmers' patience is constant (e.g., same in the short-run and in the long-run) and there is no time inconsistency. More complex models augment this simple set-up and allow for more patience in the long-run than in the short-run (i.e., a higher initial discount rate and a lower discount rate for later). This can be modeled, for example, with hyperbolic or quasi-hyperbolic discounting (Benhabib et al., 2010, Rubinstein, 2003) or with subadditive discounting (Wang et al., 2016).

For illustration, assume the relationship between the present value of a cash flow, denoted by PV, and its future value in period t, denoted by FV (Wang et al., 2016):

$$\mathrm{FV} = \mathrm{PV}(1 + r)^t, \tag{1}$$

where r is the discount rate, which is derived as:

$$r = (\mathrm{FV}/\mathrm{PV})^{1/t} - 1. \tag{2}$$

The higher r, the stronger is a farmer's time preference. This assumes exponential discounting. In this model, future periods could be any t (e.g., 1 year, 10 years etc.) and relationships in Equations (1) and (2) assume time preferences between any adjacent periods are constant.

For (quasi-) hyperbolic discounting, instead of only using one, constant discount rate, captured by a single parameter, two or even three parameters are used. These parameters capture the standard discount rate, the present bias, and the hyperbolicity. The required data will normally come from experiments in which not only the reward for waiting is varied but also the time delays, so that for example, short- and long-run time discounting is revealed. A general model that nests exponential, hyperbolic, quasi-hyperbolic discounting looks as follows (Benhabib et al., 2010, Tanaka et al., 2010):

$$\mathrm{FV} = \mathrm{PV}\beta(1 - (1 - \theta)rt)^{1/(1-\theta)})\text{for } t > 0(\text{and simply PV for } t = 0). \tag{3}$$

Here, r captures the standard discount rate, β captures farmers' present bias, and θ captures the hyperbolicity of the discount function. With $\beta = 0$ and θ close to one, we get standard exponential discounting. With $\beta = 1$ and $\theta = 2$, we get hyperbolic discounting. With β free and θ close to one, we get quasi-hyperbolic discounting.

2.2 | Elicitation of time preferences

The most common approach to elicit time preferences is experimentally, and especially using multiple price lists (MPL). Supporting Information S1: Table S1 shows a simple example how this is commonly set up (adapted from Bougherara et al., 2021). In these experiments, respondents are usually asked to choose between smaller but sooner and larger but later monetary gains and the more money they require to be willing to wait, the stronger their inferred time preference (e.g., Bougherara et al., 2021, Gruener, 2021).

Experimental approaches, such as multiple price lists, single choice, or the investment alternatives approach, are the dominant time preference measurement approach. Moreover, self-evaluations and proxy statements are used frequently too (see also Cohen et al., 2020,

Harrison et al., 2005). In self-evaluations, respondents are directly asked to rate their time preferences, sometimes very general, such as "how patient would you rate yourself on a scale from 1 to 6?." These questions can also be made domain (or problem) specific, for example, such as "How long a payback period would you allow to consider investing in biochar?" (Maroušek et al., 2014).

An example for a proxy statement can be found in the World or European Value surveys (www.worldvaluessurvey.org), where respondents state which child qualities they find important to be encouraged at home. One includes "thrift, saving money and things." This can be used as a proxy for respondents' time preferences (Galor & Özak, 2016, Wuepper, 2020).

An important concern for any way of measuring farmers' time preferences is that time preferences should not be confounded with risk preferences. For example, assuming risk neutrality when farmers are actually risk averse would lead to an overestimation of farmers' time preferences (because risk neutrality implies a linear utility function and risk aversion a concave one). This has been found in several recent time preference elicitation studies (e.g., Andersen et al., 2008; Laury et al., 2012). One way to prevent this is a joint elicitation of risk and time preferences (Andersen et al., 2008, Falk et al., 2018). Another is the estimation of time preferences from convex budgets (Andreoni & Sprenger, 2012). For a review and critical discussion, see Cheung (2016).

Important to note is the large number of specific choices that have to be made when designing elicitation experiments, and it has often been found that many of these choices meaningfully change estimated time preferences. For example, the magnitude and range of offered alternatives systematically change inferred time preferences (Andersen et al., 2013; Hermann & Musshoff, 2016b). An open question is how important monetary incentivization is. Whereas economists have a natural inclination to highly value incentive compatibility, Cohen et al. (2020) actually find little evidence for systematic discount rate differences between incentivized and unincentivized experiments. A disadvantage of monetary incentivization (i.e., actual money is paid back in the time horizon defined in the experiment) is that it becomes infeasible to use "agricultural" investment time spans in all contexts (e.g., years and decades). Commonly, incentivized experiments thus use relatively short time spans, sometimes as short as a few weeks, and then elicited discount rates are extrapolated to a per annum basis. Especially with nonexponential discounting, this can create a bias.

We investigate a range of empirical patterns. First, we investigate whether monetary incentivization might lead to systematically lower discount rates (e.g., because without incentivization farmers strategically display more impatience to potentially get more compensation in actual programs, or because they make more extreme choices when nothing real is at stake). Second, we investigate whether short time spans in the experiment lead to higher discount rates (e.g., if respondents discount more in the short term than in the long term). Third, whether a higher reward for waiting leads to more patience (Hermann & Musshoff, 2016b).

In the Supplementary Materials, we investigate further patterns:

First, whether fundamentally different elicitation methods give systematically different results (e.g., whether a multiple price list, an investment alternative, or a single choice approach has been taken), Second, whether using increasing probability of a fixed payment leads to higher discount rates than increasing payments (if e.g., farmers respond more sensitive to monetary variation than probabilistic variation because the former is more salient). Third, whether farmers in the United States have systematically different preferences from their European counterparts (e.g., because of cultural or economic differences). fourth, whether a wider range of offered rewards leads to a lower discount rate, and fifth, whether a shorter time delay until the earlier option is paid out increases the estimated discount rate.

3 | MATERIAL AND METHODS

We follow the Prisma-P method, a standardized protocol for systematic reviews that was proposed by Shamseer et al. (2015). This approach aims to mitigate arbitrary decision-making and aims to enable readers to assess for the presence of selective reporting (Shamseer et al., 2015). We explain

the approach and the used steps and criteria below and provide additional information in the Supplementary Materials. The remainder of this section is organized as follows: First, criteria for study eligibility, considered information sources for the search, and the precise search strategy are presented. Second, we outline tools and methods for data processing and the selection of relevant articles. Third, selected data that were extracted for the analysis and a comparison of results from different studies are shown.

3.1 | Search strategy and inclusion criteria

We used a Boolean search string on Web of Science as well as Scopus to obtain a first broad selection of studies that include a measurement of farmers' time preferences in Europe and North America (see Table 1 for the keywords and databases used). We only considered studies with empirically elicited time preferences, a focus on farmers and agriculture, with underlying data not older than 1990, published in English. Whether time preferences were elicited as primary goal or not did not matter for inclusion of studies. We could include all articles published before March 2022.

3.2 | Screening

The procedure described above led to a database containing 2746 articles. After the removal of duplicates, 1813 unique articles remained. The further processing of the articles was done using the application "Rayyan" (Ouzzani et al., 2016). The goal was to find relevant articles for further,

TABLE 1 Keywords and database settings for literature search.

Actor keywords	Concept keywords	Databases/Specifics
farmer*	"marginal return*"	Web of Science Core Collection ("Topic", title, abstract, author keywords, and keywords) Scopus (article title, abstract, and keywords)
agriculture*	"time-inconsisten*"	
peasant*	"time inconsisten*"	
agronom*	"time-consisten*"	
"time preference*" discount*	"time consisten*"	
"long-term orientation*"	visceral AND influence	
"long term orientation*"	"delayed payment*"	
patience*	"present-bias*"	
(intertemporal AND (choice* OR decision* OR model* OR arbitra*)	"present bias*"	
du model*	"myopic decision*"	
"marginal utility"	"myopic model*"	

Note: AND, OR, NOT are Boolean operators that allow to connect keywords in the search. * Are wildcards that allow variations of a keyword, quotation marks specify that only the exact wording is searched for.

qualitative analysis. All articles were categorized into one of the following categories based on their abstracts:

i. Included: articles that matched all our selection criteria.
ii. Excluded: articles that did not match all our selection criteria.
iii. Maybe: articles that were potentially relevant and thus kept for discussion.

If eligibility was not apparent from solely reading the abstract, the full text of the article was used for verification. This process yielded nine fully eligible articles. In addition, three articles were added manually, as they met all our criteria but were not found in the systematic search. These are the articles by Hermann and Musshoff (2016a), Kovacs and Snell (2021), and Wuepper (2020). Thus, our final review includes 12 articles (see Table 2). See Supplementary Materials for further details.

3.3 | Organization and final processing

We classified all selected articles along various dimensions of interest, such as sample characteristics, elicitation method, design choices, and other relevant details (see Supplementary Materials). Whenever possible, we transformed elicited time preferences into annual discount rates, allowing us to make further comparisons. This required different degrees of own calculations, as shown in the Supplementary Materials. For example, in some studies, there was no annual discount rate reported, but this could be directly inferred from the provided information. For example, Bougherara et al. (2021) and Gruener (2021) both use a multiple price list and they report the row in which respondents switched from option A to option B. In these instances, we assigned the relevant rows' average implied discount rate and computed the studies' average annual discount rates based on this.

A salient difference between the selected studies was how they dealt with respondents who always picked the earlier option in multiple price list experiments, that is, never switch. We followed authors' choices in these instances. For example, Khanna et al. (2017) assigned a discount rate of 100% to farmers who always chose the earlier option when given several choices between a constant payment now and an increasing payment later. In the experiments of Gruener (2021) and Bougherara et al. (2021) in contrast, participants always choosing the earlier option are assumed to have a discount rate of 150% and 60%, respectively.

4 | RESULTS

The 12 published articles meeting all our inclusion criteria all been published after 2011. The recent increase in published studies on time preferences may reflect an increasing interest of scholars in empirically measuring and analyzing time preferences as well as the advance of methodological approaches to do so (e.g., using experimental methods).

In terms of covered countries, there is clustering in Germany, France, and the United States. However, the sample of Maroušek et al. (2014) includes respondents from three Western European and three Eastern European countries (Austria, Germany, France, Poland, Slovakia, and Czech Republic) and the sample of Wuepper (2020) includes respondents from all over Europe (based on the European Value Survey).

As can be seen in Table 2, discount rates elicited in the reviewed studies are highly heterogeneous across studies, even in the same country. The average annual discount rate estimates range from 3.90% (Philipp Steinhorst & Bahrs, 2014) to 45.5% (Kovacs & Snell, 2021). Both the average and the median discount rate is 23%.

TABLE 2 Selected studies with corresponding study characteristics.

Study	Country	Sample	Method(s)	Setting	Incentivized	Discount rate (%)
Bocquého et al. (2013)	France	107	MPL	In-person	Yes	13.6
Bougherara et al. (2021)	France	123	MPL	Online	No	27.06
Duquette et al. (2012)	USA	208	Single-choice	Letter and Online	Yes	30.13
Gruener (2021)	Germany	150	MPL	Online	Yes	30.11
Hermann and Musshoff (2016a)	Germany	146	MPL	Online	Yes	6.76
Hermann and Musshoff (2016b)	Germany	111	MPL	Online	Yes	18.11
Khanna et al. (2017)	USA	424	MPL	Letter	No	33.76
Philipp Steinhorst and Bahrs (2014)	Germany	761	Investment alternatives	In person	No	3.90
Kovacs and Snell (2021)	USA	282	Investment alternatives	Phone Survey	No	32.5
Maroušek et al. (2014)	Austria, Czech Republic, German, France, Poland, Slovakia	45	Survey questions	Online plus interview	No	NA
Schattman et al. (2021)	USA	24	Full interviews	In person	No	NA
Wuepper (2020)	Europe[a]	2360[b]	Survey questions	At-home-interview	No	NA

Note: MPL denotes multiple price list. In Investment alternatives experiments respondents are asked to rank different potential investments that differ in their payout sequence over six periods. In single choice experiments, respondents just make a single choice between two alternatives that differ in their delay of a payout. Most experiments were online, but some were based on a paper-survey sent as a letter, and some were done in person. Incentivization refers to whether choices were purely hypothetical or there was actual money at stake.

[a]47 countries participated in the EVS 2008 (EVS, 2018).

[b]The sample contains 2360 farmers as stated by Wuepper (2020), which corresponds to about 4% of the total sample.

Heterogeneous discount rates in different experiments may emerge for a variety of reasons. We thus use the collected data to explore a few possible research design effects on the elicited time preferences below. Additional analysis is presented in the Supplementary Materials. First of all, a key question is how important is monetary incentivization of the experiment to avoid hypothetical bias. Figure 1 separately plots the distribution of discount rates elicited in incentivized and unincentivized experiments. In incentivized experiments, the elicited discount rates tend to be smaller than those in unincentivized ones (on average, 22% and 29%, respectively). However, there is considerable overlap between both distributions, suggesting that if there is an effect, it is probably small, but more research is needed to clarify this.

Another important question is whether the chosen time spans in the experiments matter. There is large variation between the studies about the average time respondents must wait longer if they choose option B instead of A. This ranges from 9 weeks (Gruener, 2021; Hermann & Musshoff, 2016b) to 5 years (Khanna et al., 2017). In an agricultural context, all of these can be considered quite short, as many agricultural investments rather play out longer than this. Figure 2 plots the average time span between option A and option B in each study, and the respective discount rate elicited. The pattern suggests that there is no clear connection between average time spans and elicited discount rates overall, even though holding constant the country, there might. Gruener (2021) and Hermann and Musshoff (2016b) use a relatively short time span (63 days) and elicit a relatively high discount rates (27% and 18% (per annum), respectively). Hermann and Musshoff (2016a) in contrast, use a longer average time span (183 days) and elicit a relatively low discount rate (7%). In France, Bougherara et al. (2021) use a relatively short average time span (365 days) and elicit a relatively high discount rate (27%), whereas Bocquého et al. (2013) use a relatively long time span (502 days) and elicit a relatively low discount rate (14%). In the United States, however, Duquette et al. (2012) and Khanna et al. (2017) differ the most on average time spans (256 and 1825 days, respectively) and elicit highly similar discount rates (30% and 34%, respectively). Thus, also here, more research is needed for clarification.

The third methodological choice investigated here concerns the association between expected reward for waiting and elicited discount rates (the "magnitude effect"). Figure 3 plots the magnitude of each study's payouts against elicited discount rates. This question has been directly analyzed in Germany by Hermann and Musshoff (2016b) using a split sample design separately with low and high incentives for waiting (shown separately in Figure 3). In this study, there is a weakly negative relationship between the magnitude of the expected reward for waiting and displayed time preferences.

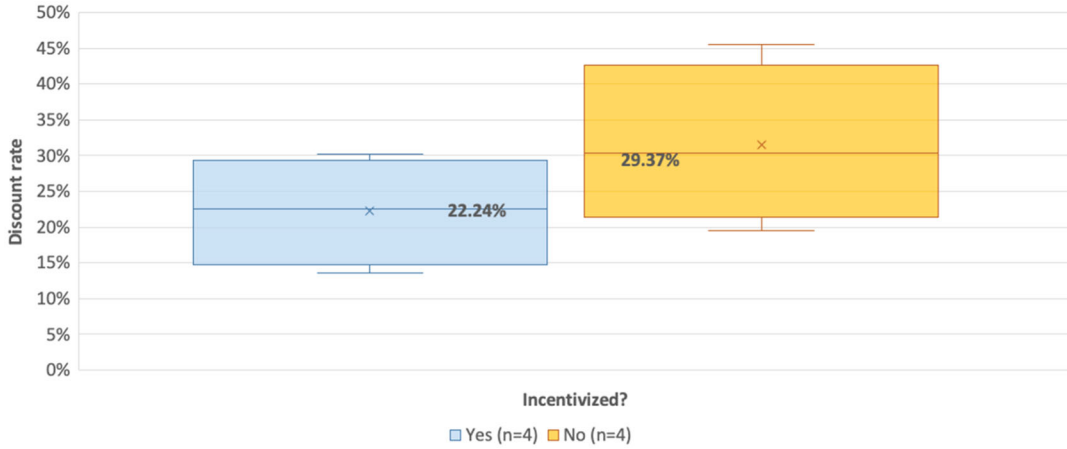

FIGURE 1 Discount rate and incentivization.

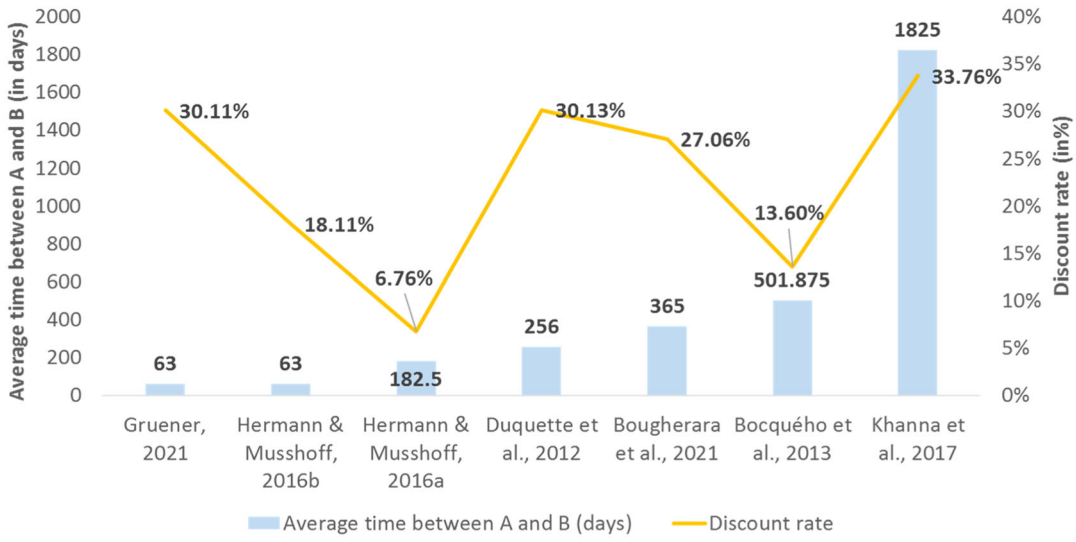

FIGURE 2 Discount rate and time between choice options.

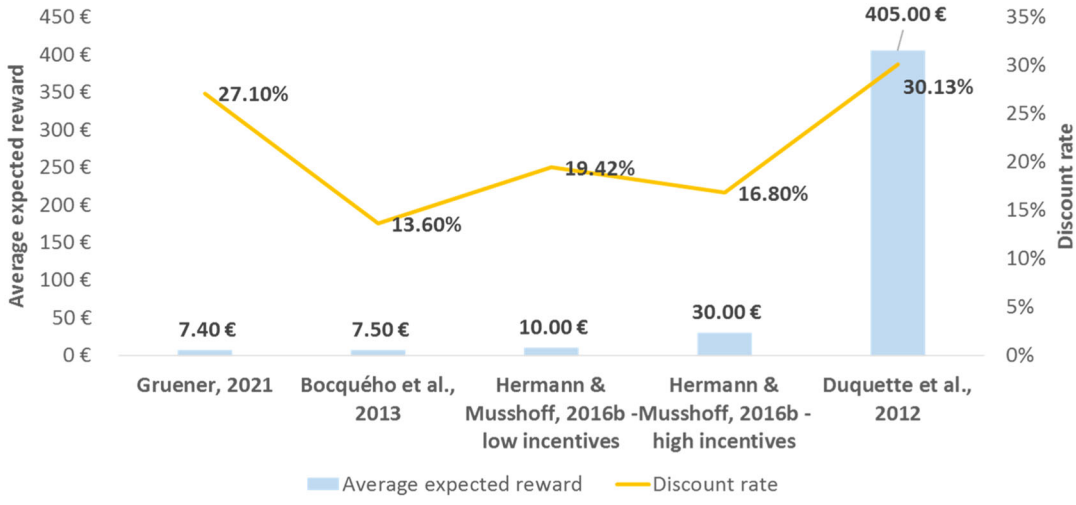

FIGURE 3 Discount rate and expected reward.

Across all reviewed studies, however, there is no clear relation, and the lowest and the two highest discount rates come from the two studies that differ the most in terms of offered incentive to wait.

In the Supplementary Materials, we present additional patterns. This includes an investigation of whether fundamentally different experimental approaches lead to systematically different discount rate estimates. Almost all reviewed studies using an experimental approach use a version of a multiple price list (such as shown in Supporting Information S1: Table S1). However, Philipp Steinhorst and Bahrs (2014) use an "investment alternatives" approach, in which respondents were asked to rank alternative investments that differ in their future payout sequences (e.g., stable, decreasing, or increasing payments over six dates). Also, Kovacs and Snell (2021) conduct an "investments alternatives" approach, but they use a contingent valuation (CV) set-up, with alternative irrigation investments. Finally, Duquette et al. (2012) use a "single choice" approach, that

is, respondents make only one choice instead of multiple. Comparing the elicited discount rates from these alternative experimental methods (Supporting Information S1: Figure S1), the discount rate elicited with the "investment alternatives" approach and the "Multiple Price List" approach are practically the same, whereas the discount rate elicited using the single choice approach is a bit higher (but very similar to the discount rate elicited with other methods in the same country, the United States).

Another relevant methodological comparison is about the choice whether to specify the reward for waiting either as increasing payments or as increasing probabilities to receive a fixed payment (Supporting Information S1: Figure S2). Also here, only two studies deviate from the "main approach," which is increasing payments in this instance. In both cases, using increasing probabilities (Gruener, 2021, Hermann & Musshoff, 2016b) instead of increasing payments led to higher discount rates (27% vs. 18%, respectively).

Comparing countries' average discount rates (Supporting Information S1: Figure S3), elicited time preferences in Germany and France are similar, but those elicited in the United States are higher (18%, 20%, and 32%, respectively).

Finally, in the Supplementary Materials, we also show the association between the range of offered rewards and the elicited discount rate (Supporting Information S1: Figure S4), and between the time delay until the earlier option is paid out and the elicited discount rate (Supporting Information S1: Figure S5), but we do not find clear patterns in either instance.

5 | DISCUSSION AND CONCLUSION

The literature on farmer time preferences of farmers in Europe and North America is still young and limited: We ultimately only found 12 studies that met all our criteria, none of which was published before 2011. Within the scope of our study, most studies were conducted in Germany, France, and the United States. Despite this clustering, elicited time preferences are widely heterogeneous, ranging from average discount rates of 3.9% or 6.77%—elicited in Germany by Steinhorst Bars (2014) and Hermann and Musshoff (2016a), respectively—to as high as 45.5%—elicited in the USA by Kovacs and Snell (2021). Based on the synthesized studies, the average annual discount rate of the farmers in Europe and North America reported in the studies is 23% per annum. This is slightly lower than what is commonly found in the general population (e.g., Harrison et al. [2002] estimate the average annual discount rate in Denmark is 28%, Wang et al. [2016] estimate the global average around 29%, and Matousek et al. [2022] estimate the global average at around 33%).

The most common approach to elicit farmers' time preference is a multiple price list, in which respondents choose between two alternatives that most commonly differ in how long one must wait to receive a premium for waiting longer and this premium increases gradually. The premium that respondents require to choose waiting longer is used to compute their discount rate. Nonexperimental alternatives are direct questions about respondent's time preferences and the use of reasonable proxies available in secondary surveys, such as the World or European Value Survey, which however have the important disadvantage that they do not allow a calculation of discount rates. Another alternative is the use of convex time budgets. Andreoni et al. (2015) compare this approach with the multiple price list approach and find that while both elicitation approaches perform similar within sample, the former outperforms the latter out of sample. The convex time budget method thus holds considerable promise for future studies in agricultural economics, either instead or in addition to other approaches.

Comparing elicited time preferences across experimental studies, we observe stronger time preferences in unincentivized than in incentivized experiments (29% vs. 22%) and we observe stronger time preferences in North America than in Europe (18% in Germany, 20% in France, 32% in the United States).

When comparing experiments that incentivized waiting with increasing payments and those that used increasing probabilities to receive a fixed payment, elicited time preferences are stronger

among the latter (18%–27%, respectively). An important caveat is that the number of studies is small, for example, only two experiments actually used the latter.

For other methodological choices, such as waiting time for the earlier alternative in a multiple price list experiment, and the difference in rewards for waiting between the first and the last choice, we do not find clear associations with elicited discount rates. But it should also be noted that in this entire exercise, we compare only a handful of heterogeneous studies to each other.

A general limitation in the literature is the tendency to offer the farmers alternatives to choose from that are mostly short-term if compared to actual agricultural investment time frames (spanning usually from few to several years). Especially when monetary incentives are used, it is often infeasible to use realistically long time spans and so some studies are focusing on choices that are as short as 6 weeks apart. The longest time span used in an elicitation was 6 years (Khanna et al., 2017). In contrast, many actual agricultural investments take much longer even than 6 years to materialize, even decades in some cases (e.g., considering investments in buildings and machinery). It is not clear whether extrapolating from the short experimental time spans causes bias, but it is a possibility, especially if farmers are not actually using a single, exponential discount factor, but discount e.g., hyperbolically. This is because the required absolute premium for waiting for a later payment, when exponential discounting and hyperbolic discounting behavior are compared, diverges with an increasing time span (see e.g., Kovacs & Snell, 2021). Grijalva et al. (2018) demonstrate this for a nonfarmer, student sample. They use the convex time budget approach with cash payments over a 20-year time horizon and find much smaller annual discounts rates than comparable studies, in the range of 2%–6%. This is because they find declining discounting rates, which effect grows with the time horizon.

One option to deal with the above is to conduct hypothetical experiments where no monetary incentives beyond show-up fees are provided. This allows researchers to conduct analyses with longer time horizons. However, purely hypothetical experiments of course have the important catch that hypothetical bias could affect the elicited time preferences. In our reviewed studies here, indeed there is a difference in discount rates between monetarily incentivized and unincentivized experiments, with stronger time preferences in unincentivized than in incentivized experiments (29% vs. 22%). It is an open question whether the bias from not incentivizing an experiment is smaller, the same, or larger than the effect of using unrealistically short time horizons to elicit farmers' time preferences. Coller and Williams (1999) tested several treatments to improve the reliability of experimentally elicited discount rates, including a comparison of real and hypothetical payments, and find that with hypothetical payments, participants' revealed discount rates are slightly higher and their choices a bit more random than when payments are real. Harrison et al. (2002) conducted an experiment on time preferences with real payments. On the one hand, they find that elicited time preferences are lower than previous experiments that used hypothetical payments. On the other hand, not all participants actually received a payment, but instead, some were randomly chosen. Because experimental group sizes varied, Harrison et al. (2002) can thus test whether the probability to be actually paid has an effect on participants time preferences. This is clearly not the case (coefficient 0.02, standard error 0.37). Brañas-Garza et al. (2023) provide the most direct test by experimentally comparing actual and hypothetical payments. Their elicited time preferences are the same, whether payments are purely hypothetical, completely real, or 1 out of 10 participants is randomly picked to receive a real pay-out.

A relevant choice is whether to better use increasing payments (standard) or increasing probabilities in multiple price lists (e.g., Laury et al., 2012). It is not yet a settled issue which reimbursement method is better suited for the elicitation of the discount rate but the method with increasing probabilities offers the advantage of not having to make assumptions about the risk attitudes of participants or requiring additional tasks to elicit participants' levels of risk aversion. Conceptually, the joint elicitation of time and risk preferences, as done for example, by Andersen et al. (2008) should lead to the same discount rates. However, Hermann and Musshoff (2016b) who elicit discount rates with a combination of a common multiple price list with increasing payments and a risk preference elicitation approach with increasing probabilities find higher average discount rates with the latter approach compared to the

former. This is in line with the findings across the analyzed studies above.[2] One explanation for this effect is the high cognitive abilities that are required for this approach (Hermann & Musshoff, 2016b). One possibility to address this could be to display implied discount rates to participants, which could help them to correctly process their choices.

The number of decision rows in multiple price lists varies within empirical studies, affecting time preference estimates. More specifically, if many decision rows are provided, increments in implied discount rates are typically small. This allows for assigning precise discount rates to participants depending on the row in which they switch from preferring the "earlier" option to preferring the "later" option.

An empirical puzzle we find is the following: The farmers in Europe and North America are found to have globally comparably strong time preferences (i.e., are rather impatient), even though the rest of the European and North American population has globally comparably weak time preferences (i.e., are rather patient) (Falk et al., 2018, Matousek et al., 2022, Wang et al., 2016). Notwithstanding, there is large within-country heterogeneity that is far larger than any between-country differences. Anecdotal evidence on time preferences of farmers in developing countries (note that we have not reviewed this literature systematically) (e.g., Alemayehu et al., 2019; Fischer & Wollni, 2018; Kramer & Kunst, 2020) and Asia (e.g., Liu et al., 2020; Mao et al., 2021; Sarwosri & Mußhoff, 2020), show often lower time preferences than revealed in the studies for Europe and North America. For example, subsistence farmers often have elicited discount rates below 10% (e.g., the cattle herders in Mali and Burkina Faso surveyed by Liebenehm and Waibel [2014]). At this point, we can only hypothesize what explains this pattern, and recommend further studies on the topic. One possibility are endogenous preferences. Farmers in high-income countries tend to have more profitable investment opportunities than farmers in low-income countries. With endogenous preferences, this could imply that farmers in high-income countries have higher investment standards than farmers in low-income countries. Then, offering both groups of farmers a certain income-gain in percentage (e.g., 5 years waiting leads to 20% more income) could be highly attractive to farmers who are used to only have investment opportunities that yield 5% more income but not so attractive to farmers who are used to make investments that return 30% over that period. This is purely speculative at this point and should be rigorously tested, aside alternative explanations.

Overall, it appears that the literature on farmer time preferences in Europe and North America is still in its infancy: we identified 12 studies that are all from after 2011. The small sample size means that we are only able to describe basic patterns, such as whether unincentivized experiments yielded different time discounting estimates than incentivized one, but we do not control for the other features of the studies (e.g., their country, elicitation method, etc.). A meta-regression would improve upon this but would require a much larger sample size.

Our empirical findings have implications for policy and industry. New technologies and many agri-environmental schemes have a long-lasting character, where efforts today (e.g., in terms of soil or biodiversity conservation, digital technologies for more sustainable agriculture) only pay-off slowly over time. Thus, the here documented high discount rates are a clear obstacle to achieve high adoption and participation rates. Policies supporting adaptation and diffusion of technologies and agri-environmental schemes need to account for farmers time preferences and heterogeneities therein. As one specific example, currently, when countries attempt to increase the take up of sustainable farming practices, they mostly increase the magnitude of payments (Mirzabaev & Wuepper, 2023, Wang et al., 2023). Knowing how impatient farmers are, it could be more cost-efficient to pay earlier instead of more, even in the form of credits or other upfront payments. Moreover, understanding that the farmers in Europe and North America tend to apply relatively high discount rates makes it less surprising that general adoption of sustainable farming practices advances rather slow, requires a lot of support, and varies a lot regionally (Wuepper, 2020).

[2]In most of the analyzed studies with increasing payments, risk preferences were not included into the discount rate calculation that generally leads to an overestimation of discount rates.

Finally, our analysis also has implications for future research. Given the importance of farmers time preferences for industry and policymakers, more insights are needed. More coherent time preference elicitation with farmers shall be conducted, also at different scales, including in large cross-country studies (e.g., Wang et al., 2016). For example, systematic time preference elicitations (e.g., spanning across countries and farming systems) and using large-scale replications (e.g., Rommel et al., 2022) shall be initiated in future research. Further relevant avenues for future research are especially the question of how methodological choices affected elicited time preferences, which trade-offs might need to be accepted (e.g., monetary incentivization vs. agriculture-typical time spans), and what explains farmers' time preferences and their heterogeneity. An ambitious but also potentially highly relevant review or meta-analysis could furthermore compile the empirical evidence of risk preferences from all over world, and compare farmers and nonfarmers, and populations in high- and low-income countries. There is also a need to directly test a range of methodological influences, e.g., using split samples (see for example, Hermann & Musshoff, 2016a, 2016b), interaction effects (Wuepper et al., 2019), or related approaches. This way, it will be possible to understand more systematically how exactly experiments are optimally set-up and how to avoid biases.

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DATA AVAILABILITY STATEMENT

All used data is publicly available.

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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