Review

Meta-analysis of landowner participation in voluntary incentive programs for provision of forest ecosystem services

Yohei Mitani [iD][1][*] and Henrik Lindhjem[2,3]

[1]Division of Natural Resource Economics, Graduate School of Agriculture, Kyoto University, Kyoto, 606–8502, Japan
[2]Menon Centre for Environmental and Resource Economics, Sørkedalsveien 10B, Oslo, NO-0369, Norway
[3]Norwegian Institute for Nature Research, Sognsveien 68, Oslo, NO-0855, Norway

Abstract: Many voluntary incentive programs for provision of forest ecosystem services (ES) have low participation rates, insufficient enrollment areas, and inefficient ecological outcomes. Understanding participation behavior in such programs has therefore become a crucial part of policy success. We synthesized a large body of literature on the behavior of nonindustrial private forest owners based on surveys of stated (intended) participation or data on actual participation in existing or hypothetical programs. Using metaregression analysis, we examined how methodological, program-characteristic, and economic-incentive variables affected participation rate estimates. Participation rates tended to be overestimated when landowner participation was elicited in hypothetical choice situations (compared with real situations) and when dichotomous choice surveys (compared with census data) were used. The marginal effect sizes were quite large, for example, a 31% increase with use of stated choices in hypothetical scenarios, and practitioners should therefore be aware of them. However, use of choice experiment surveys in a modified scenario based on existing programs had no effect on participation when all other determinants were controlled for. Participation rates decreased significantly as length of the contract increased and when there was no withdrawal option. These results suggest that perpetual contracts have a lower negative impact on participation than time-limited contracts with a duration of over 50 years. We confirmed that as compensation amounts increased, participation increased. One-time up-front payments were more effective in increasing initial participation than annual payments for contracts of over 5 years. We identified the robust determinants and the effect sizes of those determinants on landowner participation rate estimates, thereby contributing to a better understanding of forest owner behavior and offering useful insights to enable researchers and resource managers to improve the design and efficiency of new and existing forest ES programs.

Keywords: conservation easements, ecosystem services, incentive programs, landowner behavior, private forestland, voluntary participation

Metaanálisis de la Participación de Terratenientes en los Programas de Incentivos Voluntarios para el Suministro de Servicios Ambientales Forestales

Resumen: Muchos programas de incentivos voluntarios para el suministro de servicios ambientales forestales tienen tasas bajas de participación, áreas insuficientes de inscripción y resultados ecológicos ineficientes. Por lo tanto, el entendimiento del comportamiento de participación en dichos programas se ha convertido en una parte crucial del éxito de las políticas. Sintetizamos un gran acervo de literatura sobre el comportamiento no industrial de los dueños de terrenos forestales privados con base en censos de la participación manifestada (pretendida) o información sobre la participación actual en los programas existentes o hipotéticos. Mediante un análisis de metarregresión, analizamos cómo las variables metodológicas, características del programa o económica-incentivas

afectaron los estimaciones de las tasas de participación. Las tasas de participación tuvieron una tendencia a estar sobreestimadas cuando la participación se obtuvo por medio de situaciones hipotéticas de elección (en comparación con las situaciones reales) y cuando se usaron encuestas de elección dicotómica (en comparación con la información de los censos). Los tamaños del efecto marginal fueron bastante grandes, por ejemplo, un incremento del 31% con el uso de opciones manifestadas en los escenarios hipotéticos y, por lo tanto, los practi-cantes deberían estar conscientes de estos tamaños. Sin embargo, el uso de las encuestas con el experimento de elección en un escenario modificado con base en los programas existentes no tuvo efecto sobre la participación cuando todas las demás determinantes estuvieron controladas. Las tasas de participación disminuían significativa-mente conforme incrementaba la longitud del contrato y cuando no había opción de rescisión. Estos resultados sugieren que los contratos perpetuos tienen un impacto negativo más bajo sobre la participación que los contratos con límite de tiempo y una duración de más de 50 años. Confirmamos que conforme aumentan las cantidades de la compensación, incrementa la participación. Los pagos únicos y adelantados fueron más efectivos al momento de incrementar la participación inicial que los pagos anuales para los contratos de más de cinco años. Identificamos las determinantes contundentes y los tamaños de los efectos de aquellas determinantes sobre los estimados de las tasas de participación de los terratenientes, contribuyendo así a un mejor entendimiento del comportamiento de los dueños forestales y ofreciendo conocimiento útil para permitir a los investigadores y a los administradores de recursos mejorar el diseño y la eficiencia de los programas de servicios ambientales forestales nuevos y existentes.

Palabras Clave: comportamiento del terrateniente, mitigación por conservación, participación voluntaria, pro-gramas de incentivos, servicios ambientales, tierras forestales privadas

摘要: 许多与森林提供的生态系统服务相关的自愿激励项目存在参与率低、参与土地面积不足,且生态效益低的问题。因此,了解这些项目中的参与行为已成为政策成功的关键。本研究综合了大量关于非产业化私人森林的所有者行为文献, 这些文献报道了土地所有者对已有或假设中的保护项目参与意愿)表明有意参与或实际参与(的数据。我们利用荟萃回归分析, 研究了方法、保护项目特征和经济激励变量对参与率估计值的影响。相比于真实情况, 在假设的情况下做选择时, 土地所有者的参与率往往会被高估;使用二分选择调查与普查数据相比, 参与率也被高估。研究发现的边际效应相当大, 例如, 在假设存在的情景中, 使用规定选择产生的边际效应为 31%, 因此保护实践者应注意这个问题。然而, 当所有其它决定因素都得到控制时, 在基于现有方案而所修改的保护情景中使用选择实验调查, 对参与率估计没有影响。此外, 参与率会随着合同期限延长或在没有退出选项时显著下降。这些结果表明, 永久合同对参与率的负面影响低于期限超过 50 年的有期合同。我们还发现, 参与率会随着报酬增加而提高。对于 5 年以上的合同, 一次性预付比每年支付可以更有效地增加初次参与率。本研究确定了自愿激励项目中稳健的决定因素及其对土地所有者参与率估计的影响程度, 从而可以帮助更好地理解森林所有者的行为, 且可以提供有用的见解, 使研究者和资源管理者改善新的和现有森林生态系统服务项目的设计及有效性。【翻译:胡怡思;审校:聂永刚】

关键词: :自愿参与, 激励计划, 保护地役权, 私人林地, 土地所有者行为, 生态系统服务

Introduction

In response to conflict–fraught and often unsuccessful direct regulation, voluntary incentive programs that en-courage the provision of additional ecosystem services (ES) on private forest land have received increasing atten-tion in recent years (Hanley et al. 2012; Ando & Langpap 2018; Langpap et al. 2018). Such programs pay landown-ers compensation in exchange for management practices or for set-asides that deliver a flow of ES that would not otherwise have been provided. Programs may be charac-terized by several attributes and may take many forms. For example, contracts may be time limited or unlimited, have a withdrawal option or not, and cover management practices that prevent negative impacts or enhance pos-itive impacts on certain ES. The programs may also have a forest management focus (i.e., provisioning services), such as planting and general silviculture (Kilgore et al. 2008; Markowski-Lindsay et al. 2011; Dickinson et al. 2012) or an environmental protection or conservation focus (i.e., supporting, regulating, and cultural services), including measures to preserve biodiversity and protect habitat of endangered species (Layton & Siikimäki 2009; Mitani & Lindhjem 2015; Nielsen et al. 2017).

Many such voluntary-based incentive programs, in-cluding the U.S. Conservation Reserve Program and the EU Agri-Environmental Schemes, have low landowner participation rates and consequently smaller enrolled areas than desired, resulting in inefficient ecological outcomes (Yang et al. 2005; Sorice et al. 2013; Rolfe et al. 2018). Participation rate is one of the most significant performance indicators for program effi-ciency because there is often a minimum participa-tion threshold that needs to be reached to create additional ES (Finn et al. 2007; Dupraz et al. 2009; Nielsen et al. 2017). Thus, understanding the partici-pation behavior of nonindustrial private forest (NIPF) owners in such programs has become a crucial fac-tor for policy success (Langpap 2004; Kabii & Horwitz 2006; Kauneckis & York 2009). The choice of program

attributes may influence the performance of programs as well as participation rates. For example, longer contracts may be positively correlated with the performance of conservation programs and negatively correlated with expected participation rates, which may, at the same time, reduce conservation performance (Shah & Ando 2016). Therefore, it is of interest to researchers and program managers to understand the relationship between program attributes and expected participation rates.

This demand for understanding has helped establish a large body of literature on NIPF owners' participation behavior. The studies are heterogeneous in terms of the methodological approaches and behavioral environments that owners encounter. Individual case studies may observe NIPF owners' intention to participate in a hypothetical or contingently modified existing program or their actions in the actual program through a dichotomous choice (DC) survey, a choice experiment (CE) survey, or through census registration. We categorized behavioral environments into 3 decision types. First, actual participation decisions in an existing program can be collected through census registration or self-reports in a survey. We categorized this type of revealed or reported actual participation as action. Second, policy makers who design a new program often use survey methods to elicit landowners' willingness (i.e., intention) to participate in a hypothetical program. We categorized these stated choices regarding a hypothetical program as a hypothetical decision. Third, program managers are often keen to know how modification of an existing program affects landowners' prospective participation. Landowners are asked to state their decision (i.e., intention) contingent on hypothetical changes in certain attributes of the existing program that are familiar to them. To distinguish this from hypothetical decisions, we categorized it as stated contingent behavior.

To combine chosen data collection methods with observed decision types, one type of study uses forest owners' actual participation in an existing program, where dichotomous participation decisions (i.e., actions) are observed through survey or enrollment data (Lynch & Lovell 2003; Mäntymaa et al. 2009). This literature typically investigates important factors, such as owner characteristics and forest conditions, that determine the likelihood of participation. Another type of study uses the owner's willingness to participate in an experimentally designed hypothetical multiattribute program, in which the owner's contingent participation decision (i.e., intention) is collected by a CE survey (Layton & Siikimäki 2009; Broch et al. 2012). This approach makes it possible to investigate the effect of policy variables, including the amount of financial compensation, on the likelihood of participation. In many cases, for both forest management and conservation programs, it is clear that motives other than financial incentives alone may be important for enrollment decisions (Amacher et al. 2003; Lindhjem & Mitani 2012).

The literature to date on NIPF owner participation behavior is limited but steadily growing. They primarily comprise a number of individual case studies of actual and hypothetical programs, especially in the West. To the best of our knowledge, there is no study to date that comprehensively reviews this literature by means of metaanalysis to evaluate the impact of study and policy variables on estimated participation rates. This is the primary contribution of our study. A metaregression is a statistical method that combines the results of multiple studies, often to synthesize the overall evidence on a topic. The method has been used for more than a century in medicine and other natural sciences. Since the 1990s, it has been increasingly recognized in other fields, such as economics and conservation research (Fernandez-Duque & Valeggia 1994; Whitburn et al. 2020). Following established guidelines on how to conduct metaregression analyses in a rigorous way, we provide a scientifically sound synthesis of the literature of relevance and quantitative information that can be used to forecast the rate of landowner participation in forest ES programs.

The main question we asked was how the methodological choices and program attributes of the studies, while controlling for other characteristics, influence estimated participation rates in voluntary incentive programs that aim to provide additional forest ES. We utilized the rich variation in methodological choices employed and program attributes investigated in individual case studies to provide evidence of the effects of these various study and policy variables on estimated participation rates. More specifically, we sought to provide comprehensive information on the relationship between the policy variables and expected participation rates. Is there a robust and systematic tendency regarding the impact of policy variables on the likelihood of participation?

We also sought to determine the relationship between the methodological choices and estimated participation rates of the studies. Did the methodological choices affect participation rates we obtained? Was there any systematic variation? If so, it is important for those impacts to be considered by managers who use estimates based on individual studies and by researchers who choose these methodological attributes in their studies. For instance, when managers design programs on the basis of the results of surveys of ex ante NIPF owners' intentions to participate in hypothetical programs, it would be good to know how methodological choices may influence the estimated participation rates and how close they are to realized participation rates. For example, there is a well-known tendency in the stated preference (SP) literature (Lindhjem & Navrud 2011), and in survey methodology literature more generally (Biemer et al. 2017), for respondents to exaggerate answers to

questions about socially desirable behaviors. In the environmental economics literature, this tendency is observed in SP surveys of people's willingness to pay for ES, for example, due to the hypothetical nature of the survey (Loomis 2011; Mitani & Flores 2014). When compared with participation rates from existing forest programs, does this tendency carry over from the general SP literature to NIPF owner literature? In other words, are participation rates estimated on the basis of landowners' intentions significantly higher than those estimated on the basis of their actions? If so, participation rates derived from such surveys need to be considered carefully before being used as a basis for assessing the uptake of new programs.

To answer these questions, we reviewed 52 (before being further reduced to 45) studies from the last 24 years of NIPF owner participation behavior in different voluntary forest ES programs. In meta-analysis, there is a trade-off between heterogeneity and the ability to identify the robust determinants of landowner participation rates. To keep the types of programs relatively homogeneous, we deliberately excluded studies of agro-environmental schemes. We also limited our scope to northern Europe and the United States because policy schemes have similar properties in terms of objectives, procedures, contract types, enforcement, and management, and NIPF owners can be expected to have relatively similar motivations and objectives (Amacher et al. 2003). Moreover, forest and ES types are also similar. This scope ensures an acceptable level of heterogeneity in the data and gives our estimates more statistical power (Lindhjem & Tuan 2015).

Meta-Data

Data Sources and Collection

We followed the general guidelines for metaregression analysis summarized in Nelson and Kennedy (2009). We searched online databases (Web of Science, Google Scholar, and EconLit) for relevant literature analyzing both survey and real data on landowner participation in various forest ES programs, limiting the scope to North America and northern Europe. Searches were initially performed using the following search strategy: "*voluntary forest conservation*" OR "*forestry management program*" AND "*private forest (land) owner*" AND "*participation*." The resulting gross sample consisted of 307 papers after the elimination of duplicates. The initial search was completed in January 2019. Studies were screened and assessed by title, abstract, and full text for their relevance for coding for meta-analysis. We also cross-checked with the reference lists of previous review articles on similar topics (Amacher et al. 2003; Beach et al. 2005; Langpap & Kim 2010). This produced a final

selection of 52 primary studies published from 1983 to 2018. This number was further reduced to 45 primary studies (described below) because studies with incomplete data were eliminated from the meta-analysis, but remained in the systematic review (described below). We included only published papers to ensure consistent and high-quality studies and data.

Key Characteristics of Included Studies

The main characteristics of the studies are summarized across program and method characteristics in Table 1. The number of studies offering complete reporting for all characteristics or for which all characteristics are relevant varied. The sample sizes from which participation rates were taken or calculated varied from 57 to 9318 (mean = 826, median = 442). Almost 80% of the studies used some kind of survey data (either CE or DC questions). Remaining studies were based on revealed data (census or registration data). The studies in which surveys were used included hypothetical (37%), modified (31%), or existing programs (18%). These results indicate more research into actual participation behavior is needed. Mail surveys were used to collect data in most of the surveys (71%), and the response rates for the surveys averaged 33%. Geographically, the majority of the studies came from the United States (71%). The remainder came from 7 northern European countries (Denmark, Finland, Norway, Ireland, the United Kingdom, Germany, and the Netherlands).

Program characteristics were broken down into 6 different themes (Table 2): contract length, whether there was a withdrawal option or not, type of payment schedule (i.e., time and frequency) and incentive type (i.e., form of payment), management instrument (i.e., a forestry or a conservation type program), and primary target of the program (e.g., biodiversity, carbon). There was a fair distribution of studies across all these program characteristics. The most common contract was characterized by time limitation (76%) followed by no withdrawal option (33%), annual payment (61%) of the compensation type (52%), forestry and conservation management instruments (both 41%) with a multipurpose objective (25%) (i.e., no specific ES targeted). The contract length across the 25 studies that reported a time limit ranged from 5 to 100 years (mean 23 years, median 15 years).

Metaregression Method

Participation Rate Effect Size

The dependent variable of the metaregression (i.e., effect-size estimates) was participation rates for forest incentive programs obtained or calculated from primary

Table 1. Study characteristics of the meta-data in an analysis of landowner participation in forest ecosystem service programs.

Characteristics (no. of papers)	Frequency	Percent
Data collection methods (52)		
dichotomous choice survey	23	44.23
choice experiment survey	18	34.62
others	11	21.16
Behavioral types (51)		
hypothetical (program does not exist)	19	37.25
stated contingent (modified programs based on existing ones)	16	31.37
stated actual participation (actual action)	9	17.65
registered participation (actual action)	7	13.73
Survey instruments (52)		
mail	35	67.31
census (registration)	6	11.54
interview (in person)	5	9.62
others (combination)	4	7.7
web	1	1.92
phone	1	1.92
Study area (52)		
United States	37	71.15
Denmark	5	9.62
Finland	5	9.62
Norway	2	3.85
Ireland	1	1.92
United Kingdom	1	1.92
Germany & Netherland	1	1.92

studies. The participation rate was continuous and had values from 0 to 1, which satisfies the consistency criterion for the dependent variable across observations (i.e., the criterion of comparability across observations). For the first data source (census registration), we used reported participation rates if available. If they were not, we calculated participation rates, based on reported information, as the percentage of eligible landowners who enrolled in a program. An empirical calculation of the total number of eligible landowners was not crystal clear. For the second source, a DC survey asked landowners about their actual participation in an existing program or their intention to participate in a hypothetical or contingently modified existing program. We used the participation rates reported in primary studies if available; otherwise, we calculated participation rates as the percentage of respondents who stated that they would enroll in a program. For the third data source, CE surveys, we used estimated coefficients reported in primary studies to calculate the probability of participation in a hypothetical program. A hypothetical program was created as the combination of each level of each attribute. A single CE study could have a number of hypothetical programs, depending on the number of attributes included in our metaregression and the number of levels in each included attribute. Let β be the vector of estimated coefficients and let $\mathbf{x}_j$ be the vector of the attributes for a program j. Using the binary logit specification, the program j participation rate is calculated as the probability of participating in program j over nonparticipation, $P_j = \frac{\exp(\beta'\mathbf{x}_j)}{\{\exp(0)+\exp(\beta'\mathbf{x}_j)\}}$, by assuming that the nonparticipa-

tion utility for the owner is normalized to 0. If primary studies reported only random parameter estimates, such as mixed logit estimates, we used the mean values of estimated coefficients.

Among the 45 primary studies included in our meta-analysis, 12 participation rates were obtained from 8 census registration studies, 56 were obtained or calculated from 21 DC survey studies, and 232 were constructed from 16 CE studies. The grand mean (SD) from all reported or calculated participation rates per 300 observations from 45 primary studies was 0.49 (0.27).

Determinants of Participation

The independent variables of the metaregression analysis were categorized into 3 groups according to the underlying mechanism determining participation rate estimates: methodological or behavioral variables, policy variables, and economic incentives or market variables. The last 2 groupings follow the categorization of variables commonly used in the NIPF literature (Beach et al. 2005). The first grouping concerns the researcher's choice of data-collection methods and decision types.

Does the choice of methods applied in each study explain a significant portion of the variation in participation rate estimates among studies? Appendix S5 shows participation rates of the 3 different data collection methods: DC, CE, and census registration. The average participation rate of 0.28 for census studies was significantly lower than that of 0.48 for DC survey studies ($t = 3.12$, $p = 0.0027$ by an unbalanced t-test of the mean

Table 2. Program characteristics of the meta-data in an analysis of landowner participation in forest ecosystem service programs.

Characteristics (no. of papers)	Frequency	Percent
Contract length (29)		
perpetual	4	13.79
reported in years	22	75.86
both perpetual and years	3	10.34
Withdrawal option (15)		
no withdrawal option	5	33.33
(unconditional) withdrawal option	3	20.00
conditional withdrawal option	1	6.67
conditional option or (unconditional) option	3	20.00
no option or (unconditional) option	2	13.33
no option or conditional option	1	6.67
Payment schedule (31)		
annual payment	19	61.29
one-time up-front payment	8	25.81
payment when active action taken	3	9.68
one time up-front or annual payment	1	3.23
Incentive type (46)		
compensation payment	24	52.17
cost-sharing (to cover part of management costs)	6	13.04
tax reduction	5	10.87
combination	6	13.04
other economic incentives	5	10.87
Management instruments (43)		
conservation (set aside or reserve)	18	41.86
forest managements (thinning, replanting, etc.)	18	41.86
combination	7	16.28
Primary targets (44)		
multipurpose	11	25.00
carbon	8	18.18
wildlife protection	7	15.91
general ecosystem services	6	13.64
biodiversity	5	11.36
forestry	3	6.82
recreation	2	4.55
water	1	2.27
combination	1	2.27

difference) and 0.50 for CE studies ($t = 2.61$, $p = 0.0096$). No difference was found between DC survey and CE studies ($t = 0.51$). For metaregression, these methodological choices were coded as 2 dummy variables, with census registrations as the reference category: DC survey and CE survey.

Research indicates that individuals' incentivized behaviors (i.e., actions) can deviate from their stated behaviors (i.e., intentions), especially in the context of prosocial behavior (Hoffman et al. 1996; Camerer & Hogarth 1999). Does the behavioral environment where landowner participation is elicited systematically influence participation rate estimate? Intentions seemed to produce higher participation rates than actions (Appendix S5). The average participation rates were 0.55 for stated participation in a hypothetical program, 0.47 for stated participation in a contingently modified program, and 0.30 for actual participation in an existing program. The average participation rate based on actions was significantly lower than the rates based on intentions (hypothetical program: $t = 3.75$, $p = 0.0003$; contingently

modified program: $t = 2.70$, $p = 0.0077$), whereas the average participation rate in a hypothetical program was higher than that in a contingently modified program ($t = 2.54$, $p = 0.0117$). For metaregression, these behavioral environments were coded as 2 dummy variables, with actual participation as the reference category: hypothetical and stated contingent.

Contract length is generally expected to reduce the average participation rate in the program (Mitani & Lindhjem 2015). Contract lengths were reported in 26 primary studies, producing 232 observations. Contract length was negatively correlated with participation rate estimates for lengths ≤ 100 years (Appendix S6): OLS, constant 0.549 ($t = 22.8$, $p < 0.001$), contract length (year $\times 10^{-2}$) -0.251 ($t = -4.18$, $p < 0.001$), $n = 212$, adjusted $R^2 = 0.072$ (Appendix S6). This OLS result suggests that a 10-year longer duration of contracts is associated with a 2.5% decrease in participation rate estimates. For metaregression, contract lengths were coded as 4 dummy variables, with length specified as 1–30 years as the reference category: 31–50 years, 51–100 years,

perpetual, and length not specified in the study. The not specified includes all studies in which the authors did not report information on (or that retrieves) contract length. Because we did not use this category as the baseline, our estimates were independent of observations in this category.

Does the option to withdraw lower the psychological burden of participation, such as dealing with uncertainty and irreversibility? If so, this should result in higher participation rates for programs with this option. A withdrawal option may be available under some conditions. For example, a contract may be cancelled during the first 5 years of the contract and the compensation has to be repaid with a penalized interest rate. Would allowing withdrawal under such conditions have a similar impact on participation? We found not clear indication of this (Appendix S5). The average participation rates were 0.55 for programs with no withdrawal option, 0.58 for programs with a withdrawal option conditionally available, and 0.62 for programs with a withdrawal option unconditionally available (without penalty). Although the average participation rate increased with this option available, we found no statistical difference between any 2 rates at the 10% confidence level ($t = 1.26$ for no option vs. unconditional, $t = 0.59$ for unconditional vs. conditional, $t = 0.39$ for no option vs. conditional). For the metaregression, these withdrawal options were coded as 3 dummy variables. Observations were specified as (unconditional) option available as the reference category: conditional option, no withdrawal option, and option not specified in the study.

Do the purpose of the program and its primary management instrument systematically influence participation rate estimates? Landowner participation behavior regarding a conservation program (e.g., set-aside) is likely to differ from behavior regarding a forestry management program (e.g., afforestation) due to different underlying motives or types of landowners (Lindhjem & Mitani 2012). The effect of the main purpose of the program (conservation rather than forestry management) was strong (Appendix S5). The average participation rate in conservation programs was 0.57, which is significantly higher than 0.35 for forestry management programs ($t = 7.77$, $p < 0.0001$). For metaregression purposes, these primary management instruments were coded as dummy variables, with observations specified as forestry management (including combinations of forestry and other types of management) as the reference category: conservation and management not specified in the study.

Do higher timber prices reduce the likelihood of participation in programs? This could be the case because higher prices increase the opportunity costs of participation in cases where such costs are not fully compensated. We examined this question based on external data on export unit prices in U.S. dollars for roundwood in the year and country of the survey. We used the UNECE/FAO

(2019) (Food and Agriculture Organization of the United Nations) data set on historical timber prices to collect export unit prices for 1000 m³ of roundwood in the year of the survey or data for each country as a proxy. Unit prices were adjusted for inflation to 2015 values in the respective national currencies. Domestic customer price indexes (CPI) for the relevant countries were used and then converted to 2015 U.S. dollars; purchasing power parity (PPP) factors based on actual individual consumption were used. These adjustment factors were taken from the Organisation for Economic Co-operation and Development iLibrary comparative price levels. Timber prices were negatively correlated with participation rate estimates: OLS, constant 0.806 ($t = 14.7$, $p < 0.001$); timber price (US$ $\times 10^{-2}$) -0.264 ($t = -6.02$, $p < 0.001$), $n = 300$, adjusted $R^2 = 0.105$ (Appendix S6). These results suggest that a US$100 increase in a timber price is associated with a 26.4% decrease in participation rate estimates.

The financial compensation is known to encourage landowner participation in programs, although it is not the only motivation (Mitani & Lindhjem 2015). Can we confirm this result across different programs, different countries, and different methods? Financial compensation amounts have been reported in 19 studies but in different units (per hectare or acre), based on different currencies and years, and for annual payments or one-time up-front payments. Compensation in primary studies was first normalized to amount per hectare. Next, all amounts (per hectare) were adjusted for inflation to 2015 values in the respective national currencies based on domestic CPI and then converted to 2015 U.S. dollars with PPP factors. We retrieved 206 observations from 15 studies for annual payments and 35 observations from 4 studies for one-time up-front payments. The effect of compensation on participation rate estimates was observable across different studies: OLS for annual payments: constant 0.364 ($t = 19.9$, $p < 0.001$), compensation amount (US$ $\times 10^{-3}$) 0.569 ($t = 9.53$, $p < 0.001$), $n = 206$, adjusted $R^2 = 0.305$; OLS for one-time up-front payments: constant 0.509 ($t = 5.67$, $p < 0.001$), compensation amount (US$ $\times 10^{-3}$) 0.047 ($t = 2.78$, $p = 0.009$), $n = 35$, adjusted $R^2 = 0.165$ (Appendix S6). For metaregression purposes, we included a dummy variable D(annual pay) equaling 1 if the payment schedule was specified as annual payments and 0 for cases of one-time up-front payments.

Metaregression Models

In the metaregression data sets, 24 primary single studies (53.3%) produced multiple observations, and 21 single studies produced one observation each. The number of observations in a single study ranged from 1 to 48 (average of 6.67, median of 2). We employed random-effects panel data models to account for the within-study

autocorrelation of observations drawn from a single study. Use of random-effects panel data models is the recommended estimation procedure for metaregression analysis of this type (Nelson & Kennedy 2009). These are similar to multilevel models. Because the dependent variable was truncated from 0 to 1, we report, as main results, random-effects Tobit estimates as well as the equivalent random-effects generalized least-squares (GLS) estimates provided in Appendix S1. We included the 3 different types of independent variables defined above: methodological or behavioral ($\mathbf{X}^M$), policy ($\mathbf{X}^P$), and economic incentive or market ($\mathbf{X}^E$) variables in the metaregressions to investigate determinants of landowner participation rates in forest incentive programs. This rich set of variables would to some extent mitigate between-study correlations by capturing the observable heterogeneity among studies and shared characteristics among groups of studies (Nelson & Kennedy 2009).

The estimated metaregression is

$$p_{ij} = \alpha + \mathbf{X}_{ij}^{M'}\beta^M + \mathbf{X}_{ij}^{P'}\beta^P + \mathbf{X}_{ij}^{E'}\beta^E + u_i + \varepsilon_{ij}, \quad (1)$$

where the dependent variable p_{ij} is the participation rate estimate; i is the study level (range: 1–45), which is the total number of different primary studies; j is the observation level (range: 1–300), which is the total number of observations; u_i is an error term at study level, and ε_{ij} is an error term at observation level. These error terms are assumed to follow a normal distribution, with means equal to 0 and independent of one another. The α is the intercept, which can be interpreted as the expected participation rate for the null case in which all dummy variables are set to 0 and continuous variables are set at their average (Nelson & Kennedy 2009). For this reason, 2 continuous variables (timber price and compensation amount) were demeaned before analysis. The $\mathbf{X}$ is the vector of independent variables, and β is the vector of coefficients.

Because the inclusion of economic incentive variables in addition to methodological and policy variables reduced the number of observations and studies, we estimated 2 models with the different sets of independent variables. This process also functioned as a sensitivity or robustness analysis for policy variables. Model 1 included $\mathbf{X}^M$, $\mathbf{X}^P$, and timber price of $\mathbf{X}^E$, resulting in 300 observations from 45 studies. Model 2 had the same variables as model 1 with the addition of compensation amount, which significantly reduced the number of studies to 19 and produced 244 observations. We also excluded $\mathbf{X}^M$ from model 2 due to the lack of variation in $\mathbf{X}^M$ and some collinearities among them. Sets of variables for 2 models are summarized in Table 3.

Results

We used random-effect Tobit estimates for 2 model specifications as our main results because our dependent variable was double censored (Table 4). The study and observation-level SDs were statistically significant at the 1% level, and the percent contribution to the total variance of the study-level variance component (ρ) was 0.5 for model 1 and 0.99 for model 2. This indicates that a significant part of the variance was due to the study-level variance, especially in model 2, where 17 of 19 primary single studies (89.5%) produced multiple observations. The adjusted R^2 values of equivalent GLS models were 0.4 for model 1 and 0.42 for model 2 (Appendix S1). Thus, our metaregression models explained approximately 40% of the variance, roughly equal to the average explanatory power of 44% found in the metaregression studies reviewed by Nelson and Kennedy (2009). The constant in model 1 was positive and significant at the 5% level. It indicated that the expected participation rate was 0.264 when census was used to collect landowners' action data for participation in forestry programs with a contract length of 1–30 years with an option to withdraw available at the average timber price. Statistically significant effect sizes were based on the average marginal effect Tobit coefficients of model 1 reported in Table 4 (Fig. 1).

With regard to methodological or behavioral variables, a hypothetical choice environment and DC survey had highly significant and robust effects across alternative models and specifications. Investigating the effect of behavioral environments showed that compared with action, stated choices within a hypothetical program increased the participation rate by about 30%, whereas stated choices on a contingent scenario had no effect on participation after all other determinants had been controlled for. For study method, we found that DC surveys produced about 20% higher participation rates than census registration, whereas CE surveys had no significant effect on participation. This suggests that participation rates tended to be overestimated when landowner participation was elicited in hypothetical choice situations or through DC format surveys after all other determinants had been controlled for. Hence, both methodological and behavioral factors mattered for participation rates.

All policy variables had expected, significant, and robust effects on the participation rate. We used the results of model 1 to demonstrate the effects of policy variables because the magnitude and significance of coefficients of the 2 models were quite similar and because the model 1 sample represented a much wider study population than the model 2 sample (45 vs. 19). A check of the effect of contract length confirmed that longer contracts tended to have lower participation rates. The

Table 3. Descriptive statistics for subsamples used for metaregression models 1 and 2 in an analysis of landowner participation in forest ecosystem service programs.

Variable	Model 1		Model 2	
	mean	*SD*	*mean*	*SD*
Dependent participation rate	0.49	0.27	0.50	0.28
Study method (baseline: census, others)				
dichotomous choice survey	0.19	0.39	0.15	0.36
choice experiment	0.77	0.42	0.84	0.36
Behavioral (baseline: action from stated actual or registered participation)				
stated choice hypothetical program	0.41	0.49	0.369	0.48
stated choice contingent scenario	0.53	0.50	0.627	0.48
Contract length (baseline: length specified as 1–30 years)				
31–50 years	0.09	0.29	0.11	0.32
51–100 years	0.08	0.28	0.09	0.29
perpetual	0.07	0.25	0.06	0.24
length not specified	0.23	0.42	0.19	0.40
Withdrawal option (baseline: specified as option available)				
conditional	0.12	0.33	0.09	0.29
none	0.13	0.34	0.15	0.36
not specified	0.60	0.49	0.61	0.49
Management instruments (baseline: specified as forestry, recreational, or combined)				
conservation	0.49	0.50	0.46	0.50
not specified	0.09	0.29	0.07	0.26
Timber price (export unit price in US$/100 for 1000 m³ roundwood in survey year and country)				
timber price	1.20	0.34	1.19	0.36
Compensation (US$ per ha/1000 in survey year) & pay schedule (annual or one time up-front)				
compensation US$ × $D_{\mathrm{annualpay}}$			0.31	1.75
compensation US$ × $(1 - D_{\mathrm{annualpay}})$			0.65	1.91
$D_{\mathrm{annualpay}}$[a]			0.86	0.35
No. of studies	45		19	
No. of observation	300		244	

[a] *Dummy variable equaling 1 if the payment schedule is specified as annual payments.*

Table 4. Random-effect metaregression Tobit estimates in a study of landowner participation in forest ecosystem service programs.

Determinants	Model 1[a]		Model 2[a]	
	coefficient	Z[b]	coefficient	Z[b]
DC[c] survey	0.197	(2.27)**		
Choice experiment	0.063	(0.67)		
Hypothetical	0.309	(3.56)****		
Stated contingent	0.124	(1.34)		
Length 31–50 years	−0.119	(−3.24)***	−0.129	(−4.68)****
Length 51–100 years	−0.305	(−8.06)****	−0.32	(−11.33)****
Length Perpetual	−0.189	(−4.26)****	−0.202	(−5.81)****
Length NS[d]	0.041	(0.60)	0.798	(0.99)
WithdrawCondAv	−0.103	(−2.37)**	−0.117	(−2.87)***
No Withdraw[d]	−0.128	(−3.34)****	−0.09	(−3.00)***
Withdraw NS[d]	−0.207	(−2.93)***	−0.878	(−1.21)
Manag. Conservation	0.25	(5.01)****	0.45	(8.54)****
Manag. NS[d]	0.084	(0.96)	−0.271	(−0.15)
Timber Price[e]	−0.143	(−1.72)*	0.288	(0.44)
CompenAmount*D_{annual}[e]			0.349	(9.05)****
CompenAmount*$(1 - D_{annual})$[e]			0.069	(4.37)****
D_{annual}[f]			−0.139	(−0.92)
Constant	0.264	(2.40)**	0.462	(0.74)
σ_u (study level)	0.153	(6.36)****	1.311	(4.81)****
σ_ε (observation level)	0.155	(22.23)****	0.114	(20.43)****
$\rho\left(\frac{\sigma_u^2}{\sigma_u^2 + \sigma_\varepsilon^2}\right)$	0.5		0.99	
Log likelihood	91.9		112.9	
No. of observations	300		244	
No. of studies	45		19	

[a] Seven out of 300 observations are right censored in model 1, whereas 5 of 244 are right censored in model 2. No observation is left censored.
[b] Significance: ****p < 0.001; ***p < 0.01; **p < 0.05; *p < 0.1.
[c] Dichotomous choice.
[d] Not specified.
[e] All continuous variables are demeaned.
[f] A dummy variable equaling 1 if the payment schedule is specified as annual payments.
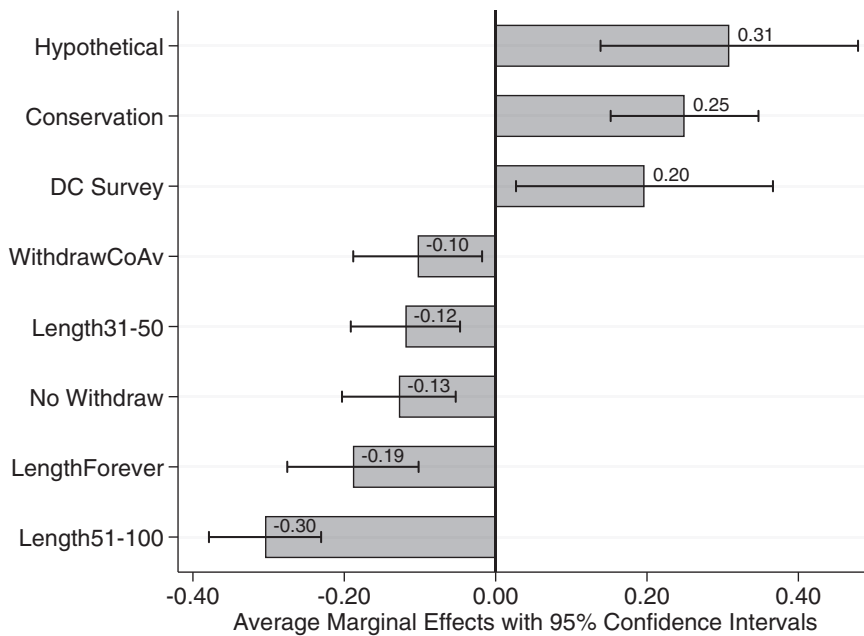
Figure 1. *Significant regressors (based on average marginal effect Tobit coefficients of model 1 reported in Table 4) in the metaregression model of landowner participation in forest ecosystem service programs (hypothetical, stated choice hypothetical program; conservation, conservation programs; DC survey, dichotomous choice survey; WithdrawCoAv, withdrawal conditional option; length 31–50, 31–50 years contract; no withdraw, no withdrawal option; length forever, perpetual contract; length 51–100, 51–100 years contract).*

estimated participation rates of contracts of 31–50 years, 51–100 years, and perpetual duration were about 12%, 30%, and 19%, respectively, lower than those for 1–30 years contracts. We found statistically significant differences between contracts of 31–50 years and 51–100 years ($p < 0.01$) and between contracts of 51–100 years and perpetual duration ($p = 0.022$). Contracts of 51–100 years had a stronger negative effect on participation than perpetual contracts, even after controlling for all other determinants. Estimates from studies in which the contract length was not specified did not forecast the participation rate statistically any differently from that for the 1- to 30-year baseline contract. This suggests that landowners in these studies did not expect the contract length to be longer than 31 years or that the studies actually had a 1- to 30-year contract on average, but this was not reported in the articles. An alternative model with contract lengths in years measured as a continuous variable showed that the coefficient of contract year was −0.005 ($p < 0.01$) and the coefficient of length perpetual dummy was −0.265 ($p < 0.001$) (Appendix S2). The coefficient of contract year squared was not significant ($p = 0.615$), suggesting that participation rates were linearly decreasing as contract length increased. With the reservation that this alternative specification significantly reduced the number of studies, from 45 to 26, the results indicated that a 53-year contract, reducing participation by 26.5%, would be equivalent to a perpetual contract, giving a 26.5% reduction in the participation rate.

With respect to the effect of the availability of withdrawal options on participation, the metaregression results showed that programs with no withdrawal option had 13% lower participation rates, and programs with a conditional option had 10% lower participation rates

(compared with a baseline with a withdrawal option). Estimates from studies in which the availability of a withdrawal option was not specified forecast almost 21% lower participation rates than the baseline with a withdrawal option and almost 8% lower than estimates from studies with no such option. This suggests that landowners in such a study expected no withdrawal option to be available or something worse, possibly due to the subjective evaluation of uncertainty in withdrawals. With respect to the purpose and major management instrument of the program, conservation programs forecasted 25% higher participation rates than forestry or other management programs.

Timber prices had an expected effect in the model 1 specification, although the statistical significance of this factor was weak. The metaregression result suggested that a US$100 increase in the export unit price for 1000 m^3 roundwood would reduce the participation rate by about 14%. The inclusion of compensation muted the effect of timber prices in model 2. The effects of compensation were highly significant and robust across alternative Tobit model specifications. A US$1000 increase per hectare in annual payments increased the participation rate by about 35%, whereas the same increase in one-time up-front payments increased the rate by about 7%.

The results of our robustness checks across various models and specifications showed that our main random-effect Tobit estimates (Table 4) were highly robust in terms of statistical significance and magnitude of the estimated coefficients (Appendix S4). All the signs and significance at the 5% level remained unchanged when we removed 10% extreme observations (Appendix S1) and when we added geographical region dummies (Appendix S2). Coefficient of the annual payment amount

became insignificant when we estimated the equivalent GLS model (Appendix S1). This would be because our dependent variable was truncated at 1 on the right tail and Tobit models correctly accounted for the upper bound of participation rate estimates.

Discussion

Our metaregression analysis yielded results that are highly relevant for researchers investigating the participation behavior of landowners and for managers designing programs based on various types of data, including data from surveys. Even though a minimum participation requirement for efficient outcomes is case specific and depends on the marginal ecological benefit and spatial configuration of the land enrolled, our results will allow researchers to investigate how their choices of study and program attributes affect the forecast of the participation rate of interest. First, it is clear that both methodological choices and the behavioral environment of a study will influence the estimated participation rates. Importantly, the use of stated choices in hypothetical scenarios (31%) collected by the DC format survey (20%) tended to inflate participation rates substantially compared with actual data. This confirmed our initial expectation that there is a tendency to overstate answers to questions about socially desirable behaviors in hypothetical choice situations, a phenomenon known as "social desirability bias" or "demand effects" (Hoffman et al. 1996). In addition, we may have observed what is sometimes called the "yea-saying" effect associated with DC questions (Blamey et al. 1999) because we did not find the same result for CE surveys. Practitioners should be aware of this effect and either adjust estimated participation results from DC surveys ex post (Loomis 2011) or, perhaps better, use a CE approach to investigate participation behavior.

Second, the contract length influenced the participation rate significantly, but in nonintuitive ways. We found that landowners tended to hesitate to participate when the contract length is more than 50 years, but still time limited. This had a stronger negative effect than perpetual contracts. It was hard to determine the underlying causal mechanism from our analysis, but it could be related to psychological effects or landowner expectations. For example, the perpetual contract might reduce future uncertainty by removing the need to consider what to do with the land when the contract expires (which is after 50 years or even longer from the time they make a decision). Although many studies showed that duration reduces participation significantly, the literature is not entirely conclusive, especially when payment for ES and agro-environmental schemes is viewed in a broader perspective (Mamine & Minviel 2020). If one takes our results at face value, they imply that program managers and policy makers would be better off, in terms of ex-

pected initial participation rates and environmental outcomes, using perpetual contracts rather than contracts that last 50 years or longer.

Third, we found that including a withdrawal option increased participation rates, as expected. However, making withdrawal options conditional did not seem to make a big difference to participation relative to a contract with no withdrawal option. This suggests that including different kinds of conditions for withdrawal is not very effective for remediating low participation compared with having no such option at all (a mere 3% difference).

Fourth, although our results showed that compensation increased participation, as expected, they also suggested that conservation programs with low budgets may increase participation by changing the type, rather than the actual level, of payments. Our comparison between annual and one-time payments indicated that one-time up-front payments were more effective in increasing initial participation than annual payments for contracts longer than 5 years. If one ignores discounting, this means, for example, that a US$1000 increase in total payments for a 30-year contract would increase the initial participation rate by 1.17% for annual payments and 6.9% for one-time up-front payments. Further, the same U.S. dollar increase in compensation for a 5-year contract would increase participation by about 7% for both annual and one-time up-front payments, suggesting that the latter increase initial participation more than annual payments as long as the contract is longer than 5 years. Even stronger support can be expected for one-time up-front payments, given that individual discount rates tend to be much higher than the market interest rate (Frederick et al. 2002).

Although we were not able to investigate causal relationships in depth by means of meta-analysis, our results confirmed prior expectations where such were available from theory and empirical studies. They were also robust across model specifications, indicating that our findings demonstrate clear underlying relationships between our explanatory variables and participation rates. Our study also has some natural extensions. To keep the types of programs and studies relatively homogenous, we deliberately excluded studies of payment for ES programs in other parts of the world (Alix-Garcia & Wolff 2014) and studies of agro-environmental schemes (Mamine & Minviel 2020). In practical meta-analyses, there is often a trade-off between heterogeneity and the ability to explain particular phenomena accurately. One avenue of future research may be to explore the possibility of including a broader set of contract types and making the study global in reach.

Several results from the meta-analysis warrant further research suitable for more in-depth studies of individual programs. It would be intriguing, for example, to investigate the mechanisms underlying the effects of contract attributes on participation, including contract

length and payment types. Also, it would be important to consider the effects of payment types on withdrawal rates. Program managers want robust contract attribute levers that can increase forest conservation at low or no cost by utilizing behavioral or psychological knowledge. For SP researchers, there is interesting further research to be done on the mechanisms underlying the exaggerated responses we observed for hypothetical choice situations and DC surveys. Such surveys are increasingly used to assess (intended) landowner behavior; so, without correction, overly optimistic forest programs may be initiated.

Finally, our results showed that managers of forestry-oriented programs have a harder time upping participation rates than managers of conservation programs: conservation programs forecasted 25% higher participation rates than forestry or other management programs. This is consistent with a previous literature review of forest owner participation in carbon sequestration programs (Langpap & Kim 2010). Why this is so is not clear, but it may have to do with the types of forest owners surveyed and their underlying motivations. Alternatively, targeting biodiversity and wildlife protection may reinforce the owner's prosocial behavior or increase socially desirable responses. Whatever the case, investigation of these motivations is a crucial area of future research if one wants to fully understand how to make landowners participate in forest programs.

Acknowledgments

Supporting Information

Appendix S1: Robustness Checks (Different Estimation Models and Trimmed Samples)
Appendix S2: Robustness Checks (Random-effect Tobit with Different Specifications)
Appendix S3: Overview of All Studies Included in the Meta-analysis
Appendix S4: Significant Effects in Regressions
Appendix S5: Determinants of Participation (Histograms)
Appendix S6: Determinants of Participation (Scatter Plots) Appendix S7: Literature Included in the Meta-analysis

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