Do Gamified Social Interactions on a Green Fintech App Nudge Users' Green Investments?*

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July, 2024

Abstract

Using a novel dataset from Ant Forest, a green fintech app in Alipay, we explore how gamified social interactions influence the users' green investment decisions. We find that the users' green preference, measured by daily low-carbon activities, is enhanced when they engage more in gamified social interactions designed for environmental education, thereby increasing their investment proportion in green mutual funds. Our findings are stronger among male and younger users and those less involved in environmental conservation actions. Our study provides the first mechanism in which gamified social interactions facilitate green investments by enhancing individuals' green preferences.

JEL Classification: A13, D14, D91, G11, G18, G41, G51, Q56
Keywords: Gamified social interactions; Gamification; Green preference; Green investment; Retail investors; Green fintech app; Digital carbon footprint

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1. Introduction

How to nudge retail investors to engage in green investments?[1] This is crucial in a world facing climate change. First, green investment is widely seen as a key financial practice for fighting against it. However, since 2020, assets under management (AUM) in green investments have declined significantly, dropping from 35.9% to 24.4% by 2022, according to GSIR (2022), with the decline mainly coming from the U.S. and Europe. Second, the latest report from the Intergovernmental Panel on Climate Change (IPCC, 2022) reveals that even if all current government pledges are fully implemented, they would still fail to meet the goal of achieving energy-related carbon emissions to net zero by 2050 and limiting global warming to 1.5°C.

Gamification could be a promising incentive for individuals to invest in green assets. Defined as applying game-design techniques in non-game contexts, gamification has been shown to influence people's behavior. Research in medical and cognitive studies has demonstrated that game-like features can enhance user engagement in desired activities (Long et al., 2023), promote mental wellness (Cheng and Ebrahimi, 2023), and improve cognitive abilities (Anguera et al., 2013). Moreover, in today's fintech era, many online platforms—including payment, trading, and banking apps—are progressively adopting gamification elements to attract users and influence their behavior. However, there is little evidence in finance on whether gamification can effectively incentivize individuals to invest in a sustainable way.

Our paper fills this gap by demonstrating how gamified social interactions in a green fintech app, designed to provide green education and cultivate green consciousness, can increase the proportion of green investments in users' portfolios. Specifically, we explore a novel mechanism in which gamified social interactions enhance green preference, thereby motivating individuals to invest more sustainably.

[1] In this paper, we use green investment that includes sustainable investing, ESG (environmental, social, and governance) investing, or SRI (socially responsible investing). As Starks (2023) argues in her 2023 AFA's Presidential Address, there is no clear consensus on the meaning of sustainable finance or the acronyms ESG (environmental, social, and governance) and SRI (socially responsible investing). Sustainable investing is a broad concept that incorporates environmental and social issues into traditional finance. Both ESG investing and SRI share a values-based motivation in their investment approaches. We focus on investments related to environmental issues (the "E" in ESG).

We partner with Ant Group and collect data from their representative super app, Alipay. Alipay hosts a large ecosystem of mini-apps. Our study focuses on two of these mini-apps: Ant Forest, which tracks users' gamified social interactions and their daily digital carbon footprint by engaging in low-carbon activities, and Ant Fortune, which provides detailed information on users' fund holdings.

Ant Forest, initially launched as a green public initiative, has evolved into a popular social game aimed at encouraging people to adopt low-carbon lifestyles. It automatically records users' everyday carbon footprint and rewards them with "green points" (also known as "green energy points", a type of virtual currency) for making eco-friendly choices. These points don't immediately enter the user's account but must be collected daily. The appealing feature is that users can "rob" uncollected green points from their friends, benefiting effortlessly by adding these points to their own accounts. The interesting fact about this game is that the more you engage in robbing activities—whether robbing or being robbed—the funnier it becomes, which increases the likelihood of being nudged toward green behaviors through other parts of the app, ultimately leading to greater green commitment and stronger green preferences. We document this robbing feature and use the sum of green points robbed by a user's friends and green points gained by robbing friends as a proxy for "gamified social interactions."

As a green initiative, Ant Forest provides a rich record of users' digital carbon footprints and certifies 48 types of low-carbon activities to reward green points. Take walking, the most common low-carbon activity, as an example: a user automatically earns 0.0164 green points for each step because she reduces carbon emissions by substituting other modes of transportation, such as driving. However, some green activities may be subject to alternative explanations. Still, taking walking as an example, a high step count might result from running for exercise or limited access to transportation, rather than a green preference. Therefore, we select 16 activities that better reflect users' proactive environmental preferences. One example is "Green

Takeout" when users opt out of single-use cutlery when ordering takeout (He, Pan, Park, Sawada, and Tan, 2023). In our analyses, we use the green points obtained from these 16 activities as a proxy for green preference, which we refer to as "intentional green points".

The green points don't have monetary value, but with enough, a user can redeem them to plant a real tree or protect one square meter of ecologically damaged areas or ocean on her name. Ant Forest is a global leader in such carbon offsetting projects and was awarded the 2019 Champions of the Earth Award, the United Nations' highest environmental honor, for reforestation practices.[2] By the end of 2022, Ant Forest had motivated more than 600 million app users to plant 400 million trees across 4.5 million acres, an area more than four times the size of Singapore, and established 24 conservation lands nationwide, safeguarding over 2,700 square kilometers of land.[3]

To link a user's investment behaviors to her Ant Forest profile, we use the same user's account on Ant Fortune, another mini-app where users can trade all publicly mutual funds in the Chinese market. Ant Fortune account is separate from the Ant Forest account, and users' fund investment choices do not give them any edge in earning green points. We obtain users' detailed information on mutual fund portfolio holdings and perform text analysis on the name of each fund to define green funds. We then use the ratio of green fund holdings to total fund holdings as a proxy for a user's green investment. After merging these datasets, we create a user-month panel sample spanning from October 2018 to September 2022 with 100,000 randomly selected users.

We first adopt two-stage least squares (2SLS) regression to examine the mechanism through which gamified social interactions foster green preference, thereby encouraging greater green investment. In the first-stage regression, we find that a user's gamified social interactions positively correlate to her green preference. Rooted in the marketing literature, gamification has been shown to enhance user loyalty and

[2] https://www.unep.org/news-and-stories/press-release/chinese-initiative-ant-forest-wins-un-champions-earth-award

[3] See Ant Group 2022 Sustainability Report. https://www.antgroup.com/en/esg/reportdetail

engagement (e.g., Teng, 2017). In the context of Ant Forest, gamification serves a similar purpose but aims specifically to promote green behavior. As gamification triggers users to stay longer in Ant Forest, they are increasingly exposure to environmental education content, such as posts on endangered species and tips for low-carbon activities, which plausibly boost their green preferences.

In the second stage, the increased green preference induced by gamified social interactions leads to a higher proportion of green mutual fund holdings. Since these gamified interactions are designed only to enhance users' green preference by encouraging participation in this green-nudging game, they are unrelated to any financial investment gains and do not directly impact users' green investments. Thus, our two-stage design reveals the mechanism by which gamified social interactions drive users toward green investments by enhancing their green preferences. Economically, a one-standard-deviation increase in gamified social interactions increases the subsequent month's proportion of green mutual funds holding by about 5.19% relative to the sample mean (0.24% in the absolute term). These results hold when personal traits, such as innate time-unvarying green preference, are controlled for by including user fixed effects in the regressions.

Establishing causality between non-pecuniary motives and green investments is challenging, as certain user psychological factors like social preferences and altruism may influence both the extent of gamified participation and investment choices. To overcome this identification challenge,we conduct a difference-in-difference (DiD) analysis, using a positive shock to the gamified social interactions as a quasi-experimental design. In August 2020, Ant Forest launched an in-game item, Energy Double Click Card, that allows users to rob double the usual amount of green points but with a limited period of use. This specially designed item offers greater marginal benefits to users with lower prior engagement in the game. In the same spirit of the DiD setup by Fang, Tian, and Tice (2014) and Amihud and Levi (2023), we define the users who had fewer gamified social interactions before the shock as the treated group, as

they are expected to experience a higher increase in gamified interactions. Our result shows that after the shock, the treated group holds a higher proportion of green funds than the control group (previously more socially active users). The finding supports the causality, indicating that gamified social interactions positively incentivize users' green mutual fund investment.

Our analyses also show a stronger gamification effect among male users, young users, and users who participate less in environmental conservation actions such as planting real trees or protecting eco-damaged areas. These results collectively suggest that users with relatively lower levels of green consciousness, preferences, and investments, are more affected by the gamified social interactions (Bauer, Ruof, and Smeets, 2021; Giglio et al., 2023).

To establish the robustness of our findings, we perform several additional exercises. First, we explore alternative channels for green investments, such as the Simple Gamification Effect, where users derive satisfaction from merely collecting green points, and the Positive Feedback Effect, where users experience a sense of achievement from earning green points to planting trees. To evaluate these channels, we conduct horse race tests and the results remain robust. Second, since Ant Forest users can consume green points to plant real trees and protect ecologically damaged areas, these actions, similar to green points acquisition, also serve as indicators of users' green preference. Hence, we aggregate acquired and consumed green points as an alternative proxy for green preference. The results are qualitatively similar. Third, the results remain when using different measures of green investments. In particular, gamification increases a user's green fund holdings but not her non-green fund holding values. Last, as green investment behavior may be reflected in broader categories of sustainable funds, we expand our green fund list by using both funds' names and the Wind Sustainable Fund list. The main findings remain robust.

Our paper is related to three streams of literature. First, we add to studies on gamification in economic decisions. Gamification is now commonly employed as a

strategy in customer relationship management to boost user engagement and stickiness (e.g., Werbach, Hunter, and Dixon, 2012; Huotari and Hamari, 2017). Although an increasing number of retail broker apps, such as Robinhood, are incorporating game-like features to attract retail investors (e.g., Barber, Huang, Odean, and Schwarz, 2022; Pedersen, 2022), the empirical evidence directly linking gamification with retail investors' financial decisions is rather limited. One notable exception from an experimental setup is Chapkovski, Khapko, and Zoican (2024) who find that hedonic gamification elements like confetti and achievement badges increase a user's trading volume. Our paper provides the first observational evidence regarding the bright side of gamification in a major fintech by showing that social gamification elements can guide users' behavior in a socially desirable direction. When such gamification is designed properly, more green investments via the "green nudge" can be achieved.

Second, we contribute to the emerging literature on retail investors' non-pecuniary motives for sustainable investments.[4] This literature primarily relies on survey data. However, survey responses could be elusive (e.g., talk is cheap; attitude-behavior gap) as shown by White, Hardisty, and Habib (2019). Our paper differs from the survey studies by providing a more accurate proxy of users' daily behavior in a fintech app. More importantly, we introduce a new mechanism, gamified social interactions, through which the non-pecuniary motives for green investments are enhanced. To the best of our knowledge, our paper is the first to demonstrate a causal effect of gamified social interactions on individuals' green investments. We hence also contribute to the literature on social interactions.[5] Our paper adds to this literature by documenting that

[4] Studies have shown that individuals invest in sustainable assets because they gain positive emotions (Heeb et al., 2023), exhibit social preferences (Riedl and Smeets, 2017; Bauer, Ruof, and Smeets, 2021), demonstrate altruism (Brodback et al., 2022), concern about climate change (Anderson, 2021), possess higher financial literacy (Anderson and Robinson, 2022), maintain consistent preferences in consumption (Brunen and Laubach, 2022), and compensate for carbon footprints (Brunen, 2019; Kormanyos, 2023).

[5] This literature explores concepts such as "keeping up with the Joneses" or trading for status (Bernheim, 1994; Hong, Jiang, Wang, and Zhao, 2014), herding or peer effect (Banerjee, 1992; Hong, Kubik, and Stein, 2004), and information cascade (Bikhchandani, Hirshleifer, and Welch, 1992) in financial decisions. This body of work posits that social interactions with friends or communities influence investors' decisions to enter the stock market after witnessing their friends' lucrative stock trading profits (Kaustia and Knüpfer, 2012), purchase a house when their friends experiencing an increase in housing prices (Bailey, Kuchler, and Stroebel, 2018), mimic the trading behavior as their work peers (Hvide and Östberg, 2015; Ouimet and Tate, 2020), or hold similar investment portfolios among sophisticated investors, such as fund managers (Pool, Stoffman, and Yonker, 2015). See Kuchler and Stroebel (2021) for an overview.

gamified social interactions facilitate fintech app users' green investment decisions through enhanced green preference.

Last, we contribute to the literature on how financial technology apps influence users' behaviors in investment, borrowing, spending, and saving decisions.[6] In particular, our paper is related to Gargano and Rossi (2024) who study the causal impact of fintech on sustainable consumption behaviors. They measure sustainable behaviors based on in-app transaction activities. Our paper differs from theirs in several dimensions. While they show that the Carbon Calculator in the fintech app enhances users' green consumption behaviors, our research focuses on how gamified social interactions elevate users' green preference, leading to more mutual fund investment allocation to green ones. Moreover, our measure of sustainable daily behaviors encompasses a broader range of daily activities beyond in-app transactions.

The rest of our paper is organized as follows. Section 2 highlights the institutional background of Alipay. Section 3 describes our datasets from Alipay Ant Forest and Alipay Ant Fortune. In Section 4, we present the main empirical results, along with heterogeneity and robustness tests. Finally, Section 5 concludes.

2. Institutional Background: Alipay

Alipay is a super app owned by the Ant Group, the financial affiliate of Alibaba Group. Ant Group, formerly known as Ant Financial, was set for one of the world's largest IPOs in October 2020 raising $34.5 billion. In 2024, Ant Group remains the sixth largest fintech company overall and the largest private fintech company globally.[7] According to the IPO prospectus in 2020, Ant Group owns the world's largest mobile (digital) payment platform Alipay, which serves over 1.3 billion users and 80 million merchants, with total payment volume reaching RMB 118 trillion in June 2020.[8] In

[6] D'Acunto, Prabhala, and Rossi (2019) find that a wealth-management robo-adviser can mitigate users' behavioral biases and enhance diversification benefits. Di Maggio, Ratnadiwakara, and Carmichael (2022) find that fintech platforms provide broader access to credit, particularly for borrowers with low credit scores. Lee (2023) reports improvements in spending habits among app users after receiving overspending messages from a money management app. Gargano and Rossi (2022) show that fintech app helps users save more by facilitating goal-setting for savings. We contribute to this literature by exploring the benefits of financial technology in promoting users' green preference, thereby nudging their green investments.

[7] https://courses.cfte.education/ranking-of-largest-fintech-companies/

[8] https://web.archive.org/web/20201020200428/https://www1.hkexnews.hk/app/sehk/2020/102484/document

2024, Alipay has become the top digital payment platform, followed by WeChat Pay, Apple Pay, Google Pay, and PayPal.[9]

Alipay's primary function is to facilitate online payments and on-site payments through QR code scanning. As it has evolved into a super app, Alipay integrates a broad selection of mini-apps including Buy-Now-Pay-Later, Ant Forest, Ant Fortune, DiDi Travel, Eleme, etc.[10] In this paper, we focus on two of these mini-apps: Ant Forest and Ant Fortune.

2.1 Ant Forest

Ant Forest was launched in 2016 as a public green initiative. Its original aim was to encourage Alipay users to adopt low-carbon lifestyles and nudge them to participate in real environmental conservation. To achieve this goal, Ant Forest introduced appealing gamified features that leverage social interactions with friends. Through these interactions, Ant Forest aims to expand user engagement through their social network and ultimately inspire more people to participate in the green initiative.

Figure 1 illustrates how Alipay users participate in the Ant Forest. Users must first open an Ant Forest account (like a "carbon account") and grant permission for Ant Forest to collect and analyze their digital data within Alipay. With this permission, Ant Forest tracks their everyday activities like walking, subway rides, takeout orders, and online payments, and evaluates the carbon footprint of these activities. When Ant Forest identifies a user's participation in certified low-carbon activities, it awards the user with a form of virtual currency called green points. These green points appear as "green bubbles" on the app homepage, as illustrated in the top-left of Figure 1. By clicking on the bubbles, users collect the green points, which are then added to their carbon accounts. Once collected and stored in a carbon account, green points are secure and cannot be robbed.

Besides engaging in low-carbon activities and collecting green points, the

s/sehk20082500535.pdf

[9] https://fintechmagazine.com/articles/top-10-digital-payment-platforms-2024

[10] Buy-Now-Pay-Later is a type of consumer credit allowing users to make purchases but defer payments. DiDi Travel is an app for ording rides, like Uber. Eleme is an app for ording takeout, like Uber Eats.

bottom-right of Figure 1 displays the game-like feature of Ant Forest, which encourages social interactions by robbing friends' green points. To do this, a user can visit her friends' Ant Forest homepages and rob part of the green points that appear there before her friends collect them. Those robbed points are added to the user's carbon account, while her friends lose those points. But friends always have the chance to rob points back, keeping the competition lively. Such competitive gameplay is designed to enhance user engagement and loyalty to the game, nudging users toward more eco-friendly behaviors.

The top-right of Figure 1 highlights Ant Forest's green initiative feature, which allows users to engage in environmental conservation. When users accumulate enough green points in their carbon accounts, they can redeem them to sponsor a real tree or protect one square meter of ecologically damaged land or ocean. For instance, redeeming a tree means the user "pays" with green points to add a real tree to the earth, with Ant Group handling the purchase, planting, and cultivation on the user's behalf. Then, the user will receive a digital badge indicating that they have planted a tree and saved carbon dioxide for the earth. The underlying concept is that if a user offsets carbon emissions equivalent to those absorbed by a real tree over its lifetime, they can double their environmental impact by planting a real tree for the earth. This green fintech initiative is among the first globally to offer people an accessible way to participate in environmental conservation. To visualize their environmental impact, users can view satellite images of their planted trees and watch wildlife activity videos of conservation land. Figure 1's bottom-left panel summarizes these two key features.

As users spend more time on Ant Forest, whether drawn by its gamified features or the green initiative, they gain increasing exposure to abundant environmental educational content on nearly every interface of the app. This exposure helps to induce and amplify users' green preference. Figure 2 displays a series of app interfaces that aim to educate users about a low-carbon lifestyle and encourage positive environmental impact. Specifically, Panel A demonstrates posts and topics that encourage users to

protect the environment and wildlife. Panel B shows visible environmental contributions made by users through satellite images of planted trees and videos of wildlife in conservation lands. Panel C outlines a list of daily low-carbon activities, educating users to take practical steps for a sustainable lifestyle. Together, these interfaces provide continuous environmental education, cultivating and reinforcing users' green preferences over time.

2.2 Ant Fortune

Ant Fortune, Alipay's online wealth management platform, offers a wide range of investment products and services for Alipay users. Ant Fortune cooperates with banks, wealth management providers, securities brokers, and insurers to provide various investment options such as deposits, fixed-term wealth management plans, mutual funds, and gold investments.[11] It has grown into China's largest online wealth management platform for delivering a user-friendly experience, providing diverse investment options, and making investing affordable to all. This paper focuses specifically on mutual funds. Users can explore and trade from a selection of over 10,000 mutual funds in the public market, with a minimum investment starting at just 1 RMB (equivalent to $0.14). As of May 2022, Ant Fortune has served 500 million active users with assets under management at $605 billion.[12]

3. Data

Our sample includes data from two Alipay mini-apps: the Ant Forest and the Ant Fortune. We also obtain the Wind Sustainable Fund list from the Wind database for robustness checks.[13] Our study is remotely conducted in the Ant Open Research Laboratory in an Ant Group Environment.[14] The data is sampled and desensitized by

[11] https://www.youtube.com/watch?v=5xKQro7z0ws

[12] https://news.smu.edu.sg/news/2023/05/20/how-ant-fortune-grew-provide-affordable-wealth-management-services-china

[13] The Wind Sustainable Fund list is a list of sustainable funds in the Wind database. The list, as of August 31, 2023, includes a total of 640 funds. This list can be acquired by paying a data license fee in the Wind database. Specifically, the list consists of funds that explicitly incorporate sustainable investment strategies in their investment objectives, investment scope, investment strategies, decision-making foundations, investment focus, investment criteria, portfolio restrictions, investment philosophy, performance benchmarks, and risk disclosure scope.

[14] https://www.deor.org.cn/research/laboratory

the Ant Group Research Institute and stored in the Ant Open Research Laboratory. The laboratory is a sandbox environment where the scholars can only remotely conduct empirical analysis and individual observations are not visible.

By merging all these datasets, we obtain a monthly panel sample, which spans from October 2018 to September 2022 and consists of 100,000 users. These users are randomly selected based on (i) having activated their Ant Forest accounts and (ii) having made at least one fund transaction during this 48-month sample period. Then, to avoid missing observations, we restrict the sample to users who have (i) engaged in proactive low-carbon behaviors with at least one observation of "intentional green points" or (ii) invested in a green fund at least once. Our final sample contains a user-month panel sample of 86,690 users from October 2018 to September 2022.

3.1 Ant Forest Profiles

The users' profiles in Ant Forest include green points awarded for each certified behavior, total trees planted, total areas protected, and gamified interactions. Ant Forest labels a total of 48 daily activities as "low-carbon," including green transportation, energy conservation, etc. Each activity is assigned a corresponding number of green points, equivalent to the grams of carbon emissions reduced by participating in that activity. These numbers are determined by environmental scientists from the China Beijing Green Exchange and the Nature Conservancy.[15] Appendix Table A1 reports detailed information on all the 48 certified low-carbon activities. We refer to the green points awarded to users as *GreenPoints*.

In terms of game features, we define *RobSI* as the green points acquired by robbing friends, and *RobbedSI* as the green points lost due to friends' robberies.*GamifiedSI* is defined as the sum of both, representing the total gamified social interactions with friends. In Ant Forest, users must first be awarded green points first so that friends can interact with them through robbing activities. One concern is that our proxies for gamified social interactions, especially *RobbedSI*, could be a

[15] To see the detailed explanation of the scientific algorithm, refer to the websites of China Beijing Green Exchange (https://www.cbeex.com.cn/) and the Nature Conservancy (https://www.tnc.org.cn/)

function of *GreenPoints*. However, we show that the correlations between gamified interactions and *GreenPoints* range from 0.38 to 0.6, indicating a not highly strong relationship. In Table A3, we further show that green points account for less than 35% of the variance in gamified social interactions. Thus, our gamification proxies are not a redocumentation of the green points awarded to users. Another concern is that if one user is robbed too much, it will defeat her commitment to a green lifestyle. This is not the case. As shown in Table A4, being robbed motivates users to adopt more green behaviors. In fact, the spirit of gamification is that the more your friends rob your green points, the funnier the game becomes, leading to greater commitment and stronger green preferences.

In terms of green features, we evaluate 48 certified low-carbon activities that collectively provide a comprehensive measure of daily environmentally friendly behaviors. However, not all of them exclusively reflect a user's green preference. For instance, users may choose to take the subway simply because they live near a subway station or cannot afford private transportation, rather than a deliberate choice to reduce carbon footprints. To address this limitation, we manually select 16 activities requiring a clear commitment to environmental responsibility. We label the green points awarded from these activities as "intentional green points," as they more accurately represent a user's deliberate efforts to adopt a sustainable lifestyle.

Figure 3 displays the monthly average "intentional green points" per person for each of the 16 intentional low-carbon activities. Among all activities, "Green Commuting by Not Driving" (parking private cars at home while taking public transportation or walking instead) yields the highest number of green points, with each user earning an average of 77.12 green points per month.[16] "Green Takeout" (opting out of single-use cutlery when ordering takeout) and "Plastic Reduction" (choosing not to use plastic bags when shopping offline) follow, contributing 26.53 and 14.78 green

[16] To earn green points for the activity "Green commuting by not driving", an app user must: (i) own a private car, (ii) park it at home for over 24 hours, and (iii) upload the car's mileage at the start and end of the parking period for verification.

points respectively. Notably, among all 16 activities, 7 activities contribute a relatively small number of points. This is because some low-carbon activities occur in scenarios that are not as common in daily life. For example, if you choose not to use disposable toiletries when booking a hotel or motel, your behavior will be categorized as "Eco-friendly Accommodations", and you will earn 92 points for each reservation. However, booking hotels is not an everyday activity; thus, the green points from categories like "Eco-friendly Accommodations" are relatively low when measured on a monthly basis.

3.2 Fund Accounts

We collect mutual fund holding information from Ant Fortune for the same users, including monthly updates on users' purchase values, selling values, end-of-month holding values (shares), and returns for each fund. Additionally, we gather user demographic data such as profile creation dates, age, gender, risk attitude, and residence location. In constructing the proxies for individuals' green investment behavior, the key issue is how to identify green funds. In this regard, we conduct text analysis on the names of funds in our sample, defining "green funds" as those with names containing environmental-related (the "E" in ESG) keywords such as "green," "environmental protection," "beautiful," "ecological," "clean," "carbon neutrality," "new energy," "low carbon," "sustainable," and "ESG." We also collect "the Wind Sustainable Fund list" from the Wind dataset as an alternative measure of green funds. For each user *i* in month *t*, we calculate the proportion of her total fund holding values allocated to green funds, denoted as $GreenHoldprop$, as our core measure of green investments:

$$GreenHoldProp_{i,t} = \frac{GreenHoldValues_{i,t}}{GreenHoldValues_{i,t} + nonGreenHoldValues_{i,t}} \quad (1)$$

The variables $GreenHoldValues_{i,t}$ and $nonGreenHoldValues_{i,t}$ present the total holding values of user *i* in "green funds" and "non-green funds", respectively, at month *t*.

In robustness checks, we focus exclusively on funds from the Wind Sustainable Fund list and define three fund categories: "Sustainable Funds", "E Funds", and "ESG Funds". These categories represent funds in the Wind Sustainable Fund list that regardless of their names, contain E words in their names, and contain ESG words in

their names, respectively. We argue that our "Green Fund" definition better captures retail investors' awareness of green funds. The rationale is straightforward: most retail investors are unlikely aware of whether a fund is included in "the Wind Sustainable Fund list" because the Wind database's primary user base is institutional investors. Thus, the most intuitive way for a retail investor to recognize a green fund is by assessing its name. Based on the Wind Sustainable Fund list, we construct a set of alternative measures for green investments. The measures include the proportion of an individual's total fund investment allocated to sustainable funds (*SustainHoldProp*), E funds (*EHoldProp*), and ESG funds (*ESGHoldProp*) at the end of the following month.

In our sample, users hold 10,169 unique funds, including 238 green funds, making our sample representative of the Chinese mutual fund market. We find that user portfolios tend to be highly concentrated: 19.8% of users own just one mutual fund, and 61.5% own fewer than five. For green investments, due to the emergence of green funds, they are not commonly found in users' investment portfolios. Specifically, 76.6% of the observations show no investment in green funds, and those who do invest generally allocate less than 2,000 RMB to such funds.

In contrast, investments in non-green funds are considerably higher, with 40% of investors allocating more than 10,000 RMB to these funds. Figure A1 reports the time-series trends of average holding values and green fund holding proportions. Panel A shows an increase in the average holding values of green and non-green funds during our sample period, suggesting a rise in overall fund investments. Panel B demonstrates a growing preference for green investments; it shows that the market-wide proportion of green funds to total funds held by investors in our sample has increased, reaching about 5% in January 2022.

3.3 Descriptive Statistics

Table 1 reports summary statistics. Panel A shows app users' activities in Ant Forest. On average, each user in our sample gains 2,578 green points per month (*GreenPoints*), compared to just 8.03 points from intentional low-carbon activities

(*IntentGreenPoints*). Additionally, each user robs an average of 1,161 green points from friends per month (*RobSI*), and in turn, they are robbed of 803 green points per month (*RobbedSI*). By redeeming these points, each user plants an average of 0.06 trees (*Trees*) and protects an average of 0.16 square meters of land (*Areas*) per month. On average, each user has planted 2.64 trees (*AccumTrees*) and protected 3.50 conservation lands (*AccumAreas*) since the profile creation date.

Panel B provides summary statistics of users' fund-holding information. The gender distribution in our sample is nearly equal, suggesting that Ant Forest appeals similarly to both men and women. App users are relatively young, with an average age of 30.61 years old, in line with other fintech studies. Consistent with their young age, the median of monthly fund holding value is 30,554 RMB (approximately 4,200 USD). Most user investments are in non-green funds, with an average value of 29,250 RMB, while investments in green funds average only 1,304 RMB. In our sample, the average monthly return for green funds (*GreenReturn*) is 0.23%, slightly lower than that of non-green funds (*nonGreenReturn*), which is 0.34%. This aligns with the literature indicating that green funds typically have lower overall returns. We refer to "*GMinusN Return*" as the difference between the past month's *GreenReturn* and the past month's *nonGreenReturn* for each user, representing the relative performance of green funds versus non-green funds in a user's portfolio.

Finally, our main dependent variable, "*GreenHoldProp*" is defined as the ratio of total mutual fund holdings to green funds. The average *GreenHoldProp* of 4.62% indicates that users allocate only a small proportion of their funds to green funds. Over 75% of the *GreenHoldProp* observations have the value zero, suggesting that our users do not hold green funds most of the time. This leads to a high degree of autocorrelation in *GreenHoldProp*, as indicated by its AR(1) coefficient of 0.74. To address autocorrelation issues, we include a lagged term of the dependent variable in Table A6, and the results still hold. Panel C shows Pearson's correlation coefficients among the main variables of interest.

4. Empirical Results

4.1 Baseline Results

We start with two-stage least squares regression to examine the mechanism that gamified social interactions incentivize users to green investments by enhancing green preference. We first show that individuals' gamified social interactions are positively correlated with their green investments. This result is shown in Table A5, where we directly regress green investments on gamified interactions. Next, to formally examine the mechanism, we estimate the following two-stage least-squares (2SLS) regression as our baseline model:

$$IntentGreenPoints_{i,t} = \beta_1 + \beta_2 GamifiedSI_{i,t} + \gamma X_{i,t} + User\ FE + Time\ FE + \varepsilon_{i,t} \quad (2)$$

$$(GreenHoldProp|holding\ funds)_{i,t+1} = \beta_1 + \beta_2 FittedIntentGreenPoints_{i,t} + \gamma X_{i,t} + User\ FE + Time\ FE + \varepsilon_{i,t} \quad (3)$$

where *i* and *t* represent user and year-month, respectively. In the first stage, the independent variable $GamifiedSI_{i,t}$ captures a user's in-app gamified social interactions with her friends, namely, the sum of green points robbed by her friends and green points gained by robbing her friends. The dependent variable $IntentGreenPoints_{i,t}$ represents the user's green preference and is measured by the intentional green points obtained from 16 selected low-carbon activities that more accurately represent an individual's pro-environmental preferences.

In the second stage, we regress the proportion of green mutual fund holdings in the following month, $(\text{GreenHoldProp}|holding\ funds)_{i,t+1}$, on *FittedIntentGreenPoints*, calculated as the fitted value of intentional green points in the first-stage regression. Here, $(GreenHoldProp|holding\ funds)_{i,t+1}$ represents the user's green investment behavior, calculated as the proportion of mutual fund investment allocated to green funds, conditioned on holding funds at the end of next month.

Two clarifications are necessary before we proceed. First, we restrict the sample to users who participate in mutual fund investments during our sample period to exclude

missing values at the user level. Second, we focus on the subsequent period's green investments. Since our data are collected at the end of each month, we need to exclude any fund purchases that may have been made before the recording of this month's green points to establish causality.

We control for several users' characteristics in our regressions, including fund wealth (*TotalHoldValues*), and the difference between the past returns of green funds and non-green funds in each user's portfolio (*GMinusN Return*). We also control for user fixed effects (*User FE*) to exclude time-invariant and unobservable personal traits that may collectively affect gamified social interactions and green investment. By doing so, the variation of our gamification-induced green preference comes from time series changes at the user level. We add year-month fixed effects (*Time FE*) in the regressions as well to exclude macroeconomic shocks that may jointly influence users' green investment and preference. We cluster standard errors by users, which adjusts for time-series dependence in the panel data at the user level.

Table 2 presents our primary findings based on the two-stage least squares regression approach. Panel A reports the first-stage results from regressing intentional green points on various measures of gamified social interactions. These gamified social interactions are proxied by green points gained from robbing friends (*RobSI*), green points robbed by friends (*RobbedSI*), and the total sum of both (*GamifiedSI*) across columns 1 to 3, respectively. All the estimated coefficients on gamified social interactions are positive and statistically significant at the 1% level. The positive relation suggests that gamified social interactions within the fintech app enhance users' green preference.

The second-stage results are shown in Panel B of Table 2. Using the fitted value of intentional green points based on Eq. (2), we regress next month's green investment proportion on fitted intentional green points. All the estimated coefficients on fitted intentional green points are still positively significant. This result supports our hypothesis that higher green preference due to changes in gamification leads to higher

investments in green funds.

In terms of economic magnitude, column 3 of Panel A suggests that a one-standard-deviation increase in *GamifiedSI* contributes to an increase of 3.65 (0.11× 33.18) in *IntentGreenPoints*, representing an approximate 45.45% increase relative to the sample mean of *IntentGreenPoints* (8.03).[17] For the second-stage results in column 3 of Panel B, we find that for a one-standard-deviation increase in gamification-induced green preference, the proportion of green mutual fund holdings in the following month increases by 1.43%. Taken together, a one-standard-deviation increase in *GamifiedSI* would contribute to a 0.24% (1/21.80×0.11×33.18×1.43%) increase in the absolute value of *GreenHoldProp*.[18] This means that a user interacting with friends to exchange an additional 91.12 green points per day (or 2733.74 green points per month) would increase their green investment proportion by 5.19% relative to the sample mean of 4.62%.

The economic magnitude of our estimated effect is comparable to other drivers of green fund investment proportion. For example, people may invest more in green funds when the past returns from these funds are significantly higher compared to non-green funds in their portfolio. Hence, the difference in past returns between green and non-green funds (*GMinusN Return*) is a typical monetary determinant in green fund investment. A one-standard-deviation change in *GMinusN Return* corresponds to a 6.3% higher proportion of green investment. In comparison, the economic impact of green points, shown in Panel B of Table 2, is approximately one-fourth that of the *GMinusN Return*.

4.2 Causal Analysis

In this section, we establish causality between gamified social interactions and green investments using a difference-in-difference approach. We use the introduction

[17] Specifically, a one-standard-deviation increase in green points is equivalent to acquiring 33.18g of intentional green points per month. This is roughly equivalent to intentionally declining single-use cutlery when ordering takeout 2 additional times, bringing your own cups when ordering coffee one more time, or substituting fuel-powered cars with electric cars when taking a Taxi once more per month.

[18] Note that the standard deviation of *FittedIntentGreenPoints* is 21.80.

of an in-game item, "Energy Double Click Card," in August 2020, as a positive shock for gamified social interaction. This in-game item enables a user to rob double the usual amount of green points when robbing her friends' green points. But each card can only be used for a limited period of time. Due to its usage limitation, this in-game item disproportionately benefits users with less prior engagement in gamified interactions. Taking robbing as an example, socially inactive users can easily double the green points they rob with this card because they spend less time in the game and are not affected by the time limit. In contrast, socially active users who spend more time robbing are subject to this restriction, thereby only achieving a partial increase in gamified interactions. Therefore, this card offers greater marginal benefits for previously socially inactive users.

The introduction of the item creates an exogenous variation in gamified interactions as it directly affects these interactions but is unlikely to influence users' green investment decisions. The changes in interactions surrounding this item exhibit variation in the cross-section of users, thereby providing a quasi-natural experiment to examine changes in green fund holding proportions. Based on this, we argue that users with lower prior gamified social interactions are more influenced by this in-game item, leading to a larger increase in the proportion of green investments following the launch of this item. To this end, we estimate the following standard DID regression:

$$Y_{i,t} = \beta_1 + \beta_2 Post_t \times Treat_i + \gamma X_{i,t} + User\ FE + Time\ FE + \varepsilon_{i,t} \quad (4)$$

where $Treat_i$ is a dummy variable equal to one for users with cross-sectionally lower gamified social interactions before the in-game item launch, and zero otherwise. $Post_t$ is a dummy variable equal to one for the period after August 2020, and zero for August 2020 and earlier. The interaction term, $Post \times Treat$ is our focus, and the estimated treatment effect of the "Energy Double Click Card" on the dependent variables is measured by β_2. $Y_{i,t}$ is a series of dependent variables reflecting users' green fund holding proportion (*GreenHoldProp*), intensity of gamified interactions (*GamifiedSI/GreenPoints*), number of clicks in the app (*Engagement*), and green

preference (*IntentGreenPoints*).

In particular, our empirical design follows the spirit of the prior work using Decimalization in 2001 as a liquidity shock in the US stock markets (e.g., Fang, Tian, and Tice, 2014; Amihud and Levi, 2023) to construct our treatment and control groups. Specifically, we sort users based on their level of gamified interactions before the launch of the Energy Double Click Card, dividing them into three groups: 30%, 40%, and 30%. The lowest 30% are designated as the treatment group, while the highest 30% form the control group. To alleviate the systematic differences between the treatment and control groups, we then employ a one-to-one nearest neighbor propensity score matching algorithm, without replacement. We based on users' characteristics, including age (*Age*), gender (*Gender*), risk attitude (*RiskAttitude*), the total number of real trees planted (*AccumTrees*), the total number of ecologically damaged areas protected (*AccumAreas*), monthly return from green funds minus her monthly return from non-green funds (*GMinusN Return*), and total end-of-month holding values (*TotalHoldValues*).

Table 3 presents the DID results. Panel A reports the covariate balance results before DID tests. Using our propensity scores matching method, we match each socially inactive user with a socially active user in July 2020, one month before the introduction of the Energy Double Click Card. We require the absolute difference in the Euclidean distance of standardized covariates to be smaller than 0.3. This matching procedure yields 3,926 pairs of matched users. Columns 5 to 8 of Panel A show that the differences in user characteristics in our matched sample become statistically insignificant.

In Panel B, we test the change in a series of our concerned variables following the introduction of the "Energy Double Click Card." Column 1 shows after the launch of this in-game item, users who previously engaged less (treated group) in gamified social interactions now hold an 11.47% (in relative value, 0.53% in absolute value) higher proportion of green funds relative to those who were previously more socially active (control group). Columns 2 to 4 detail the impacts of this app policy shock on

other dependent variables. Column 2 confirms that the in-game item indeed increases the intensity of gamified social interactions among previously less socially active users. Column 3 presents that these users also tend to click more frequently to collect green points (*Engagement*) on the interface of Ant Forest after the item's launch, indicating increased screen time and more exposure to green educational content. Last, column 4 shows that users who are less socially active initially exhibit higher increases in green preference. Given the evidence above, we argue that the Energy Double Click Card first boosts user engagement and screen time by offering engaging gameplay. Then, this increased involvement in the green fintech app heightens green preference, ultimately leading to more investments in green mutual funds.

Next, to provide a more direct inference in the causality, we follow the two-stage least squares regression design outlined in Equations (2) and (3), utilizing this in-app gamification shock as an instrumental variable. In Panel C of Table 3, where we only show the second-stage results, the coefficient of fitted intentional green points (*FittedIntentGreenPoints*) is positively significant. This result indicates that after the Energy Double Click Card launch, users with previously lower levels of gamified social interactions experience higher increases in green preference and, consequently, invest more in green mutual funds.

We also provide evidence by plotting the difference-in-differences estimates surrounding the event with 95% confidence intervals in Figure A2. Visual inspection shows that the proportion of green investment increases significantly for socially inactive users relative to socially active users following the introduction of the in-game item. This finding further substantiates our hypothesis that users enhance their green investment via an enhanced green preference by gamified social interactions.

4.3 Why Gamification Enhance Users' Green Preferences?

Gamified social interactions in Ant Forest are primarily designed to boost user engagement, but how do they ultimately lead to a stronger green preference? This can be attributed to Ant Forest's origins as a green initiative aimed at promoting

environmental literacy. It educates users on sustainable behaviors and offers tangible opportunities to make a positive environmental impact. Previous studies suggest that environmental literacy, including knowledge of low-carbon activities and an understanding of climate change, can significantly influence users' green preferences and investment decisions (e.g., Anderson and Robinson, 2022). Building on this, we argue that: (i) gamified social interactions effectively enhance user engagement, and (ii) increased engagement through these interactions exposes users to more green educational content, thereby fostering higher green preferences.

First, we provide evidence in Table 4 showing that gamified social interactions are associated with increased user engagement on the app. Taking column 3 as an example, a one-standard-deviation increase in gamified social interactions corresponds to 822 additional clicks in the in-app activity of collecting green points, representing a 62.32% increase relative to the sample mean of collecting times (*Engagement*). Then, we assume more engagement in Ant Forest leads to more exposure to green education material. The Ant Forest interface is filled with content promoting environmental literacy. As shown in Figure 2, the app features posts and topics that educate users on wildlife protection, highlight the visible environmental benefits of adopting a low-carbon lifestyle, and provide guidelines for daily low-carbon activities. All these materials help to nurture users' green preferences. To this end, we document that gamified social interactions will boost user engagement and exposure to green educational content, which in turn enhances environmental literacy and fosters stronger green preferences.

4.4 Heterogenous Analysis

In this section, we explore heterogeneity based on several investors' characteristics that potentially relate to the propensity to invest in green funds, including gender, age, total fund holding values, and environmental conservation actions such as tree planting and area protection.

Table 5 presents the heterogenous analysis of our baseline regression. Panel A

shows that our results are stronger among males and young users, which is expected. First, the existing literature usually points out that females are more likely to engage in green investment (Bauer, Ruof, and Smeets, 2021). Hence, male users could benefit more from the induced green preference, leading to more green investment. Second, younger users are more inclined to bring their green preference into actual fund investments. This finding is consistent with the study by Giglio et al. (2023), which suggests that younger individuals tend to purchase green funds.

In Panel B, users are divided into paired groups based on whether they have redeemed fewer real trees or protected areas than the sample mean. The results show a stronger effect when users participate less in environmental conservation actions such as planting real trees or protecting eco-damaged areas. This finding suggests that investors who are less involved in Ant Forest initiatives are nudged more in bringing their enhanced green preference into green investments.

Table 6 reports the additional analyses that help explain our heterogeneous results. Panel A of Table 6 demonstrates that the positive relationship between green preference and green investment follows a concave pattern. That means such a relationship is stronger for users with very low or high levels of environmental consciousness. Then, in Panel B, we show that males and young, users who redeem fewer trees, and users who redeem fewer square meters of conservation areas tend to exhibit lower levels of green preference. Combining the concave pattern with the lower green preference observed, the results in Tables 5 and 6 indicate that those with lower green preference and preference are influenced more by the gamified social interactions in their green investments.

4.5 Robustness Checks

In this final section, we assess the robustness of our inferences by considering alternative channels related to the decisions to increase the holding proportion of green mutual funds and testing alternative measures for some key variables.

4.5.1 Simple gamification effect

Since Ant Forest incorporates many game-like elements, one concern is that users' green investment decisions may not only be driven by the part of gamification that involves interacting with friends, but rather by other parts. In Chapkovski, Khapko, and Zoican's (2024) study, gamified features such as vibrant color, celebratory animations, and badges could affect users' economic behavior. In the context of Ant Forest, users may simply enjoy the satisfaction of tapping green bubbles (top-left panel in Figure 1) and collecting green points, without paying much attention to social interactions with friends. We define the channel through which collecting green points leads to changes in green investments as the "simple gamification effect". In this regard, we control for collected green points (*CollectPoints*) in our baseline regression. In Panel A of Table 7, the results still hold in column 1. The coefficient of *CollectPoints* is negative, which suggests that simple gamification negatively affects green investments, while only gamified social interactions have a positive impact.

4.5.2 Positive feedback effect

Another concern is that users may develop green preferences due to the positive feedback from earning green points to planting trees, rather than being motivated by gamified social interactions. Planting real trees or protecting wildlife in conservation lands can provide users with a sense of accomplishment in environmental conservation practice, potentially fostering a propensity for green behavior and nurturing green preferences, which may, in turn, lead to increased green investments. We refer to the above channel as a "positive feedback effect". In Column 2 of Panel A in Table 7, we control for accumulated trees planted (*AccumTrees*) and accumulated areas protected (*AccumAreas*) to conduct a horse race regression. The results remain robust. The negative coefficients of *AccumTrees* and *AccumAreas* reveal that green preference driven by positive feedback does not lead to increased green investments.

4.5.3 Alternative measures of green preference

In our baseline model, we measure users' revealed green preference solely through their daily proactive low-carbon behaviors, proxied by "intentional green points."

However, other environmental conservation actions by users may also matter. In the Ant Forest app, users can consume green points by planting a real tree or protecting one square meter of areas in ecologically damaged regions, all done under the user's name. Since planting trees and protecting eco-damaged areas are plausibly direct manifestations of a user's green preference, we now consider using both the acquired and consumed green points as the users' revealed green preference.

To quantify the consumed green points, we provide back-of-the-envelope calculations. Each month, we multiply the number of trees planted (*Trees*) by the average green points required to redeem a real tree (89,728 grams) to calculate the consumed green points through planting trees. Similarly, we calculate the green points used for protecting eco-damaged areas by multiplying the number of square meters protected (*Areas*) by the average green points required per square meter (2,111 grams). We then define "aggregate green points" (*AggGreenPoints*) as an alternative measure of green preference, calculated as the sum of acquired intentional green points (*IntentGreenPoints*) and consumed green points. As shown in Panel B of Table 7, the main results still hold when using *AggGreenPoints* as our alternative measure.

4.5.4 Alternative measures of green investment decisions

We only focus on the percentage of green fund holdings as our dependent variable in the baseline model. However, the absolute value of green fund holdings also serves as a good proxy for users' green investments. In Panel C of Table 7, we utilize z-score standardized green fund holding values to measure users' green investments. The z-score standardized non-green fund holding values are also included for comparison. Our results reveal that gamified social interactions in our green fintech app only positively influence users' green fund holding values but have no impact on non-green fund holdings. This result suggests that gamified interactions enhance investments in environmentally friendly funds without changing traditional investment patterns.

4.5.5 Alternative identification of "green funds" via Wind Sustainable Fund list

In the baseline model, we employ text analysis of fund names to identify "green

funds" that capture Alipay users' recognition of environmentally friendly funds. However, there could be alternative ways for a retail investor to identify whether a fund aligns with environmentally friendly codes and standards. One approach is to search in the Wind Sustainable Fund list. Hence, to ensure the robustness of our analysis, we employ various alternative methods of identifying "green funds" and report the results in Panel D of Table 7.

Columns 1 to 3 show our main regression results using alternative dependent variables: the ratio of holding values for the entire Wind Sustainable Fund list, funds with names containing E words in the list, and funds with names containing ESG words in the list, respectively. All results remain robust, as the coefficients of *FittedIntentGreenPoints* are still positively significant. It is noteworthy that despite the relatively smaller number of "E Funds" and "ESG funds" compared to "Sustainable Funds," the coefficients for "E Funds" and "ESG funds" are larger. This result suggests that funds with E words or ESG words in their names draw more users' attention when they seek to invest in green funds.

5. Conclusions

This paper explores how users' gamified social interactions affect their green investments. We provide a novel mechanism in which gamified social interactions plausibly induce individuals' green preference, which subsequently enhances their green mutual fund positions. Males, younger individuals, and those less involved in reforestation and land conservation actions lead to stronger results. Overall, our paper provides the first empirical evidence based on observational data from a Chinese fintech super-app that gamified social interactions can serve as a new non-monetary motivation for green investments. Our results also suggest that a well-designed social gamification mechanism in a larger fintech platform can effectively nudge users to go green.

Our findings have important policy implications for understanding the motivations behind retail investors' green investment decisions, for large financial technology platforms aiming to deliver targeted investment information to cater to

environmentally conscious investors, and for policymakers seeking to leverage the growing demand for sustainable investments to achieve societal goals related to carbon neutrality. Our findings propose a promising avenue for future research that explores the impact of green nudges via social gamification within large fintech apps on users' economic decision-making, extending beyond sustainable investment choices.

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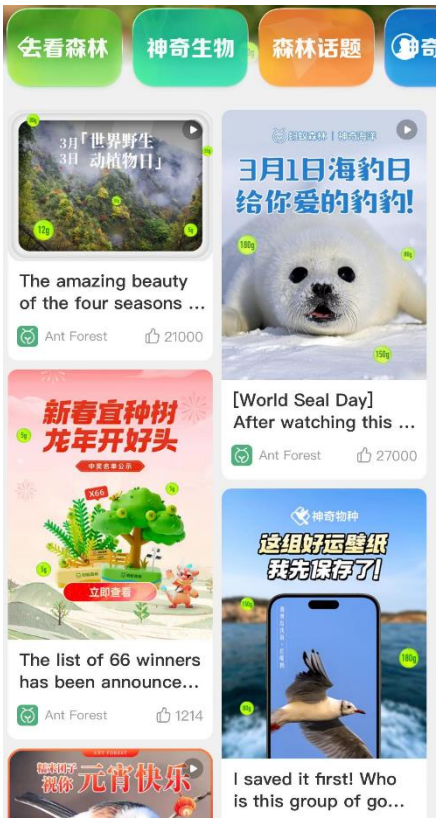
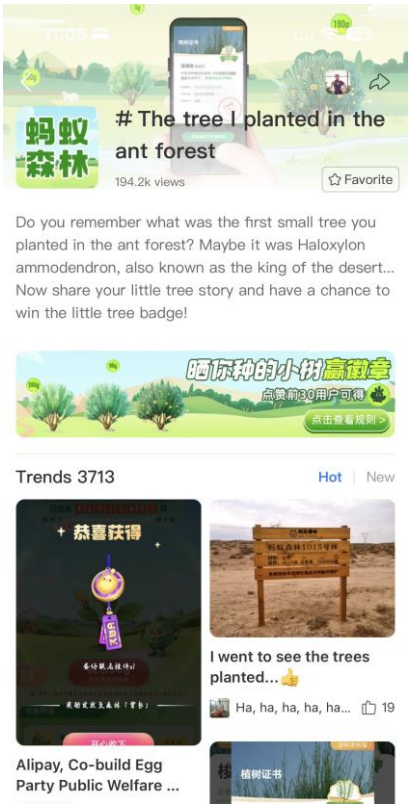
Figure 1: Two Key Features of Ant Forest: Real Environmental Conservation and Gamified Social Interactions

The figure demonstrates detailed screenshots of how Ant Forest promotes low-carbon lifestyles through real environmental conservation and gamified social interaction. A user can collect green points after participating in low-carbon activities. Once the points reach a certain level, the user can redeem a real tree by consuming her points balance. Additionally, users can visit their friends' Ant Forest homepage and rob their uncollected green points. The bottom-left part of the figure summarizes the whole process by pointing out two key features of the Ant Forest: planting real trees and gamified interactions between friends (robbing green points).

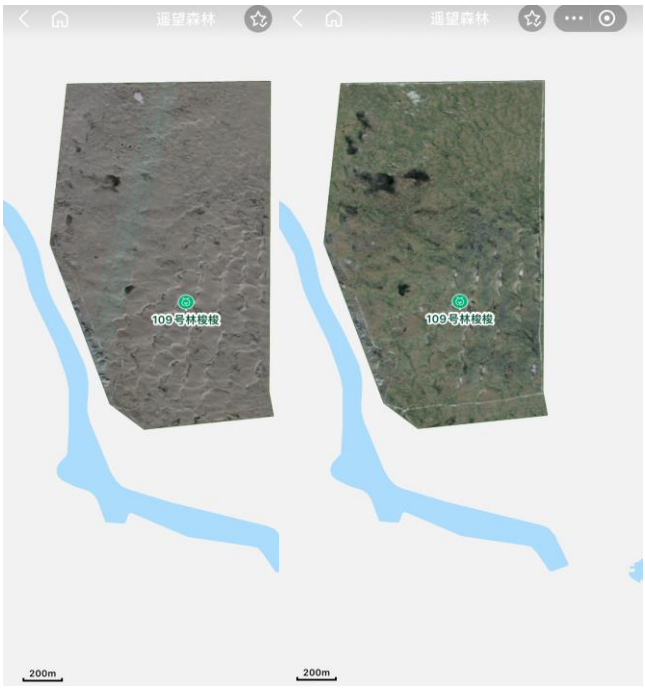
Figure 2: App Interfaces for User Exposure to Environmental Education Content

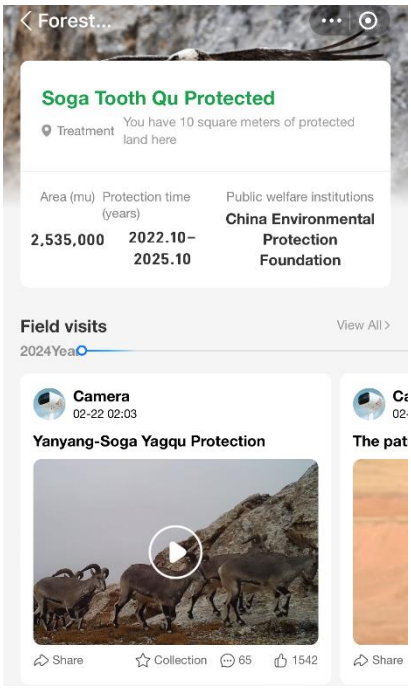
Panel A. Educational Posts and Topics on Environment and Wildlife Protection



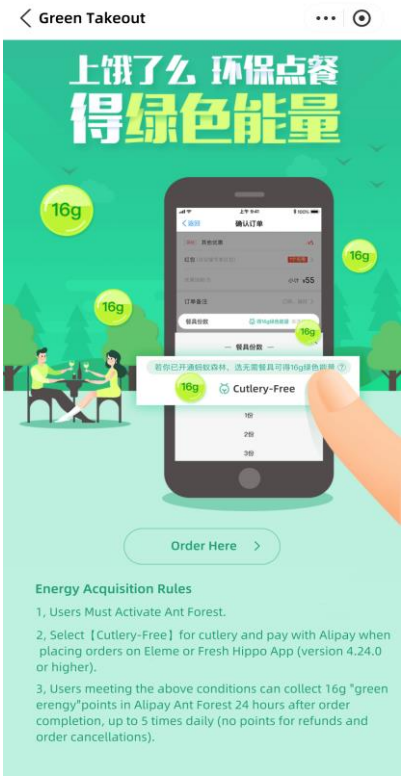


Panel B. Learning About Visible Environmental Contributions Through Satellite Images of Forests and Wildlife Activity Videos of Conservation Lands



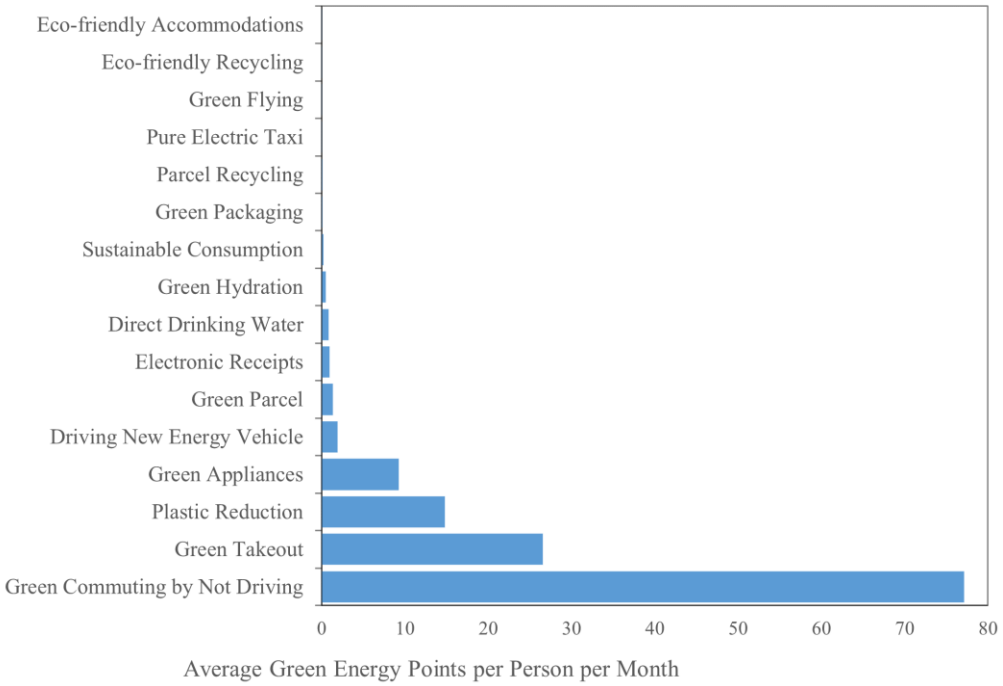


Panel C. Recognizing Daily Low-Carbon Activities and Learning How to Participate



The figure illustrates several App interfaces that expose users to environmental education content. Panel A features posts and topics that educate users on protecting the environment and wildlife and encourage them to redeem a real tree. Panel B shows the visible environmental benefits contributed by users through their participation in the Ant Forest. A user can view either all the forests established by the Ant Forest or one specific forest where she has redeemed a tree. The same applies to protected areas. For real trees, the left image displays a before-and-after satellite comparison, depicting a notable increase in greenery following the afforestation efforts in a designated desert area. As an example, we reference the 109th Haloxylon Forest, established in 2018, which comprises 340,000 Haloxylon trees. For protected areas, a user can click on the video in the right image to view wildlife activities captured by camera-enabled sensors. Panel C displays guidelines for daily low-carbon activities, with the left image displaying a selection from the low-carbon activity list. By clicking on an activity, users will learn how to engage in this activity and earn green points, as illustrated in the right image using "Green Takeout" as an example.

Figure 3: Green Points Distribution Across 16 Intentional Low-Carbon Activity Categories



This figure shows the distribution of green points across 16 manually selected intentional low-carbon activity categories. It displays the average monthly green points per person for these categories, including New energy vehicles, Green commuting by not driving, Green Takeout, Environmental Recycling, Green Appliances, Green Parcel, Electronic Receipts, Direct Drinking Water, Bring-your-own Cups, Sustainable Consumption, Green Packaging, Parcel Recycling, Pure Electric Taxi, Green Flying, Eco-friendly Recycling, and Eco-friendly Accommodations. Detailed descriptions are in the Appendix Table A1.

Table 1: Descriptive Statistics

	N	Mean	SD	Min	10th	25th	50th	75th	90th	Max
Panel A. App Users' Activities in Ant Forest										
GreenPoints	2,952,113	2,578.57	1,948.96	8	367	1,100	2,239	3,613	5232	9,990
IntentGreenPoints	2,952,113	8.03	33.18	0	0	0	0	0	16	320
RobSI	2,952,113	1,153.81	2,658.57	0	0	0	4	922	3773	18,335
RobbedSI	2,952,113	801.87	668.92	0	53	261	670	1,180	1725	3,233
GamifiedSI	2,952,113	1,955.69	2,733.74	0	94	449	1105	2,203	4667	21,568
Trees	2,952,113	0.06	0.23	0	0	0	0	0	0	1
AccumTrees	2,952,113	2.64	3.40	0	0	0	1	4	7	19
Areas	2,952,113	0.16	0.55	0	0	0	0	0	1	4
AccumAreas	2,952,113	3.50	5.83	0	0	0	1	4	10	38
Panel B. App Users' Fund-Portfolio Information										
Age	2,952,113	30.61	7.68	17	22	25	29	34	41	63
Gender	2,952,113	0.49	0.50	0	0	0	0	1	1	1
TotalHoldValues	2,952,113	30,554.56	72,155.31	0.00	80.68	844.23	5,983.45	25,792.14	77,601.62	616,454.90
GreenHoldValues	2,952,113	1,304.29	5,310.42	0.00	0.00	0.00	0.00	0.00	2,301.80	47,469.98
nonGreenHoldValues	2,952,113	29,250.27	70,052.59	0.00	59.40	747.22	5,542.89	24,237.53	73,844.07	568,984.90
GMinusN Return (%)	2,952,113	–0.10	0.06	–16.40	–7.12	–3.40	–0.25	3.04	7.28	19.15
GreenReturn (%)	2,952,113	0.23	0.04	–12.88	–0.98	0.00	0.00	0.00	2.53	19.46
nonGreenReturn (%)	2,952,113	0.34	0.05	–15.59	–6.48	–2.65	0.29	3.24	6.97	16.32
GreenHoldProp (%)	2,952,113	4.62	0.14	0.00	0.00	0.00	0.00	0.00	20.64	100.00

Panel C. Correlation Matrix

Variables	*(1)*	*(2)*	*(3)*	*(4)*	*(5)*	*(6)*	*(7)*	*(8)*	*(9)*	*(10)*
(1) GreenHoldProp	1.00	–0.02	0.00	–0.02	–0.01	–0.01	0.08	0.00	0.01	0.03
(2) GreenPoints	–0.02	1.00	0.16	0.52	0.38	0.60	–0.01	0.03	0.40	0.24
(3) IntentGreenPoints	0.00	0.16	1.00	0.14	0.14	0.01	0.02	0.05	0.15	0.15
(4) RobSI	–0.02	0.52	0.14	1.00	–0.01	0.97	–0.01	–0.01	0.57	0.36
(5) RobbedSI	–0.01	0.38	0.14	–0.01	1.00	0.23	–0.01	–0.00	0.08	–0.01
(6) GamifiedSI	–0.01	0.60	0.01	0.97	0.23	1.00	–0.01	–0.01	0.57	0.34
(7) GMinusN Return	0.08	–0.01	0.02	–0.01	–0.01	–0.01	1.00	0.03	0.03	0.06
(8) TotalHoldValues	0.00	0.03	0.05	–0.01	–0.01	–0.00	0.03	1.00	0.02	0.03

(9) AccumTrees	0.01	0.40	0.15	0.57	0.08	0.08	0.03	0.02	1.00	0.61
(10) AccumAreas	0.03	0.24	0.15	0.36	–0.01	–0.01	0.06	0.03	0.61	1.00

This table shows the descriptive statistics. Panel A is the summary of statistics for App users' activities in Ant Forest. Panel B is the summary statistics for investment information of the same App users. Panel C is the Pearson correlation matrix for core variables in our sample. All variables are winsorized in 0.5%. The variable definitions can be found in the Appendix Table A2.

Table 2: Two-stage Least Squares Regression

Panel A. First Stage: Gamified Social Interactions and Green Preference

Dependent variable = IntenGreenPoints	(1)	(2)	(3)
RobSI	0.1039***		
	(0.0016)		
RobbedSI		0.0261***	
		(0.0008)	
GamifiedSI			0.1100***
			(0.0016)
GMinusN Return	–0.0012	0.0013	–0.0013
	(0.0091)	(0.0091)	(0.0091)
TotalHoldValues	0.0013	0.0015	0.0007
	(0.0011)	(0.0011)	(0.0011)
const	0.0005	0.0006	0.0005
	(0.0005)	(0.0005)	(0.0005)
Year-Month FE	Y	Y	Y
User FE	Y	Y	Y
Obs.	2,895,184	2,895,184	2,895,184
R-squared	0.3537	0.3512	0.3541

Panel B. Second Stage: Fitted Green Preference and Green Investment Proportion

Dependent variable = GreenHoldProp$_{t+1}$	(1)	(2)	(3)
FittedIntentGreenPoints (with RobSI)	0.0127***		
	(0.0011)		
FittedIntentGreenPoints (with RobbedSI)		0.0299***	
		(0.0037)	
FittedIntentGreenPoints (with GamifiedSI)			0.0143***
			(0.0011)
GMinusN Return	0.0630***	0.0629***	0.0630***
	(0.0017)	(0.0017)	(0.0017)
TotalHoldValues	–0.0012***	–0.0012***	–0.0012***
	(0.0001)	(0.0001)	(0.0001)
const	0.0472***	0.0472***	0.0472***
	(0.0001)	(0.0001)	(0.0001)
Year-Month FE	Y	Y	Y
User FE	Y	Y	Y
Obs.	2,808,494	2,808,494	2,808,494
R-squared	0.4763	0.4762	0.4763

This table presents our main results of the two-stage least squares (2SLS) regression. In Panel A, we regress intentional "green points" on gamified social interactions using Eq. (2). The independent variable is measured through three methods: green points gained by robbing friends (*RobSI*), green points robbed by friends (*RobbedSI*), and the total sum of both (*GamifiedSI*). The dependent variable is each individual's monthly intentional green points (*IntentGreenPoints*). In Panel B, we present results from regressing green investment proportion on fitted intentional green points using Eq. (3). The independent variable is intentional green points fitted by *RobSI*, *RobbedSI*, and *GamifiedSI* in the first stage. The dependent variable is the proportion of fund investment allocated to "green funds" (funds with environmental-related words in their names) at the end of next month (*GreenHoldProp*$_{t+1}$). We control total funds' holding value (*TotalHoldValues*) and the difference between the past returns of green funds and non-green funds (*GMinusN return*), user fixed effects, and year-month fixed effects. Standard errors are clustered at the user and year-month level, with corresponding *standard deviations* in parentheses. Levels of significance are presented as follows: *p<0.1; **p<0.05; ***p<0.01.

Table 3: Difference-in-Differences Analysis Using the Launch of "Energy Double Click Card"

Panel A. Covariate Balance for Difference-in-Differences Tests

	Unmatched Users				Matched Users			
	July 2020				*July 2020*			
User number=	18,389	18,611			3,304	3,304		
	Treat	*Control*	*Diff*	*t-stat*	*Treat*	*Control*	*Diff*	*t-stat*
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Age	31.0929	29.7458	1.3471***	16.3717	27.2715	27.3148	–0.0433	–0.3170
Gender	0.4605	0.5453	–0.0848***	–16.3759	0.5357	0.5357	0.0000	0.0000
RiskAttitude	2.6415	2.8379	–0.1964***	–18.6292	2.7518	2.7518	0.0000	0.0000
AccumTrees	0.5701	4.7491	–4.179***	–148.7821	1.1607	1.2225	–0.0618	–1.8914
AccumAreas	0.7496	3.4825	–2.7329***	–104.2598	0.9936	0.9936	0.0000	0.0000
GMinusN Return	–0.0576	–0.0581	0.0005	0.4898	–0.0562	–0.0563	0.0001	0.0505
TotalHoldValues	0.0398	–0.0171	0.0569***	5.2945	–0.2547	–0.2442	–0.0105	–1.5448

Panel B. Difference-in-Differences Tests

Dependent variable =	*GreenHoldProp*	*GamifiedSI/ GreenPoints*	*Engagement*	*IntentGreenPoints*
	(1)	(2)	(3)	(4)
Post Treat*	0.0053***	0.3694***	11.3929***	0.0267***
	(0.0009)	(0.0388)	(0.2192)	(0.0071)
GMinusN Return	0.1018***	0.0922	-1.1284	–0.0413
	(0.0064)	(0.1756)	(0.9118)	(0.0302)
TotalHoldValues	0.0005	0.0332***	1.2813***	–0.0155***
	(0.0005)	(0.0134)	(0.1339)	(0.0048)
const	0.0396***	0.7083***	28.3078***	–0.1333***
	(0.0004)	(0.0115)	(0.0869)	(0.0028)
Year-Month FE	Y	Y	Y	Y
User FE	Y	Y	Y	Y
Obs.	231,795	231,795	231,795	231,795
R-squared	0.3987	0.3313	0.5995	0.3007

Panel C. Using the Launch of the "Energy Double Click Card" as an Instrumental Variable

Dependent variable =	$GreenHoldProp_{t+1}$
	(1)
FittedIntentGreenPoints (with Post Treat)*	0.1331***
	(0.0230)
GMinusN Return	0.0657***
	(0.0062)
TotalHoldValues	0.0008
	(0.0006)
const	0.0556***
	(0.0020)
Year-Month FE	Y
User FE	Y
Obs.	277,046
R-squared	0.4200

This table presents a series of difference-in-differences analyses of gamified social interactions on several dependent variables surrounding the launch of an in-game item "Energy Double Click Card" in August 2020. *Treat* is a dummy variable equal to one if an individual's gamified social interactions are below the sample average cross-sectionally, and zero otherwise. *Post* is a dummy variable equal to one for the period after August 2020, and zero for August 2020 and earlier. *Post* Treat* is the interaction between these two variables. Panel A reports average user characteristics for the treatment and control groups in 2020-07 (one month before the introduction of the Energy Double Click Card). Columns 1 to 4 show statistics for the unmatched sample, while Columns 5 to 8 show statistics for the propensity score matched sample. Columns 3 and 7 present group mean differences, and Columns 4 and 8 present the corresponding t-statistics. In Panel B, *Prop_e* represents the proportion of fund investment values allocated to "green funds". *GamifSI/ GreenPoints* denotes green points through gamified exchange divided by all green points through low-carbon activities. *Engagement* denotes the number of times users click on the Ant Forest interface to collect green points. *IntentGreenPoints* refers to green points acquired by intentional low-carbon activities. Panel C provides the second-stage results of the two-stage least square regression. The variable *FittedIntenGreenPoints* is calculated by regressing *IntenGreenPoints* on *Post* Treat* in Column 4 of Panel B. The control variables are the same in Table 2 and we control for user fixed effects and year-month fixed effects. Standard errors are clustered at the user and year-month level, with corresponding *standard deviations* in parentheses. Levels of significance are presented as follows: *p<0.1; **p<0.05; ***p<0.01.

Table 4. Evidence on Exposure to Green Education

Dependent variable= Engagement	(1)	(2)	(3)
RobSI	734.9989***		
	(1.8504)		
RobbedSI		307.0777**	
		(1.1121)	
GamifiedSI			822.4736***
			(1.8163)
Controls	Y	Y	Y
Year-Month FE	Y	Y	Y
User FE	Y	Y	Y
Obs.	2,895,184	2,895,184	2,895,184
R-squared	0.7408	0.7089	0.7532

This table provides indirect evidence on whether gamified social interactions can enhance users' exposure to green education material. *Engagement* represents the number of clicks on the Ant Forest interface to collect green points. *RobSI*, *RobbedSI*, and *GamifiedSI* are our three proxies of gamified social interactions. Standard errors are clustered at the user and year-month level, with corresponding *standard deviations* in parentheses. Levels of significance are presented as follows: *p<0.1; **p<0.05; ***p<0.01.

Table 5. Heterogeneous Analysis

Panel A. Grouped by Demographics

Dependent variable= GreenHoldProp$_{t+1}$	(1)	(2)
FittedIntentGreenPoints (with GamifiedSI)	0.0110***	0.0131***
	(0.0016)	(0.0011)
FittedIntentGreenPoints (with GamifiedSI) × Male	0.0055**	
	(0.0021)	
FittedIntentGreenPoints (with GamifiedSI) × Young		0.0051***
		(0.0024)
Controls	Y	Y
Year-Month FE	Y	Y
User FE	Y	Y
Obs.	2,808,494	2,808,494
R-squared	0.4763	0.4763

Panel B. Grouped by Tree-planting and Area-protecting

Dependent variable= GreenHoldProp$_{t+1}$	(1)	(2)
FittedIntentGreenPoints (with GamifiedSI)	0.0103***	0.0119***
	(0.0011)	(0.0011)
FittedIntentGreenPoints (with GamifiedSI) × UnderAvgTrees	0.0384***	
	(0.0038)	
FittedIntentGreenPoints (with GamifiedSI) × UnderAvgAreas		0.0233***
		(0.0040)
Controls	Y	Y
Year-Month FE	Y	Y
User FE	Y	Y
Obs.	2,808,494	2,808,494
R-squared	0.4763	0.4763

This table presents a series of heterogeneous analyses. We only present the second stage of our two-stage regression. *FittedIntentGreenPoints* is the fitted value of "intentional green points" by *GamifiedSI*. Panel A displays the heterogeneous response of green fund holding proportion by demographics. *Male* equals one for males, and zero otherwise. *Young* equals one for individuals aged below the sample average, and zero otherwise. Panel B further shows heterogeneous responses to tree-planting and area-protecting. *UnderAvgTrees* equals one if an individual's number of real trees redeemed is under the sample average, and zero otherwise. *UnderAvgAreas* equals one if an individual's number of areas protected is under the sample average, and zero otherwise. Standard errors are clustered at the user and year-month level, with corresponding *standard deviations* in parentheses. Levels of significance are presented as follows: *p<0.1; **p<0.05; ***p<0.01.

Table 6. Additional Analysis for Explaining Heterogenous Results

Panel A. Concave Relationship between Fitted Green Preference and Green Investment

Dependent variable = GreenHoldProp$_{t+1}$	(1)
FittedIntentGreenPoints (with GamifiedSI)	0.0149***
	(0.0011)
FittedIntentGreenPoints (with GamifiedSI) ^2	–0.0016***
	(0.0005)
Controls	Y
Year-Month FE	Y
User FE	Y
Obs.	2,808,494
R-squared	0.4763

Panel B. Determinants of Green Preference

Dependent variable = FittedIntentGreenPoints (with GamifiedSI)					
	(1)	(2)	(3)	(4)	(5)
Male	–0.0610***				–0.0585***
	(0.0007)				(0.0007)
Young		–0.0613***			–0.0673***
		(0.0007)			(0.0007)
UnderAvgTrees			–0.1279***		–0.0765***
			(0.0007)		(0.0007)
UnderAvgAreas				–0.1445***	–0.1111***
				(0.0007)	(0.0007)
const	0.0313***	0.0307***	0.0628***	0.0719***	0.1565***
	(0.0005)	(0.0006)	(0.0006)	(0.0006)	(0.0010)
Year-Month FE	Y	Y	Y	Y	Y
City FE	Y	Y	Y	Y	Y
Obs.	2,952,113	2,952,113	2,952,113	2,952,113	2,952,113
R-squared	0.0459	0.0459	0.0544	0.0574	0.0658

This table provides explanations for the heterogeneous results in Table 4. In Panel A, we add a squared term, *FittedIntentGreenPoints (with GamifiedSI) ^2* on the second stage baseline regression to capture the concave relationship. In Panel B, we regress "fitted intentional green points" on all grouping variables separately in columns 1-4 and jointly in column 5. Standard errors are clustered at the user and year-month level, with corresponding *standard deviations* in parentheses. Levels of significance are presented as follows: *p<0.1; **p<0.05; ***p<0.01.

Table 7. Robustness Checks

Panel A. Horse Racing Tests for Alternative Channels

Dependent variable=GreenHoldProp$_{t+1}$	(1)	(2)	(3)
FittedIntentGreenPoints (with GamifiedSI)	0.0526***	0.0170***	0.0841***
	(0.0060)	(0.0012)	(0.0088)
CollectPoints	–0.0087***		–0.0140***
	(0.0011)		(0.0016)
AccumTrees		–0.0011***	–0.0034***
		(0.0001)	(0.0003)
AccumAreas		–0.0003***	–0.0007***
		(0.0000)	(0.0001)
Controls	Y	Y	Y
Year-Month FE	Y	Y	Y
User FE	Y	Y	Y
Obs.	2,808,494	2,808,494	2,808,494
R-squared	0.4763	0.4763	0.4763

Panel B. Alternative Measures of Green Preference

	Fitted with RobSI		*Fitted with RobbedSI*		*Fitted with GamifiedSI*	
Dependent variable =	*AggGreen Points*	*GreenHold Prop$_{t+1}$*	*AggGreen Points*	*GreenHold Prop$_{t+1}$*	*AggGreen Points*	*GreenHold Prop$_{t+1}$*
	(1)	(2)	(3)	(4)	(5)	(6)
RobSI	0.2594***					
	(0.0020)					
RobbedSI			0.0186***			
			(0.0009)			
GamifiedSI					0.2551***	
					(0.0019)	
FittedAggGreen Points		0.0050***		0.0416***		0.0061***
		(0.0005)		(0.0051)		(0.0005)
Controls	Y	Y	Y	Y	Y	Y
Year-Month FE	Y	Y	Y	Y	Y	Y
User FE	Y	Y	Y	Y	Y	Y
Obs.	2,865,423	2,808,494	2,865,423	2,808,494	2,865,423	2,808,494
R-squared	0.0939	0.4763	0.0769	0.4762	0.0937	0.4763

Panel C. Alternative Measures of Green Investment Decisions

Dependent variable =	*GreenHoldValues*			*nonGreenHoldValues*		
	(1)	(2)	(3)	(4)	(5)	(6)
FittedIntentGreenPoints (with RobSI)	0.0581***			0.0037		
	(0.0091)			(0.0031)		
FittedIntentGreenPoints (with RobbedSI)		0.2722***			0.0003	
		(0.0259)			(0.0101)	
FittedIntentGreenPoints (with GamifiedSI)			0.0763***			0.0036
			(0.0084)			(0.0029)
Controls	Y	Y	Y	Y	Y	Y
Year-Month FE	Y	Y	Y	Y	Y	Y
User FE	Y	Y	Y	Y	Y	Y
Obs.	2,808,494	2,808,494	2,808,494	2,808,494	2,808,494	2,808,494
R-squared	0.4813	0.4814	0.4814	0.9264	0.9264	0.9264

Panel D. Alternative Identification of "Green Funds" Using the Wind Sustainable Fund List

Dependent variable=	*SustainHoldProp$_{t+1}$*	*EHoldProp$_{t+1}$*	*ESGHoldProp$_{t+1}$*
	(1)	(2)	(3)
FittedIntentGreenPoints (with GamifiedSI)	0.0110***	0.0143***	0.0122***
	(0.0014)	(0.0011)	(0.0011)
Controls	Y	Y	Y
Year-Month FE	Y	Y	Y
User FE	Y	Y	Y
Obs.	2,808,494	2,808,494	2,808,494
R-squared	0.4842	0.4760	0.4776

This table presents a series of robustness checks for our main results. Panel A shows horse racing tests for alternative channels. To examine the simple gamification effect, Column 1 includes collected green points (*CollectPoints*) as an additional control. To examine the positive feedback effect, Column 2 includes the accumulated number of real trees planted (*AccumTrees*) and the accumulated number of areas protected (*AccumAreas*). Column 3 examines both effects simultaneously by including all these variables as controls. Panel B shows an alternative measure of green preference based on the sum of acquired intentional green points and consumed green points, denoted as *AggGreenPoints*. Panel C demonstrates the regression of z-score standardized holding values for green funds (*GreenHoldValues*) and non-green funds (*nonGreenHoldValues*) in the next month on fitted intentional green points (*FittedIntentGreenPoints*), with only the second-stage regression results being presented. Panel D presents several alternative measures of green holding proportions, based on different identifications of "green funds." The dependent variables from Columns 1 to 3 are the proportion of fund investment allocated to sustainable funds (*SustainHoldProp*), E funds (*EHoldProp*), and ESG funds (*ESGHoldProp*) at the end of the following month. Standard errors are clustered at the user and year-month level, with corresponding *standard deviations* in parentheses. Levels of significance are presented as follows: *p<0.1; **p<0.05; ***p<0.01.

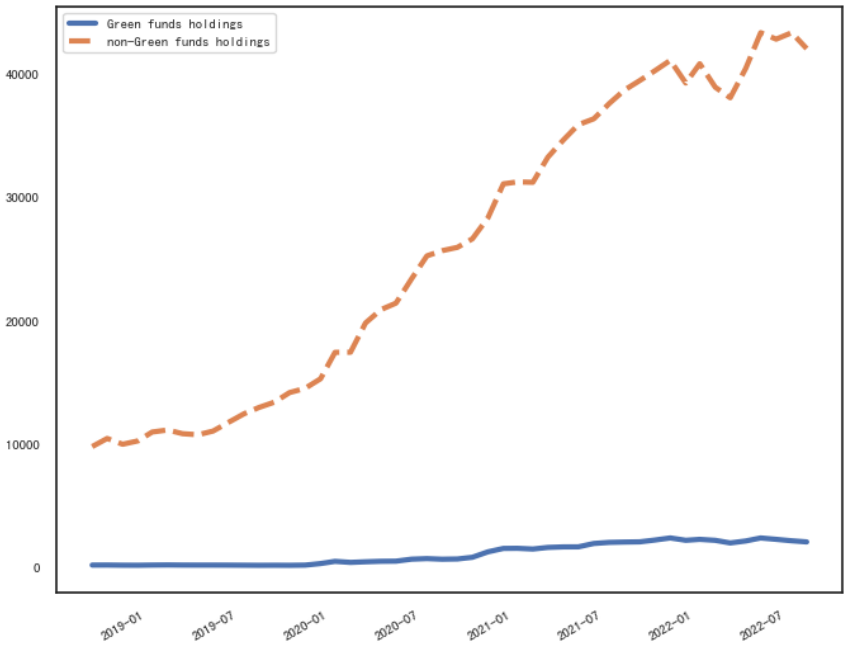
Appendix:

"Do Gamified Social Interactions on a Green Fintech App Nudge Users' Green Investments ?"

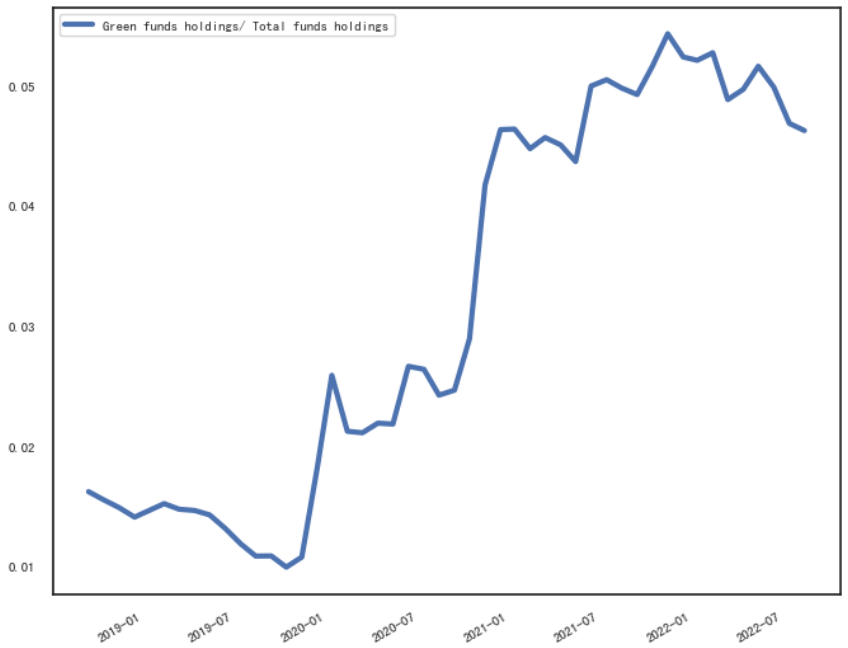
The purpose of this supplementary appendix is to provide necessary illustrations and additional tests for our findings. These illustrations and tests are labeled with the extension "A" for "Appendix" (e.g., Table A1), while the tables reported in the main text are labeled with the original table name.

Figure A1: Time-Series Trends of Average Fund Holding Values and Green Fund Holding Proportions

Panel A. Comparative Time-Series Trends: Average Holding Values of Green vs. Non-Green Fund

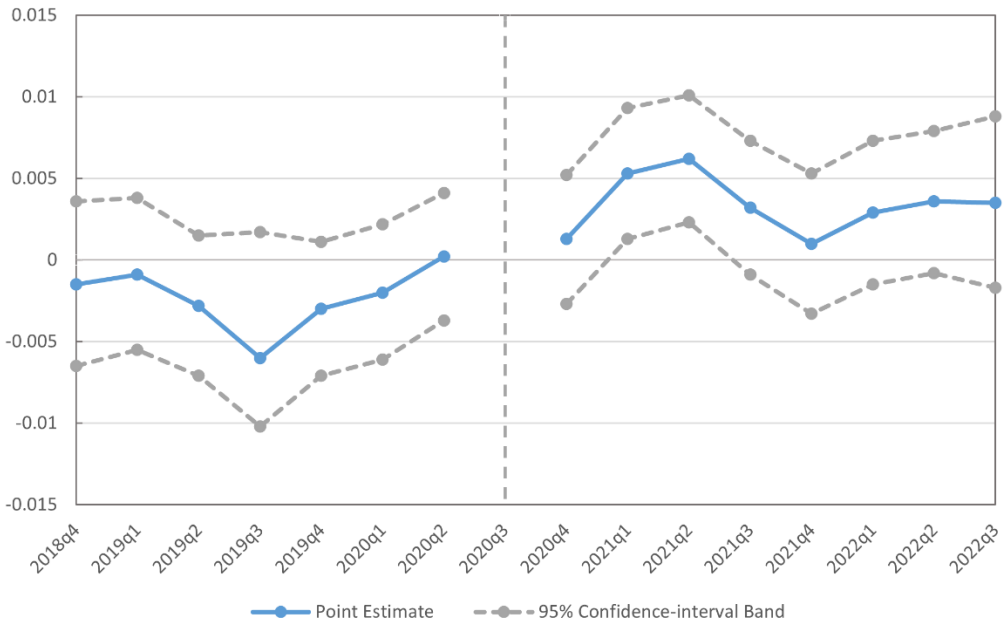


Panel B. Time-Series Trends: Proportion of Green to Total Fund Holding Values at the Market Level



This figure shows the time-series trends of "***Average Holding Values of Green vs. Non-Green Fund***" and "***Proportion of Green to Total Fund Holding Values at the Market Level***". In Panel A, we present cross-sectional average holding values for green and non-green funds, illustrated with time-series curves. In Panel B, we analyze a representative investor at the market level in our sample. We calculate the green fund holding values divided by the total fund holding values for this investor and display the time-series trends.

Figure A2: Graphical Illustrations of Difference-in-differences Estimates



This figure plots the evolution of green fund-holding proportions between socially inactive users and socially active users around the introduction of the Energy Double Click Card in 2020q3 (August 2020). We estimate the following equation: $Y_{i,t} = \beta_1 + \sum_{2018q4}^{2022q3} \beta_m Treat_i \times Dummy_m + \gamma X_{i,t} + User\ FE + Time\ FE + \varepsilon_{i,t}$. $Dummy_m$ is an event dummy variable equals to one in quarter m and zero otherwise. $Treat_i$ is a dummy variable equal to one for socially inactive users and zero otherwise. We define socially inactive (active) users as those whose level of gamified social interactions is in the bottom (top) tercile in July 2020. The event quarter, 2020q3, is excluded from the analysis. Standard errors are clustered at the user and year-month levels. We plot the difference-in-differences estimates, i.e., those estimates for interacted terms between the socially inactive users and event dummies, along with their 95% confidence intervals (dotted line) in the figure.

Table A1: List of 48 Certified Low-Carbon Activities

General category	Low-Carbon Activities	Acquisition Rules	Reducing carbon emissions by
Green Travel	Walking	0.0164g*steps (rounded up to the nearest integer), maximum 18,000 steps per day, yielding up to 296g	substituting other city transportation
	Bus	80g per trip	substituting other city transportation
	Subway	52g per trip	substituting other city transportation
	Bike-sharing	1.8g per minute	substituting other city transportation
	Public Charging Station	32g per kWh	substituting private charging stations
	Driving New Energy Vehicles	33g per kilometer	reducing fossil fuel consumption
	Pure Electric Taxi	164g per trip	substituting fuel-powered cars when taking a Taxi
	Electronic Boarding Pass	5g per use	reducing paper waste of the paper Boarding Pass
	Green Flying	211g per trip	avoiding food production and waste by choosing to not receive in-flight meals.
Reduce Travel	Online Utility Bill Payments	262g/transaction	reducing a round trip to the payment center
	Online Ticketing	136g/transaction for train tickets, 180g/transaction for motive tickets	reducing a round trip to the ticketing office
	Online Government Services	15g/transaction for social security, housing fund, and traffic management services	reducing a round trip to government offices
	Online Credit Card Repayment	21g/transaction	reducing a round trip to the credit card center
	Green Office	Video conference: 13g/day, Teleconference: 18g/day, Electronic approval and logs: 10g/day	reducing travel to meet and paper consumption
	Green Loan	219g for opening an account, 35g for a loan, and 21g for a repayment	reducing bank card consumption, travel, and paper consumption
	Green Healthcare	Online appointment: 277g/transaction, Not printing paper reports: 2g/transaction	reducing a trip to the hospital and paper consumption of paper reports
	Green Commuting by Not Driving	1.46kg/day for fuel cars and 0.25kg/day for electric cars	taking public transportation or walking while leaving private cars parked at home
Recycling	Eco-friendly Accommodations	92g/transaction	reducing the production and consumption of single-use toiletries
	Eco-friendly Recycling	Large appliances: 9763g/unit, Mobile phones: 631g/unit, Laptops: 987g/unit, Cameras: 2286g/unit, Old clothes: 158g/kg, Books: 195g/transaction, Waste paper: 100g/kg, Plastic: 144g/kg, Fabric: 78g/kg, Metal: 13g/kg, Bottles and	recycling old products and reducing the production and consumption of new products

		cans: 1g/piece, Coffee capsules: 4g/piece, Sport shoes: 1377g/pair	
	Parcel Recycling	37g/transaction	recycling parcels and reducing package production
	Green Parcel	40g/transaction	reusing courier packages and reducing package production during the delivery process
	Trading second-hand products	Maximum 2 transactions per day	reducing the production of new products by using second-hand products
	Book Borrowing	17g/book, up to 9 books per transaction	reducing paper consumption
	E-payment	5g/transaction	replacing paper consumption for cash, card swiping, and bank transfers
	Receipt-free Offline Payment	5g/transaction	replacing paper receipts with electronic ones
	Electronic Invoice	5g/transaction	replacing traditional paper invoices
	Green Takeout	16g/transaction	choosing not to receive single-use cutlery
	E-bills	8g/bill	reducing paper production, handling, and postal transportation of paper bills
	QR Code Ordering	7g/order	replacing paper menus with electronic ones
	Online Shipping	4g/transaction	replacing paper waybills with electronic ones
	Electronic Receipts	4g/transaction	avoiding the printing of paper receipts
	Bring-your-own Cups	30g/cup for bringing personal cups, 5g/cup for using direct drinking cups (no plastic straws), and 12g/order for not using takeout bags	replacing plastic cups and takeout bags with private cups
Reduce Paper and Plastic Use	Plastic Reduction	12g/transaction	choosing not to use plastic bags when shopping offline
	Green Hydration	4g/transaction	reducing the production of bottles and plastic by using private cups
	QR Code Ticket Purchase	5g/transaction	replacing paper tickets with electronic ones when purchasing scenic area tickets
	Paperless Reading	1.5g/thousand words	reducing paper book consumption by reading online
	Credit-based Accommodation	5g/transaction	replacing paper receipts when paying for hotel accommodation
	Electronic Signing	6g/page	reducing paper contracts when signing contracts
	International Tax Refund	4g/transaction	reducing paper consumption for tax refund forms
	Electronic Insurance Contracts	59g/contract	reducing paper contracts of car insurance
	Green Packaging	Refill/replacement packaging for laundry detergent, fabric softener, hand soap, etc.: 105g per bag, FSC-certified paper box packaging: 4g per box, Recycled plastic packaging: 100g per bottle	replacing plastic bags or packaging
	Green Sports Venue	5g/transaction	replacing paper tickets when booking sports venues
Energy	ETC (Electronic Toll	23g/transaction	reducing fuel consumption by saving waiting time at toll booths

Conservation	Collection) Payment		
	Battery Chargers Sharing	13g/use	reducing the production of new battery chargers
	Prepaid Parking	18g/transaction	reducing fuel consumption by saving waiting time with prepaid and contactless parking payments
	Green Appliances	Environmental-friendly air conditioners: 18,400g/unit, washing machines: 9,100g/unit, and refrigerators: 7,400g/unit, etc.	reducing energy consumption through buying household appliances with the "green and energy-efficient" label
	Near-Expired Food	45g/order	reducing food waste
	Sustainable Consumption	-	buying products with green certification

This table presents all the 48 certified low-carbon activities in the Alipay Ant Forest. The "green points" serves as virtual points that accumulate on the Ant Forest app on the Alipay app when users engage in low-carbon activities. The quantity of green points, measured in grams, is equivalent to the corresponding reduction in carbon emissions achieved through each activity. The calculation formula used by Ant Forest is a scientifically certified algorithm provided by the Beijing Environmental Exchange. Note that each acquisition rule has a limit in place to prevent an excessive accumulation of green points from a single activity. As an example, walking has a daily yield cap of 296g (equivalent to 18,000 steps) to prevent someone from generating an extremely large number of steps through cheating methods.

Table A2. Variable Definitions

Variable Name	Variable Description
App Users' Green Activities in Ant Forest	
GreenPoints	The "green points" awarded to a user through all 48 certified low-carbon activities.
CollectPoints	The green points collected by a user.
IntentGreenPoints	The "intentional green points" awarded to a user through 16 manually selected low-carbon activities. Those manually selected activities are New energy vehicles, Green commuting by not driving, Green Takeout, Environmental Recycling, Green Appliances, Green Parcel, Electronic Receipts, Direct Drinking Water, Bring-your-own Cups, Sustainable Consumption, Green Packaging, Parcel Recycling, Pure Electric Taxi, Green Flying, Eco-friendly Recycling, and Eco-friendly Accommodations.
AggGreenPoints	The aggregation of acquired "intentional green points" and consumed green points. Green points can be consumed by redeeming real trees and redeeming one square meter of ecologically damaged areas.
Trees	The monthly count of real trees an individual planted in desert areas.
AccumTrees	The accumulated number of real trees an individual has planted since the creation of her account.
Areas	The monthly count of ecologically damaged areas an individual protected. Here, "protecting" an area means redeeming the commitment to protect one square meter of the ecologically damaged area with the support of Alipay.
AccumAreas	The accumulated number of ecologically damaged areas an individual has protected since the creation of her account.
App Users' Gamified Activities in Ant Forest	
RobSI	The green points an individual gained by robbing friends (You rob your friends).
RobbedSI	The green points an individual lost when robbed by friends (Your friends rob you).
GamifiedSI	The total green points exchanged, including points gained by robbing friends and points lost to friends' robberies.
Post	A dummy that equals one for the period after August 2020, and zero for August 2020 and earlier.
Treat	A dummy that equals one for individuals with cross-sectionally less gamified social interactions before the in-game item launch, and zero otherwise.
GamifiedSI/GreenPoints	The ratio of *GamifiedSI* to *GreenPoints*. It represents the intensity of gamified social interactions.
Engagement	The number of clicks an individual made on the Ant Forest interface to acquire green points.
App Users' Fund-Portfolio Information	
GreenHoldProp	The proportion of an individual's fund investment allocated to "green funds" (funds with E words in their names).
SustainHoldProp	The proportion of an individual's fund investment allocated to funds in the Wind Sustainable Fund list.
EHoldProp	The proportion of an individual's fund investment allocated to funds in the Wind Sustainable Fund list that contain E words in their names.
ESGHoldProp	The proportion of an individual's fund investment allocated to funds in the Wind Sustainable Fund list that contain ESG words in their names.

GreenReturn	An individual's monthly return from green funds, calculated as the current month's profit relative to the previous month's holding values of these funds. The variable is present in percentage.
nonGreenReturn	An individual's monthly return from non-green funds, calculated as the current month's profit relative to the previous month's holding values of these funds. The variable is present in percentage.
GMinusN Return	An individual's monthly return from green funds minus her monthly return from non-green funds.
GreenHoldValues	An individual's total end-of-month holding values of green mutual funds.
nonGreenHoldValues	An individual's total end-of-month holding values of non-green mutual funds.
TotalHoldValues	An individual's total end-of-month holding values of all mutual funds.
App Users' Characteristics	
Male	A dummy that equals one if an individual is male and zero otherwise.
Young	A dummy that equals one if an individual's age is below the sample average and zero otherwise.
RiskAttitude	An integer from -2 to 5. It indicates an individual's willingness to take risks in fund investments, with higher values signifying a greater appetite for risk.
UnderAvgTrees	A dummy that equals one if an individual's number of real trees planted is under the sample average and zero otherwise.
UnderAvgAreas	A dummy that equals one if an individual's number of areas protected is under the sample average and zero otherwise.

Table A3: Gamified Social Interactions vs. Green Points

Dependent variable =	*RobSI*	*RobbedSI*	*GamifiedSI*
	(1)	(2)	(3)
GreenPoints	0.3807***	0.5937***	0.5144***
	(0.0009)	(0.0009)	(0.0008)
Constant	Y	Y	Y
Year-Month FE	N	N	N
User FE	N	N	N
Obs.	2,952,113	2,952,113	2,952,113
R-squared	0.1449	0.3525	0.2647

This table presents the results of contemporaneous regression using green points (*GreenPoints*) to explain gamified social interactions (*RobSI*, *RobbedSI*, and *GamifiedSI*). No control variables are included. Standard errors are clustered at the user and year-month level, with corresponding *standard deviations* in parentheses. Levels of significance are presented as follows: *p<0.1; **p<0.05; ***p<0.01.

Table A4: Does Being Robbed Undermine Users' Green Behavior?

Dependent variable=	$GreenPoints_{t+1}$	$CollectPoints_{t+1}$
	(1)	(2)
RobbedSI	0.4108***	0.1094***
	(0.0007)	(0.0006)
Controls	Y	Y
Year-Month FE	Y	Y
User FE	Y	Y
Obs.	2,865,423	2,865,423
R-squared	0.6803	0.7042

This table explores whether being robbed of green points will undermine users' subsequent green behavior. The dependent variables $GreenPoints_{t+1}$ and $CollectPoints_{t+1}$ represent the subsequent green points awarded to users and the subsequent collected green points, respectively. Standard errors are clustered at the user and year-month level, with corresponding standard deviations in parentheses. Levels of significance are presented as follows: *p<0.1; **p<0.05; ***p<0.01.

Table A5: Gamified Social Interactions and Green Investment Proportion

Dependent variable = GreenHoldProp$_{t+1}$	(1)	(2)	(3)
RobSI	0.0013***		
	(0.0001)		
RobbedSI		0.0008***	
		(0.0001)	
GamifiedSI			0.0015***
			(0.0001)
Controls	Y	Y	Y
Year-Month FE	Y	Y	Y
User FE	Y	Y	Y
Obs.	2,808,494	2,808,494	2,808,494
R-squared	0.4763	0.4762	0.4763

This table presents results from directly regressing green investment proportion (*GreenHoldProp$_{t+1}$*) on gamified social interactions (*RobSI*, *RobbedSI*, and *GamifiedSI*). The independent variable is measured by three components: green points gained by robbing friends (*RobSI*), green points robbed by friends (*RobbedSI*), and the total sum of both (*GamifiedSI*). The dependent variable, *GreenHoldProp$_{t+1}$* is the proportion of fund investment allocated to "green funds" at the end of next month. Controls are the same as our baseline model in Table 2. Standard errors are clustered at the user and year-month level, with corresponding *standard deviations* in parentheses. Levels of significance are presented as follows: *p<0.1; **p<0.05; ***p<0.01.

Table A6: Alternative Specifications of Our Main Regression

Dependent variable = GreenHoldProp$_{t+1}$	(1)	(2)	(3)
FittedIntentGreenPoints (IV =RobSI)	0.0026***		
	(0.0007)		
FittedIntentGreenPoints (IV =RobbedSI)		0.0038	
		(0.0024)	
FittedIntentGreenPoints (IV=GamifiedSI)			0.0027***
			(0.0007)
GreenHoldProp	0.7695***	0.7695***	0.7695***
	(0.0015)	(0.0015)	(0.0015)
Controls	Y	Y	Y
Year-Month FE	Y	Y	Y
User FE	Y	Y	Y
Obs.	2,808,494	2,808,494	2,808,494
R-squared	0.7809	0.7809	0.7809

This table presents the robustness of our equation setting by adding a lagged term of the dependent variable in Eq. (3). *GreenHoldProp* stands for the proportion of fund investment allocated to "green funds" at the end of this month. We only present the second-stage regression of our two-stage least square regression. The independent variables in columns 1-3 are intentional green points fitted by *RobSI*, *RobbedSI*, and *GamifiedSI* respectively. The dependent variable is the proportion of fund investment allocated to "green funds" at the end of next month (*GreenHoldProp*$_{t+1}$). Controls are the same as our baseline model in Table 2. Standard errors are clustered at the user and year-month level, with corresponding *standard deviations* in parentheses. Levels of significance are presented as follows: *p<0.1; **p<0.05; ***p<0.01.