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Data Descriptor

Dataset to Quantify Spillover Effects Among Concurrent Green Initiatives

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Abstract: Green initiatives are popular mechanisms globally to enhance environmental and human wellbeing. However, multiple green initiatives, when overlapping geographically and targeting the same participants, may interact with each other, giving rise to what is termed "spillover effects", where one initiative and its outcomes influence another. This study examines the spillover effects among four major concurrent initiatives in the United States (U.S.) and China using a comprehensive dataset. In the U.S., we analysed county-level data in 2018 for the Conservation Reserve Program (CRP) and the Environmental Quality Incentives Program (EQIP), both operational for over 25 years. In China, data from Fanjingshan and Tianma National Nature Reserves (2014–2015) were used to evaluate the Grain-to-Green Program (GTGP) and the Forest Ecological Benefit Compensation (FEBC) program. The dataset comprises 3106 records for the U.S. and 711 plots for China, including several socio-economic variables. The results of multivariate linear regression indicate that there exist significant spillover effects between CRP & EQIP and GTGP & FEBC, with one initiative potentially enhancing or offsetting another's impacts by 22% to 100%. This dataset provides valuable insights for researchers and policymakers to optimize the effectiveness and resilience of concurrent green initiatives.

Dataset: https://data.mendeley.com/datasets/bbg7szr6yr/1 (accessed on 25 September 2024).

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Keywords: green initiatives; spillover effects; Conservation Reserve Program (CRP); Environmental Quality Incentives Program (EQIP); Grain-to-Green Program (GTGP); Forest Ecological Benefit Compensation (FEBC) program; payment for environmental services; nature conservation

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1. Summary

Green initiatives, encompassing various programs and payments, aim to enhance the environmental ability to restore, sustain, and/or improve nature's capacity to benefit human well-being [1]. Over the past three decades, green initiatives have become increasingly widespread and popular across the globe, such as the Conservation Reserve Program (CRP), the Environmental Quality Incentives Program (EQIP), China's Grain-to-Green Program (GTGP), and China's Forest Ecological Benefit Compensation (FEBC) program. These initiatives represent significant strides in the pursuit of sustainable environmental management and human well-being. However, the simultaneous implementation of multiple green initiatives, known as concurrent green initiatives, often involves overlapping geographic areas and shared participants. This creates a potential for spillover interactions and influences from one initiative to another [2,3]. These unintended impacts, termed "spillover effects", occur when one initiative extends to affect another concurrently implemented initiative in the same or nearby area, or with shared participants [1]. In this paper, a comprehensive dataset encompassing four prominent concurrent green initiatives in both the United States (U.S.) and China is designed to assess and quantify the spillover effects among these initiatives. The valuable insights into the interconnected dynamics of these concurrent green initiatives derived from the dataset provide crucial information for enhancing the effectiveness of similar green initiatives and fostering a better understanding of their ecological and societal impacts around the globe.

CRP, established under the 1985 Farm Security Act, aims to re-establish valuable land cover to help improve water quality, prevent soil erosion, and reduce the loss of wildlife habitat [4]. Operated by the U.S. Department of Agriculture Farm Service Agency (FSA), CRP played a predominant role in the U.S. as an agri-environmental policy. In exchange for a yearly rental payment and cost-share assistance, farmers enrolled in the program agree to remove environmentally sensitive land from agricultural production, and plant species that will control soil erosion, improve water quality, and develop wildlife habitat. Participation is voluntary by the farmers and landowners. Contracts for land enrollment in CRP usually span 10–15 years [5]. EQIP, administered by the Natural Resources Conservation Service since 1996, offers incentive payments to producers, encouraging them to adopt environmentally friendly practices on their registered farmlands [6]. Nationally, CRP enrollment has steadily decreased since 2007, with the 2018 enrollment of 22 million acres falling below the 27 million-acre cap specified in the 2018 Farm Bill [7,8]. According to the Bill, CRP and EQIP are concurrent green programs, allowing eligible landowners to participate in or switch between the two programs.

In China, GTGP, initiated by the central government in 1999, focuses on converting eligible cropland on steep hillslopes or pastureland to forestland or grassland in the upper reaches of the Yangtze River Basin and the upper and middle reaches of the Yellow River Basin [9,10]. Similar to the CRP in the U.S., GTGP aims to restore vegetation, reduce surface runoff, and mitigate soil erosion by providing payments to cropland or pastureland holders. The second green initiative is FEBC, officially launched in 2004. FEBC's objective is to establish, nurture, protect, and manage selected natural forestlands with essential ecological benefits, enforced through a strict logging ban [11]. Payments are made to corresponding forestry entrepreneurs, communities, or individual forest stewards. Since 2004, these two programs have been concurrently implemented in China's 20 provinces, autonomous regions, and municipalities. Notably, in many regions, the same households have enrolled parcels of land in both programs [11], creating potential spillover effects between the two programs.

To detect and quantify spillover effects among concurrent green initiatives, especially focusing on what makes them succeed or fail, we first detect spillover effects between two initiatives on the same dimension, e.g., one initiative's policy dimension affects a different initiative's policy dimension. Second, we identify spillover effects across different dimensions of policy, behaviour, and gain. The spillover effects can manifest in two ways: one green initiative benefits or harms another one in the relevant dimension(s), which we name beneficial or detractive spillover effects, respectively. Third, we seek insights into leveraging such spillover effects to support green initiatives (including the associated proposals or bills) that generate substantial co-benefits and/or suspend those that undermine other concurrent green initiatives.

2. Data Description

2.1. Concurrent Green Initiatives in the U.S.: CRP and EQIP

We collected county-level CRP and EQIP data in 2018, constituting a total of 3106 records spanning the continental U.S. (Figure 1). We downloaded income data, farmland data, and population data from the relevant governmental agency's websites [12–14]. We took a random subset (15%) of all data records to avoid the negative impacts of spatial autocorrelation in regression coefficients, which resulted in a dataset with 462 counties. This dataset contains the following variables (Tables 1 and 2): CRP_Area (y for area enrolled in CRP; acres), EQIP_Area (X_1 for contracted land in EQIP; acres), Farm_Area (X_2 for total county farmland; acres), Median_Income (X_3 for county median household income in 2018; $), and Population ($X_4$ for county population in 2018).

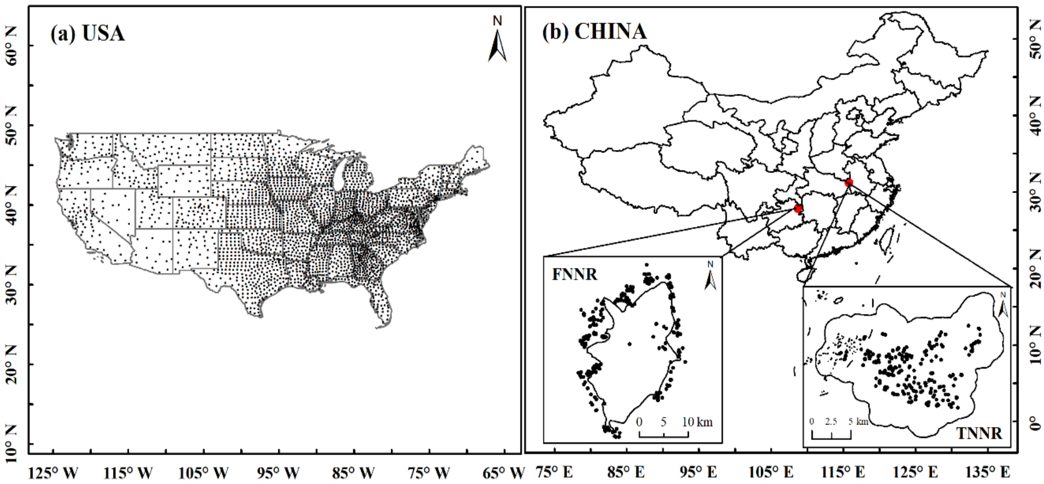

Figure 1. Location of plots for (**a**) the United States and (**b**) two reserves, the Fanjingshan National Nature Reserve (FNNR) and the Tianma National Nature Reserve (TNNR), in China.

Table 1. Number of plots and variables in each site in the United States and China.

File Name (.xlsx)	Plots	Dependent Variable (y)	Independent Variables (x)
data_USA	3106	CRP_Area	EQIP_Area, Farm_Area, Median_Income, Population
data_CHN_FNNR	303	GTGP_Area	FEBC_Payment, DryLdAmt, PadLdAmt, HHCshInc, HH_Size, TLGPDst (more in Table 3)
data_CHN_TNNR	408	GTGP_Area	FEBC_Forest_Area, hhSlope, hhElev1000, hhSize, landOwnHA, income

Table 2. Description of detailed information for each variable used in this article.

Variable	Description
CRP_Area	Area enrolled in CRP in 2018 (acre)
EQIP_Area	Areas enrolled in EQIP in 2018 (acre)
Farm_Area	Acres of farmland that is planted under EQIP contract (acre)
Median_Income	Median Household Income in 2018 (dollar)
Population	Population size in 2018
GTGP_Area	Area of cropland enrolled in GTGP (mu)
FEBC_Payment	Annual FEBC payment a household receives (1000 yuan)
DryLdAmt	Total area of dry farmland that a certain household owns or can handle
PadLdAmt	Total area of paddy farmland that a certain household owns or can handle
HHCshInc	Household's total cash income in 2014 (yuan)
HH_Size	Household size (number of people in the household in 2014)
TLGPDst	Total distance from GTGP parcel to house
FEBC_Foest_Area	Area of forest enrolled in FEBC (100 mu)
hhSlope	Slope at house location (degree)
hhElev1000	Elevation at house location (1000 m)
hhSize	Household size
landOwnHA	Area of cropland owned (ha)
income	Gross household annual income (1000 USD)

Table 3. Additional data on the willingness to participate in a future hypothetical GTGP at the Fanjingshan National Nature Reserve (FNNR), China.

Variable	Description
AllFstAmt	FEBC forestland amount managed by the relevant household (mu)
HHLbr	Household labour (# of people from 15 to 59 years old in the household)
PlotInGP	Plot already in GTGP (0 for no and 1 for yes)
Plot_Dst	Distance from plot to household (minutes of walking)
Plot_Area	Area of plot (mu)
Mny	Hypothetical amount of GTGP payment level (Yuan)
span	Hypothetical amount of GTGP span (years)
fallow	Hypothetical status for the land plot left fallow (1 for yes and 0 for no)
NB	Hypothetical percent of neighbours agreed to join GTGP (three levels of 25, 50, and 75 percent)

2.2. Concurrent Green Initiatives in China: GTGP and FEBC

We conducted independent data collection efforts within the Fanjingshan National Nature Reserve (FNNR) and the Tianma National Nature Reserve (TNNR) in 2014 and 2015, respectively. In FNNR and TNNR, we gathered data for 303 and 408 plots (Figure 1), respectively. GTGP was implemented earlier than FEBC in both reserves. We selected GTGP enrollment land as the dependent variable (GTGP_area, y for area of cropland enrolled in GTGP; mu), while FEBC payment (at the FNNR site) or forest area (at the TNNR site) as an independent variable. Similar to our approach with the U.S. data, we identified household size, total farmland (differentiated between Paddyland and Dryland at FNNR site), and income as independent variables (Tables 1 and 2). Additionally, our analysis incorporated the distance between households and parcels at the FNNR site, as well as the elevation and slope at the TNNR site.

3. Methods

According to the United Nations' Sustainable Livelihoods Framework, an entity, such as a farm or household, relies significantly on human, social, natural, physical, and financial capital when making vital livelihood decisions [15]. In this context, we adopted the area of first-enrollment green initiative as the dependent variable (y). The variability in this variable is elucidated by a set of factors including the total farmland, distance from enrolled area to household, income, population, household size, and latter-enrollment green initiative, which respectively represent natural, physical, financial, human, and social capital.

1. Natural Capital: The variable total farmland (landOwnHA, Table 2) is selected as a proxy for natural capital, as it reflects the resources available for agricultural production. Farmland represents the natural assets that households can rely on for food security and income generation. This is particularly relevant in the context of green initiatives that affect land use and sustainability.
2. Physical Capital: Infrastructure plays a critical role in supporting agricultural practices. In our study, variable distance from the enrolled area to the household (TLGPDst, Table 2) captures aspects of physical capital, such as the accessibility of land for agricultural practices, which may influence the feasibility of adopting green initiatives.
3. Financial Capital: Income serves as a direct measure of financial resources, highlighting the capacity of households or farms to invest in sustainable practices and technology. It also plays a critical role in determining economic resilience.
4. Human Capital: The population and household size (hhSize, Table 2) indicates the available labour force and suggest the education and skill levels within the community. This reflects the community's capacity for innovation and adaptation to green initiatives.
5. Social Capital: Latter enrollment green initiative (EQIP_Area in the U.S. case, FEBC_Payment and FEBC_Forest_Area in the China case) captures aspects of so-

cial capital by illustrating community engagement, trust, and collaboration. This variable emphasizes how social networks facilitate the uptake of sustainable practices.

We first explore potential spillover effects in the U.S. between CRP and EQIP. Although previous studies have indicated that there existed potential spillover effects between CRP and EQIP, no systematic studies have explicitly addressed the nature and impacts of such effects [2]. Notably, considering CRP's earlier initiation and the existence of evidence indicating EQIP's influence on CRP enrollment, it becomes necessary to delve deeper into this relationship [6]. Owing to land scarcity, along with higher pay rates and continued economic return under EQIP [16], a large proportion of landowners with land eligible for both programs declined or quit CRP contracts and registered their land for EQIP instead, which happened, e.g., in the Topashaw Canal watershed, Mississippi [17]. As EQIP's and CRP's goals of preserving soil, water, and wildlife habitat overlap significantly, many landowners' own lands are eligible for both EQIP and CRP. Given that CRP was started earlier and there was some evidence for EQIP's influence on CRP enrollment [17], we hypothesize that EQIP may account for CRP's decline since 2007.

We further explored potential spillover effects based on two of the most extensive concurrent green initiatives, GTGP and FEBC, in China. To minimize the likelihood that spillover effects, if detected, are site-specific only, we selected two sites (FNNR and TNNR) for a simultaneous examination of GTGP-FEBC relationships. In both sites, GTGP had an earlier initiation, and local farmers held more decisive power in participation in GTGP. In contrast, FEBC participation was primarily government-prescribed [18,19].

We conducted a multivariate linear regression, incorporating various socio-economic variables for control purposes. Specifically, we regressed the area of CRP enrollment (y; acres) against the area of EQIP enrollment (X_1; acres), while controlling for Farmland_Area (X_2), M_HH_Inc (X_3), and CountyPop (X_4). These variables respectively represent total planted farmland (acres; as natural and physical capital), median household income (dollars; as financial capital), and population size (as human and social capital) in Equation (1). The multivariate linear regression is expressed in the following form:

$$y = b_0 + b_1 X_1 + \sum_{i=2}^{4} b_i X_i + e \quad (1)$$

where b_0 is the intercept, b_1 is the coefficient of X_1 (EQIP_Area), the variable representing contracted land in EQIP (acres), and b_i represents the coefficients of the three control variables (i = 2, 3, and 4). The dependent variable y signifies CRP_Area, representing the land enrolled in CRP (acres). For sites FNNR and TNNR, the interpretation varies, where y represents the area of cropland enrolled in GTGP, X_1 corresponds to the payment from FEBC (at FNNR) or the area of forestland enrolled in FEBC (at TNNR), and the remaining variables (i.e., X_j; Table 2) represent the controlled variables signifying various household capitals in accordance with the Sustainable Livelihoods Framework [4].

To explore how the FEBC-GTGP spillover effects might evolve over time or under varying conditions, we surveyed local farmers' willingness to participate in the GTGP at FNNR under a set of hypothetical scenarios. We used conditional logit modeling, a well-established method for analyzing discrete choice data, which allows us to assess individuals' preferences when presented with different alternatives defined by a set of attributes [20,21]. In our study, we defined four key attributes of the GTGP that may strongly influence farmers' participation decisions, including (1) Amount of GTGP payment, (2) Years of GTGP participation, (3) Status of the land plot (fallow or not), and (4) Percentage of neighbours agreeing to join the program. We generated a range of hypothetical scenarios by varying these attributes and asked respondents whether they would be willing to enroll their cropland in the program under each scenario.

Discrete choice modelling allowed us to estimate the marginal utility of each attribute and level, helping identify the factors that most strongly affect the farmers' decision to participate or not. By examining the trade-offs that respondents were willing to make between these factors—such as how much additional payment would be needed to compensate for a longer commitment or for leaving land fallow—we were able to determine the optimal levels for each attribute.

In 2015, we selected a subset of farmland plots from the same households at FNNR that were surveyed in 2014 (see Table 2). Some of these plots were already enrolled in GTGP, while others were not. For each selected plot, respondents were asked to randomly choose a level of GTGP payment amount (per mu), payment duration, land fallow status, and the neighbour participation rate (Mny, span, fallow, and NB respectively; Table 3). With these chosen attributes, we asked farmers: "Under these conditions, would you be willing to enroll this specific plot in the GTGP?" Their answers (coded as a binary variable: 1 for "yes" and 0 for "no") were used to build a logistic regression model that analysed how the amount of FEBC forestland (AllFstAmt; Table 3) affected enrollment decisions while controlling for various household capital variables (Table 3).

4. Results and Discussion

Our regression results indicate a detractive spillover effect between EQIP and CRP. Specifically, each acre of land enrolled in EQIP is associated with a 0.22-acre reduction in CRP enrollment (Table 4, $p < 0.0001$). The significant detractive spillover effect may be attributed to factors such as land scarcity and land-use competition [1,2]. When landowners face two choices of CRP and EQIP, they choose the more profitable one when all other conditions are met. As CRP is a land retirement program, there is no (or very little) agricultural income once the land is enrolled in CRP. On the other hand, EQIP does not require land retirement but pays landowners for more environmentally beneficial practices, implying that agricultural income is still available.

Table 4. Spillover effects between EQIP and CRP in the U.S., and FEBC and GTGP at Fanjinshan (FNRR) and Tianma National Nature Reserves (TNRR) in China.

Program	Site	Coefficient	Standard Error	*p*-Value	Spillover Effect
EQIP/CRP	/	−0.22	0.0509	<0.0001	Detractive
FEBC/GTGP	FNRR	0.4393	0.2418	0.0703	Beneficial
	TNRR	0.4669	0.1503	0.002	Beneficial

In contrast, we observed a beneficial spillover effect between FEBC and GTGP at both the Fanjingshan and Tianma sites in China (Table 4). Our analysis shows that FEBC payments and land enrollment positively influence GTGP participation. Specifically, at Fanjingshan, FEBC payments increased GTGP enrollment ($R^2 = 0.4393$, $p = 0.0703$); while at Tianma, both FEBC payments and land enrollment are strongly associated with increased GTGP participation ($R^2 = 0.4669$, $p = 0.002$). Additionally, there is evidence of a gain–gain spillover effect at both sites, where GTGP forests, often located closer to households, act as buffers to reduce human activities (e.g., fuelwood collection and grazing) that would otherwise negatively affect FEBC forests. This mutual protection enhances the overall environmental benefits of both programs [19].

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Informed Consent Statement: Informed consent was obtained from all subjects involved in this study.

Data Availability Statement: All primary data underlying this publication are available at https://data.mendeley.com/datasets/bbg7szr6yr/1 (accessed on 25 September 2024).

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