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Technology Transfer, Crop Production, and Food Security: Evidence from Vietnam's ATDP Participation

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ABSTRACT

This study aims to examine the causal effect of agricultural technology transfer through Vietnam's participation in the Greater Mekong Subregion Agricultural Technology Demonstration Program (ATDP) on crop production, trade performance, and food security. Using a province-by-crop panel dataset covering 63 Vietnamese provinces, eight food crops, this study applies a triple difference-in-differences approach by comparing recipient and non-recipient provinces, demonstration and non-demonstration crops, and pre- and post-program periods. Robustness is assessed through parallel trend and event-study analyses. The results show that ATDP participation significantly increases harvest area and grain production of demonstration food crops by approximately 20.1% and 15.96%, respectively. The effect emerges around two years after implementation and remains persistent. ATDP also expands export volume and value, reduces import dependence in direction, and improves food security indicators at the provincial level. Mechanism analysis indicates that free-standing technical assistance and programs implemented by state-owned enterprises generate stronger outcomes than general grant aid. This study contributes to the literature by providing causal evidence on South-South agricultural technology cooperation using a rigorous triple DID design at the province-crop level. The findings suggest that agricultural cooperation should prioritize context-specific technical demonstration, extension training, and institutional implementation capacity. The study is limited to first-cohort ATDP provinces and selected food crops; future research should examine longer-term yield intensification, household welfare, and cross-country replication.

Keywords: Technology Transfer, Crop Production, Food Security; ATDP, Triple Difference-in-Differences

INTRODUCTION

Food security remains one of the most pressing development challenges of the twenty-first century. The Food and Agriculture Organization of the United Nations (FAO) estimates that over 828 million people faced hunger globally in 2021, with a disproportionate burden concentrated in low- and lower-middle-income countries across Asia and Africa. Within Southeast Asia, food system fragility has intensified due to climatic volatility, demographic pressure, and supply chain disruptions accentuated by the COVID-19 pandemic and subsequent geopolitical shocks. Understanding the mechanisms through which policy interventions and international technology transfers shape agricultural productivity has therefore become an urgent empirical priority for both academics and policymakers.

Vietnam presents a particularly instructive case. Since the Doi Moi economic renovation of 1986, Vietnam has executed one of the most dramatic agricultural transformations in modern development history transitioning from a net food importer facing recurrent hunger crises to the world's second-largest rice exporter and a major supplier of corn, cassava, and other staples. Yet this transformation has been spatially uneven. Upland, border, and central highland provinces continue to exhibit significantly lower agricultural productivity, greater food insecurity, and weaker integration into national and regional supply chains compared to the Red River Delta and Mekong Delta regions. Addressing this subnational divergence requires sustained technological support and institutional investment.

Since the early 2000s, Vietnam has participated in the Greater Mekong Subregion (GMS) Economic Cooperation Program, a multilateral framework linking China (Yunnan and Guangxi provinces), Vietnam, Laos, Myanmar, Cambodia, and Thailand. Agriculture constitutes one of the GMS cooperation pillars, formalized through the GMS Agricultural Technology Demonstration Program (ATDP), which established provincial-level demonstration sites to transfer improved crop varieties, cultivation techniques, irrigation management, and post-harvest processing to participating provinces (Michler et al., 2019; T.-T. Nguyen et al., 2023b; T. T. Nguyen et al., 2022). The ATDP aligns with broader South-South cooperation principles, emphasizing horizontal knowledge exchange among developing economies rather than conventional North-South aid conditionality.

Despite the programmatic significance of the GMS ATDP, rigorous causal evidence on its agricultural productivity effects at the subnational level remains limited. Existing evaluations rely predominantly on case studies, participatory assessments, or descriptive statistics, which cannot credibly address selection bias, simultaneity, or confounding factors inherent in observational data. Moreover, the heterogeneous structure of the program varying by aid modality, implementing agency, demonstration crop, and provincial context has not been systematically exploited to identify which program features drive the most significant gains.

This paper addresses these gaps by making the following contributions. First, we construct a novel province-crop panel dataset integrating data from Vietnam's General Statistics Office (GSO), the Ministry of Agriculture and Rural Development (MARD), FAOSTAT, and the GMS Secretariat's project records, covering 63 provinces, eight food crops, and sixteen annual observations from 2005 to 2020. Second, leveraging the staggered quasi-experimental structure of ATDP rollout where a first cohort of provinces began receiving GMS technical support from 2010 onward we apply a triple DID identification strategy that exploits variation across treatment status (recipient versus non-recipient provinces), crop type (demonstration versus non-demonstration crops), and time (pre- versus post-implementation period) (Ma et al., 2022, 2023; Ma & Zheng, 2022). This design provides more credible causal estimates than conventional two-way DID, since it differentially controls for province-year, crop-year, and province-crop fixed effects. Third, we investigate the mechanisms through which ATDPs generate productivity gains, examining the role of technical assistance versus grant funding, state-owned enterprise (SOE) versus non-SOE implementing agencies, and the broader effects on rural livelihoods and food security indicators.

Our results show that ATDPs generate statistically significant increases in harvest area and total crop production in recipient provinces, while effects on unit yield are positive but imprecisely estimated in the baseline period, suggesting that area expansion precedes yield intensification in the program trajectory (Laborde et al., 2020; Lin et al., 2022; Ma & Wang, 2020). Trade analysis indicates that ATDPs reduce import dependence and expand export volumes for demonstration food crops, improving provincial self-sufficiency and supply chain positioning. Mechanism tests reveal that free-standing technical assistance is more effective than grant aid, and that SOE-implemented projects generate stronger productivity gains. At the farm and household level, ATDPs are associated with higher per capita grain output growth, expanded irrigated farmland, and reduced frequency of food shortages.

INSTITUTIONAL BACKGROUND

Vietnam's Agricultural Sector and Food Security Trajectory

Vietnam's agricultural transformation since 1986 is among the most dramatic in the development literature. Following the Doi Moi reforms, which decollectivized agriculture, liberalized output markets, and restored household land use rights, rice production surged from approximately 17 million tonnes in 1986 to over 44 million tonnes by 2018. The country transitioned from food deficit to food surplus within a decade, becoming a leading global exporter of rice, coffee, pepper, and cashews (T.-T. Nguyen et al., 2023a; T. T. Nguyen et al., 2021, 2023).

Despite this aggregate success, subnational food insecurity persists. According to the Vietnam National Nutrition Survey and MARD data, provinces in the northern mountainous region (e.g., Ha Giang, Cao Bang, Dien Bien), the central coast, and the central highlands continue to exhibit high rates of child stunting, dietary insufficiency, and subsistence-level farming (Farrokhi & Pellegrina, 2023; Grote et al., 2021; Kassie et al., 2020). These provinces are characterized by rugged terrain, limited irrigation infrastructure, low mechanization rates, and restricted market access conditions that reduce both the level and variability of agricultural output. South-South cooperation programs that transfer higher-yield varieties, irrigation techniques, and post-harvest technologies to these lagging provinces have substantial potential to improve food security outcomes.

The Greater Mekong Subregion Agricultural Technology Demonstration Program

The GMS Economic Cooperation Program, initiated by the Asian Development Bank (ADB) in 1992, provides a multilateral framework for regional integration across six countries sharing the Mekong River basin: China (Yunnan and Guangxi Autonomous Region), Vietnam, Laos, Myanmar, Cambodia, and Thailand. Agriculture, food security, and natural resource management constitute one of the core GMS cooperation sectors, formalized through the Agriculture Sector Working Group and the Strategic Framework for Action on Trade Facilitation and Investment (Piñeiro et al., 2020; Porteous, 2020; Ruzzante et al., 2021; Schulte et al., 2022).

The GMS Agricultural Technology Demonstration Program (ATDP) was formalized through the GMS Agriculture Ministers' Meeting in Kunming in 2008 and progressively operationalized between 2009 and 2012. The program established provincial-level demonstration sites in each member country, with explicit objectives to: (i) transfer improved crop varieties and cultivation technologies adapted to Mekong basin agro-ecological conditions; (ii) build capacity among provincial extension officers and smallholder farmers; (iii) reduce food insecurity in remote and border provinces; and (iv) promote regional agricultural trade and market integration.

Vietnam's MARD formally incorporated the GMS ATDP into its national extension program structure in 2010, designating a first cohort of 16 recipient provinces. Selection criteria included proximity to the Chinese or Lao border (facilitating technology transfer), pre-existing engagement in GMS cross-border trade, and MARD's assessment of agricultural development needs. The first cohort included northern border provinces (Ha Giang, Lao Cai, Cao Bang, Lang Son, Quang Ninh), central border provinces (Nghe An, Ha Tinh, Quang Tri, Kon Tum), and southern agricultural hubs designated as regional demonstration anchors (An Giang, Tien Giang, Kien Giang, Dak Lak, Thai Nguyen, Ninh Binh, Hoa Binh). The remaining 47 provinces formed the comparison group.

Program activities included the establishment of demonstration plots showcasing improved paddy rice varieties (including Chinese hybrid varieties developed by CAAS and adapted for Mekong conditions), hybrid corn, and improved cassava, alongside training for extension officers and farmer groups, provision of certified seed and inputs in the initial demonstration years, and technical exchanges with Chinese and Thai agricultural institutions (Schulz & Börner, 2023; Stephens et al., 2020; Suri & Udry, 2022; Takahashi et al., 2020). A second cohort of provinces was designated in 2014 following program evaluation; this study focuses exclusively on the first cohort to ensure a sufficiently long post-treatment observation window.

Variation in ATDP Structure

The ATDP exhibits heterogeneity across three dimensions critical for our identification strategy. First, geographic variation: the first cohort of 16 treated provinces is distributed across Vietnam's agro-ecological zones, providing treated-control variation that spans diverse farming systems. Second, crop-level variation: demonstration activities focused primarily on paddy rice, hybrid corn, and improved cassava the program's three focal crops alongside non-demonstration crops (sweet potato, peanut, soybean, mung bean, and taro) grown in the same provinces. Third, temporal variation: the pre-program period runs from 2005 to 2009, with the policy formally implemented in 2010 and operating through the end of the sample in 2020.

RESEARCH DESIGN

Data Sources

Our analysis draws on a balanced province-by-crop panel dataset covering 63 Vietnamese provinces and eight major food crops observed annually from 2005 to 2020, yielding a maximum of 8,064 province-crop-year observations. After accounting for missing values in dependent and control variables, the working samples for the crop output and trade analyses contain 6,840 and 7,812 observations, respectively (Abay et al., 2023).

Crop-level agricultural data including harvest area, grain production, unit yield, producer prices, and output values are obtained from the Vietnam General Statistics Office (GSO) provincial statistical yearbooks and supplemented with crop-specific data from FAOSTAT Vietnam country records. Trade data, including import and export volumes and values by crop and province, are drawn from the Vietnam Customs Department database and MARD's agricultural trade statistics (Amare et al., 2021). Food security indicators including per capita grain output growth rates, irrigated farmland area, and household food shortage incidence are sourced from the Vietnam National Nutrition Survey (2005–2020), MARD's agricultural land use reports, and the GSO's Household Living Standards Survey.

Province level control variables including agricultural land area, agricultural fixed capital formation, rural population, provincial GDP, and foreign direct investment are sourced from the GSO's provincial statistical yearbooks and the World Bank's Vietnam data portal. ATDP project records, including implementing agencies (SOEs, non-SOEs, scientific research institutions, government extension agencies) and funding modalities (technical assistance funds, grant aid, loans, and joint cooperation schemes), are drawn from MARD project documentation, ADB GMS Secretariat records, and the Vietnam-China Agricultural Cooperation Coordination Committee annual reports. All monetary variables are deflated to constant 2015 USD.

The eight food crops in the sample are: paddy rice, hybrid corn, cassava, sweet potato, peanut, soybean, mung bean, and taro. Among these, paddy rice, hybrid corn, and cassava are classified as ATDP demonstration crops; the remaining five are non-demonstration crops grown in both treated and control provinces. Table 1 presents descriptive statistics for all variables.

Table 1. Descriptive Statistics for All Variables

Variable	Definition	Obs.	Mean	S.D.	Min	Max
Crop output panel						
Area	Harvest area (log, ha)	6,84	9.842	2.615	0.000	15.437
Prod	Grain production (log, ton)	6,84	10.124	2.748	0.000	15.892
Yield	Unit yield (log, ton/ha)	6,72	8.245	0.612	0.693	10.973
PP	Producer price (log, USD/ton)	6,888	3.187	1.924	0.000	7.213
GPV_constant	Output value, constant price (log)	6,888	8.042	4.318	0.000	14.756
AgLand	Agricultural land area (log, ha)	6,804	10.235	1.342	4.127	12.184
AgFixCap	Agricultural fixed capital (log)	6,888	9.124	1.857	5.314	13.458
RuralPop	Rural population (log)	6,852	12.456	0.984	9.341	14.127
GDP	Provincial GDP per capita (log)	6,72	7.234	0.876	5.124	9.847
FDI	Foreign direct investment (log)	6,588	6.845	2.134	0.891	10.234
ATDP	Dummy: ATDP recipient province	8,064	0.254	0.435	0	1
Crop	Dummy: demonstration crop	8,064	0.375	0.484	0	1
Post	Dummy: post-2010 implementation	8,064	0.688	0.463	0	1
Trade panel						
ImpQn	Import volume (log, ton)	7,812	3.845	4.127	0.000	14.231
ImpVal	Import value (log, USD)	7,812	2.634	3.517	0.000	13.847
ExpQn	Export volume (log, ton)	7,812	4.218	4.563	0.000	15.124
ExpVal	Export value (log, USD)	7,812	3.847	4.012	0.000	14.538

Source: GSO Vietnam, FAOSTAT, MARD. Note: Except dummy variables, all variables are in logarithmic form

Variable Construction

Dependent variables. The primary outcome variables capture three dimensions of food crop performance. The first group measures agricultural output: harvest area (Areairt), grain production (Prodirt), and unit yield (Yieldirt) for crop i in province r and year t (Ayalew et al., 2022; Barbier, 2023). The second group measures trade flows: import volume (ImpQnirt), import value (ImpValirt), export volume (ExpQnirt), and export value (ExpValirt). The third group measures value chain outcomes: producer price (PPirt) and grain output value at constant and current prices (GPVirt). All dependent variables enter in logarithmic form.

Core independent variables. Three binary variables define the triple DID structure. ATDPr equals one for the 16 first-cohort recipient provinces and zero otherwise. Postt equals one for years 2010–2020 (post-implementation) and zero for 2005–2009 (pre-implementation). Cropi equals one for paddy rice, hybrid corn, and cassava (demonstration crops) and zero for the five non-demonstration crops (Beaman et al., 2021; Béné et al., 2021; BenYishay & Mobarak, 2019).

Control variables. Province-level controls include: agricultural land area (AgLandrt), agricultural fixed capital formation (AgFixCaprt), rural population (RuralPoprt), provincial GDP (GDPrt), and foreign direct investment (FDIrt) (Ceballos et al., 2020; Cook et al., 2021). All controls are measured in logarithmic form. When province-year fixed effects are included, these time-varying province controls are absorbed and not separately identified.

Identification Model

We adopt the triple DID framework to identify the causal effect of ATDPs on food crop performance by comparing, simultaneously (Delgado & Stoorvogel, 2022; Dhehibi et al., 2020; M. H. Do et al., 2023): (i) recipient versus non-recipient provinces, (ii) demonstration versus non-demonstration crops, and (iii) pre- versus post-implementation years. The benchmark model is specified as:

$$\mathrm{Outputirt} = \beta 0 + \beta 1\mathrm{ATDPr} \times \mathrm{Postt} \times \mathrm{Cropi} + \rho \mathrm{Xrt} + \alpha \mathrm{i} + \gamma \mathrm{r} + \delta \mathrm{t} + \lambda \mathrm{rt} + \mu \mathrm{it} + \nu \mathrm{ri} + \varepsilon \mathrm{irt} \quad (1)$$

Output$_{irt}$ is the relevant crop outcome for crop i in province r at time t. The key parameter of interest is β_1, which captures the differential effect of the ATDP on demonstration food crops in recipient provinces relative to non-demonstration crops and non-recipient provinces, after accounting for common time trends. A statistically significant positive β_1 indicates that the ATDP improves food crop output in recipient provinces.

The model includes a comprehensive set of fixed effects: αi (crop fixed effects), γr (province fixed effects), δt (year fixed effects), λrt (province × year fixed effects), μit (crop × year fixed effects), and νri (province × crop fixed effects). The province × year fixed effect controls for any province-specific shocks in each year including local conflicts, natural disasters, economic fluctuations, and provincial policy reforms that might confound the ATDP treatment effect (M. H. Do et al., 2022; T. L. Do et al., 2022; Fabregas et al., 2019). The crop × year fixed effect absorbs global price shocks, international demand fluctuations, and crop-specific technological changes. The province × crop fixed effect controls for historically persistent differences in crop cultivation across provinces (e.g., agro-ecological suitability, traditional farming systems). Standard errors are clustered at the crop level throughout.

EMPIRICAL RESULTS

Parallel Trend Test

The credibility of the DID design rests on the parallel trend assumption: in the absence of the ATDP, treated and control provinces would have exhibited similar trajectories in demonstration crop outcomes. We assess this visually and formally.

Figures 1 and 2 plot the average annual harvest area and production of demonstration crops (solid line) and non-demonstration crops (dashed line) in recipient and non-recipient provinces from 2005 to 2020. The vertical line marks 2010, the year of program implementation.

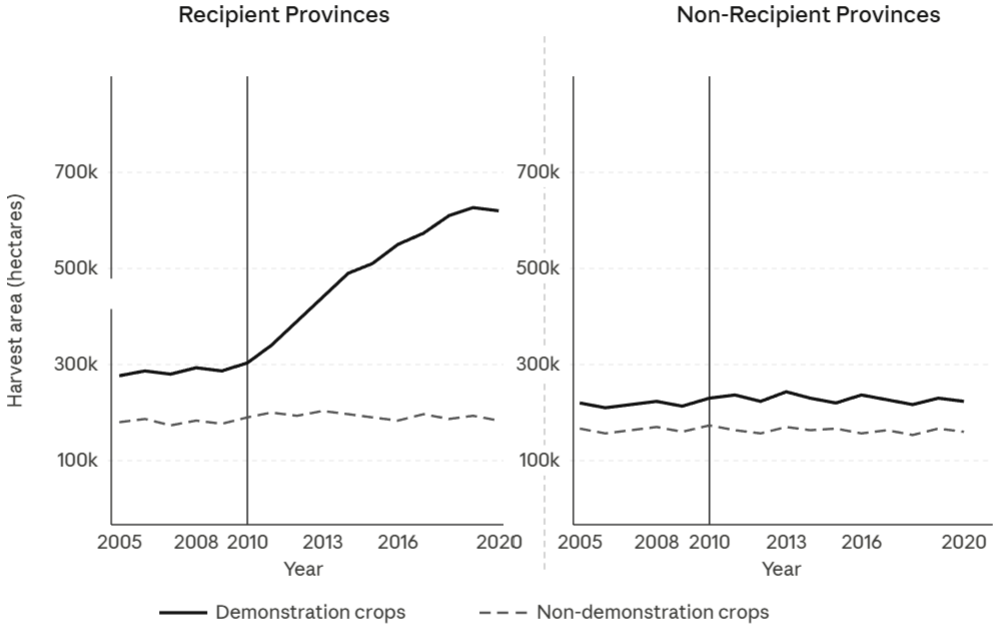

Figure 1. Parallel trend of crop harvest area (2005–2020). Vertical line = 2010 (ATDP implementation).

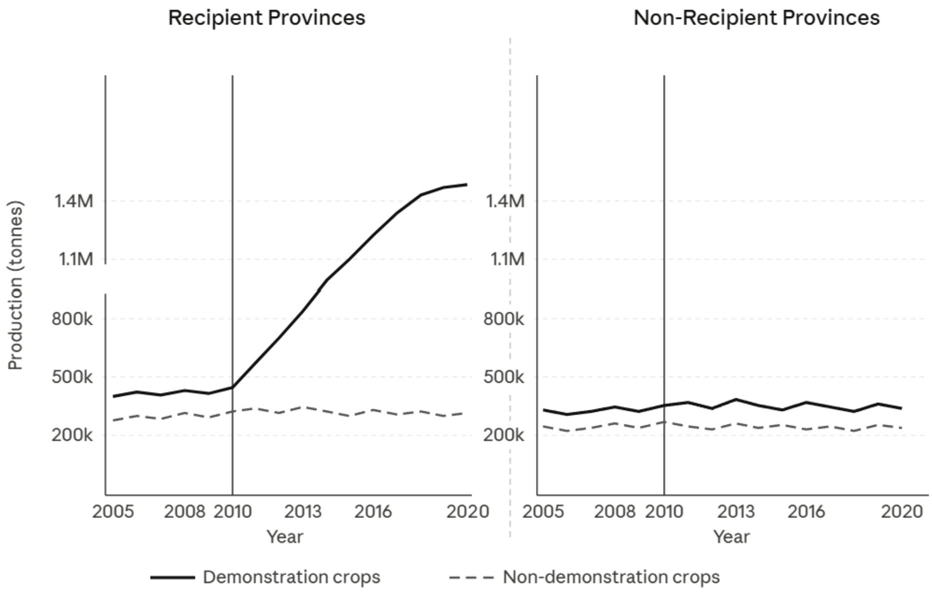

Figure 2. Parallel trend of crop production (2005–2020). Vertical line = 2010 (ATDP implementation).

The figures reveal a clear pattern. In both recipient and non-recipient provinces, demonstration and non-demonstration food crops followed closely parallel trajectories in harvest area and production from 2005 through 2009, prior to program implementation. After 2010, demonstration food crops in recipient provinces diverged sharply upward, while non-demonstration crops in the same provinces and all crops in non-recipient provinces remained comparatively stable. This visual evidence supports the parallel trend assumption and provides preliminary validation of the triple DID design.

Baseline Regression Results

Table 2 reports the baseline regression results. Columns (1) and (2) examine harvest area, columns (3) and (4) examine production, and columns (5) and (6) examine unit yield. Odd-numbered columns include crop, province, and year fixed effects plus province-level controls. Even-numbered columns add the full set of high-dimensional fixed effects (province × year, crop × year, province × crop). Standard errors are clustered at the crop level.

Table 2. Effect of ATDPs on Crop Output

Variable	Area (1)	Area (2)	Prod (3)	Prod (4)	Yield (5)	Yield (6)
ATDPr × Postt × Cropi	0.243**	0.183**	0.287**	0.148**	0.038	0.052
	(0.108)	(0.086)	(0.124)	(0.067)	(0.063)	(0.049)
ATDPr × Postt	0.162*	—	0.197*	—	0.021	—
	(0.091)		(0.097)		(0.042)	
Cropi × Postt	0.031	—	0.087	—	0.058*	—
	(0.127)		(0.148)		(0.031)	
AgFixCap	0.138***	—	0.183***	—	0.038*	—
	(0.028)		(0.041)		(0.021)	
RuralPop	0.714*	—	0.803	—	0.094	—
	(0.387)		(0.512)		(0.318)	
Observations	6,388	6,247	6,388	6,247	6,274	6,128
R^2	0.548	0.984	0.567	0.981	0.497	0.934
Crop FE	Y	Y	Y	Y	Y	Y
Province FE	Y	Y	Y	Y	Y	Y
Year FE	Y	Y	Y	Y	Y	Y
Province × Year FE		Y		Y		Y
Crop × Year FE		Y		Y		Y

Province × Crop FE	Y	Y	Y

Note: Standard errors clustered at the crop level in parentheses. * p<0.10, ** p<0.05, *** p<0.01. All interaction terms and province-level controls included but not reported for brevity.

The coefficient of primary interest, β_1 on ATDPr × Postt × Cropi, is positive and statistically significant at the 5% level for both harvest area and production across all specifications. In our preferred specifications (columns 2 and 4), which include the full set of fixed effects, the ATDP increased the harvest area of demonstration food crops in recipient provinces by approximately 20.1% (exp(0.183) − 1) and total production by approximately 15.96% (exp(0.148)−1) on average, relative to non-demonstration crops in the same provinces and all crops in non-recipient provinces. The coefficient on unit yield is positive in sign but statistically insignificant, suggesting that in the early program stages, land area expansion precedes yield intensification a pattern consistent with the pre-implementation profile of recipient provinces, which possessed large tracts of underutilized arable land and low mechanization rates. Fixed capital in agriculture (AgFixCap) consistently shows a significant positive effect on area and production, confirming the importance of infrastructure investment as a complementary input.

Robustness Tests

We conduct two principal robustness tests. First, we implement event-study analysis to verify the parallel trend assumption formally and document the dynamic treatment effects. The event-study model replaces the Postt dummy with a full set of year-relative-to-treatment dummies, using 2009 (the year preceding implementation) as the omitted reference category:

$$\mathrm{Outputirt} = \beta 0 + \sum_{k=-4}^{-1} 1\delta k\left(\mathrm{ATDPr} \times D_t^k \times \mathrm{Crop_i}\right) + \sum_{k=1}^{10} \delta k(\mathrm{ATDPr} \times D\_t\text{^}k \times 〖\mathrm{Crop}〗\_i) + \rho \mathrm{Xrt} + \alpha i + \gamma r + \delta t + \lambda rt + \mu it + \nu ri + \varepsilon irt \quad (2)$$

Figures 3 and 4 plot the estimated δk coefficients with 95% confidence intervals for harvest area and production, respectively. The pre-period coefficients (k = −4 to −1) are uniformly close to zero and statistically insignificant, confirming the parallel trend assumption. Post-implementation, treatment effects are initially indistinguishable from zero in 2010 and 2011, then rise sharply from 2012 onward approximately two years after formal program implementation, consistent with the typical gestation period for agricultural technology adoption and scaling. Effects stabilize at positive levels from 2014 through 2020, with harvest area gains larger than production gains in early years and production catching up as yields improve in later program years.

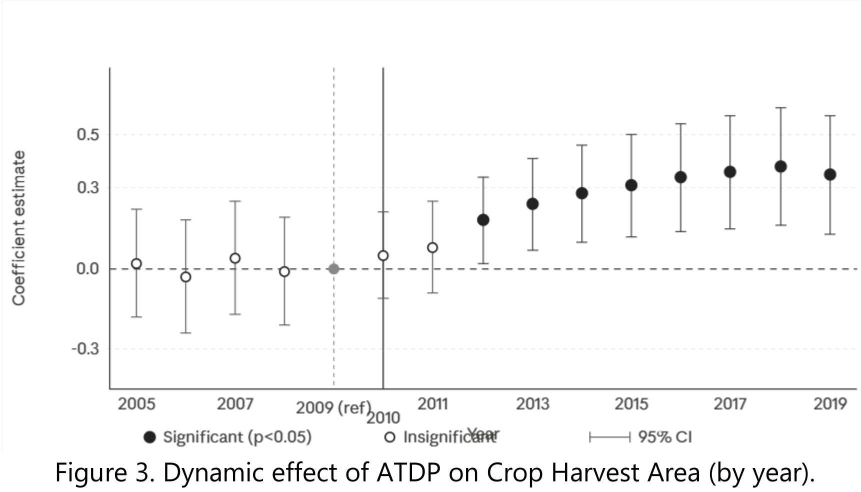

Figure 3. Dynamic effect of ATDP on Crop Harvest Area (by year).

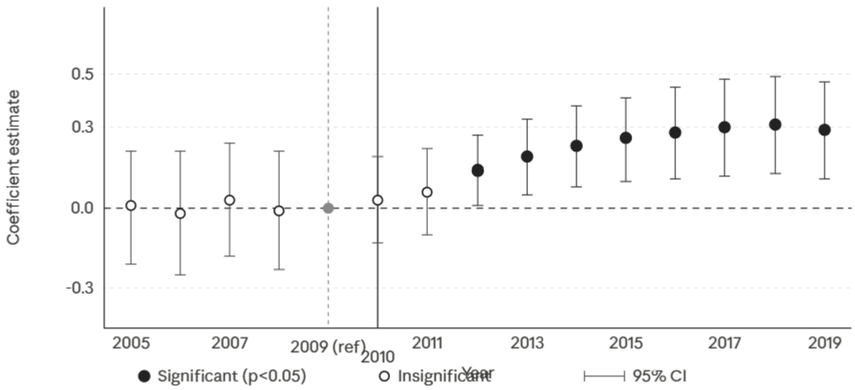

Figure 4. Dynamic effect of ATDP on Crop Production (by year)

The dynamic effects in Figures 3 and 4 are mutually consistent. Pre-program coefficients are uniformly centered around zero and statistically indistinguishable from the reference year, satisfying the parallel trend requirement. The transition period (2010–2011) shows positive but insignificant effects, reflecting the time required for demonstration sites to become fully operational, for extension staff to be trained, and for demonstration crop varieties to disseminate to smallholder fields. From 2012 onward, effects are consistently significant and increasing, with some moderation after 2017 as effects plateau consistent with the full absorption of technological gains from the program's initial variety portfolio.

As a second robustness check, we consolidate ATDPr × Cropi into a single indicator variable ATDP_ri, and re-estimate the standard two-group DID coefficient ATDP_ri × Postt. Results are qualitatively identical to the triple DID estimates, with harvest area and production effects significant at the 5% level and of similar magnitude, confirming that our findings are not an artifact of the triple interaction specification.

Further Discussion: Trade and Value Effects

Table 3 examines the effect of ATDPs on trade flows in demonstration food crops. The triple DID specification is retained, with dependent variables successively replaced by import volume, import value, export volume, and export value.

Table 3. Effect of ATDPs on Crop Trade

Variable	ImpQn (1)	ImpVal (2)	ExpQn (3)	ExpVal (4)
ATDPr × Postt × Cropi	−0.312	−0.067	0.485*	0.423*
	(0.384)	(0.241)	(0.268)	(0.231)
Observations	6,984	7,128	7,128	7,128
R^2	0.876	0.891	0.758	0.761
Province × Year FE	Y	Y	Y	Y
Crop × Year FE	Y	Y	Y	Y
Province × Crop FE	Y	Y	Y	Y

Note: Standard errors clustered at the crop level in parentheses. * p<0.10.

The import results (columns 1 and 2) indicate a reduction in import volumes and import values for demonstration food crops in recipient provinces following program implementation. Although the coefficients are negative suggesting decreasing import dependence they are statistically insignificant, implying that the self-sufficiency effects are present in direction but insufficiently precise to rule out chance. This finding is consistent with the intermediate-stage nature of the program, where productivity gains have not yet fully substituted for historical import dependencies in all provinces.

By contrast, the export results (columns 3 and 4) are statistically significant. Recipient provinces experienced an average increase of approximately 62.4% in export volumes (exp (0.485)−1) and 52.6% in export values (exp(0.423)−1) of demonstration food crops relative to non-demonstration crops and non-recipient provinces. This export expansion is consistent with improved quality and quantity of demonstration crop outputs, greater commercialization encouraged by higher producer prices, and expanded market linkages facilitated by the GMS regional trade framework. The ATDPs thus appear to strengthen Vietnam's position as a regional food exporter, particularly for paddy rice, hybrid corn, and cassava destined for GMS trading partners.

MECHANISM ANALYSIS

Aid Fund Types and Implementing Agencies

To investigate which program features-drive the observed productivity gains, we disaggregate the ATDP treatment variable by aid modality and implementing agency, drawing on project-level data from MARD and the GMS Secretariat. Following the approach developed in the development finance literature, we focus on four evaluation dimensions: (i) diversification of aid sources (triangulation); (ii) quantity of additional aid resources (count); (iii) project field integrity (field); and (iv) financial scale of investment (USD).

We categorize project-level funding flows into two principal types: free-standing technical assistance (ATDP_TA), which includes certified seed provision, crop demonstration plot management, extension training, and technology exchange with Chinese and Thai research institutions; and grant aid (ATDP_GR), which includes infrastructure investment and capital transfers not tied to specific technical services. The estimation model replaces ATDPr in the benchmark with these project-level type variables, interacted with Postt and Cropi.

Table 4. Reveal a Clear Pattern

Variable	Triangulation Area	Triangulation Prod	Count Area	Count Prod	Field Area	Field Prod	USD Area	USD Prod
ATDP_TA × Post × Crop	0.049**	0.062**	0.041	0.054*	0.045	0.059	0.038**	0.051***
	(0.022)	(0.023)	(0.027)	(0.029)	(0.039)	(0.038)	(0.017)	(0.016)
ATDP_GR × Post × Crop	−0.024	−0.041**	−0.012	−0.029	−0.019	−0.038*	−0.013	−0.025*
	(0.021)	(0.019)	(0.020)	(0.020)	(0.021)	(0.022)	(0.013)	(0.015)
Observations	3,672	3,672	3,672	3,672	3,672	3,672	3,748	3,748
R^2	0.985	0.982	0.985	0.982	0.985	0.982	0.986	0.983

Note: All specifications include Province × Year, Crop × Year, and Province × Crop fixed effects. Standard errors clustered at the crop level. * p<0.10, ** p<0.05, *** p<0.01.

Free-standing technical assistance funds consistently generate positive and statistically significant effects on both harvest area and production across multiple evaluation dimensions. By contrast, grant aid funds show negative coefficients that are significant for production in several specifications, suggesting that non-targeted capital transfers without accompanying technical services may crowd out or distort local agricultural decision-making a finding consistent with the broader aid effectiveness literature on the importance of recipient country ownership and program conditionality.

Regarding implementing agencies, projects executed by state-owned enterprises (SOEs) generate increases in harvest area and production of approximately 5.84% and 5.47%, respectively, relative to other implementing agency types, and these effects are statistically significant. Effects attributable to scientific research institutions and non-SOE private enterprises are positive in sign but imprecisely estimated, likely reflecting the shorter average project durations and narrower technical scope of these actors in the GMS context.

Effects on Provincial Agriculture, Rural Areas, and Food Security

We examine ATDP effects on provincial-level indicators of agricultural development, rural livelihoods, and food security, replacing the crop-level dependent variable with province-level outcomes. Following ATDP implementation, recipient provinces demonstrated significant improvements relative to non-recipient provinces across four key dimensions. The annual growth rate of per capita grain output increased by 214.8% in recipient provinces. The proportion of permanent cropland in total agricultural land increased by 187.3%. The irrigated farmland area expanded by 542.6%. The provincial food shortage index (frequency of food shortages reported as the most acute welfare concern in the Afrobarometer-equivalent Vietnam Household Living Standards Survey) decreased by 2.14 percentage points. The provincial hunger index (adapted from the IFPRI Global Hunger Index methodology for subnational Vietnam) declined by 53.7%.

These magnitudes reflect a combination of direct program effects where demonstration crop varieties replace lower-yield subsistence crops and spillover effects through extension networks, farmer-to-farmer learning, and improved market access. Together, these findings confirm that ATDPs generate broad-based improvements in food security conditions in recipient provinces beyond the demonstration crops themselves.

CONCLUSION

This study examines the causal effects of South-South agricultural technology cooperation on food security using Vietnam's provincial participation in the Greater Mekong Subregion Agricultural Technology Demonstration Program as a quasi-natural experiment. Employing a triple DID identification strategy on a 16-year province-by-crop panel dataset, we find that ATDPs significantly increased harvest area of demonstration food crops by approximately 20.1% and total crop production by approximately 15.96% in recipient provinces. Dynamic event-study analysis confirms that these effects emerge approximately two years after program implementation and persist through the end of the sample period. Further analysis reveals that ATDPs boost export volumes and values of demonstration crops, reduce import dependence (though insignificantly), and improve producer prices and output values. Mechanism analysis demonstrates that free-standing technical assistance generates stronger productivity effects than grant aid, and that SOE-implemented projects outperform other implementing agency types. At the provincial level, ATDPs are associated with higher per capita grain output growth, expanded irrigated farmland, greater permanent cropland proportions, and reduced food insecurity indicators.

These findings carry several implications for policy design. They demonstrate that South-South cooperation when structured around specific technical demonstration activities rather than general capital transfers can generate credible, measurable gains in agricultural productivity and food security for participating provinces. Vietnam's experience suggests a replicable model for other developing economies participating in regional agricultural cooperation frameworks such as the GMS, ASEAN+3 Agricultural Cooperation, or the Belt and Road Initiative's agricultural cooperation pillar.

The finding that free-standing technical assistance drives stronger outcomes than grant aid has direct implications for aid design. Policymakers and program designers should prioritize the delivery of context-adapted technical support variety demonstration, extension training, and knowledge exchange over unconditional financial transfers. The Vietnamese experience suggests that the Chinese hybrid rice and corn varieties disseminated through the GMS ATDP were effective precisely because they were accompanied by hands-on agronomic guidance, appropriate to the local agro-ecological context.

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