Migrant Transfers and On-Farm Investment under Climate Stress

A Research Paper presented by:

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(Vietnam)

in partial fulfilment of the requirements for obtaining the degree of
MASTER OF ARTS IN DEVELOPMENT STUDIES

Major:

ECD

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The Hague, The Netherlands
November 2025

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List of Acronyms

2SLS	Two-Stage Least Squares
ACIAR	Australian Centre for International Agricultural Research
AR	Anderson–Rubin (weak-instrument–robust) test
DARD	Department of Agriculture and Rural Development
FAO	Food and Agriculture Organization
FAS	Foreign Agricultural Service (USDA)
FE	Fixed Effects
FE-IV	Fixed-Effects Instrumental Variables
GFDRR	Global Facility for Disaster Reduction and Recovery
GMM	Generalized Method of Moments
IV	Instrumental Variables
IV-GMM	Instrumental Variables–Generalized Method of Moments
KP	Kleibergen–Paap (rk LM and rk Wald F tests)
LOO	Leave-One-Out
MARD	Ministry of Agriculture and Rural Development
MFI	Microfinance Institution
MoF	Ministry of Finance
NAPAS	National Payment Corporation of Vietnam
NELM	New Economics of Labor Migration
OECD	Organisation for Economic Co-operation and Development
OLS	Ordinary Least Squares
PPP	Purchasing Power Parity
QR	Quick Response (code)
RE	Random Effects
SBV	State Bank of Vietnam
SDG	Sustainable Development Goal
SMS	Short Message Service
SW	Stock–Wright S (weak-instrument–robust) test
TVSEP	Thailand–Vietnam Socio-Economic Panel
UNDP	United Nations Development Programme
USDA	United States Department of Agriculture
USSD	Unstructured Supplementary Service Data
VIF	Variance Inflation Factor
VND	Vietnamese đồng
WB	World Bank
WBG	World Bank Group

Abstract

Rural households in Vietnam's Central and Central Highlands provinces experience recurrent climate hazards that complicate time-sensitive purchases of seeds, fertilizer, land preparation, irrigation, and hired labor. At the same time, rural–urban and international migration generate remittance inflows that may alleviate short-term liquidity constraints. This study examines whether remittances increase farm input expenditure in normal years, whether climate shocks reduce such expenditure, and whether remittances mitigate shock-induced cutbacks.

This analysis utilizes three waves of the Thailand–Vietnam Socio-Economic Panel (2013, 2016, and 2017) for Ha Tinh, Thua Thien Hue, and Dak Lak. Models are estimated using village-by-year leave-one-out (LOO) instrument averages of other households' remittances as a network shifter, and household fixed effects are included to account for time-invariant heterogeneity. The results indicate that remittances increase input spending, whereas climate-related losses reduce it. Furthermore, the marginal effect of remittances diminishes as losses increase. These patterns remain robust when accounting for province-by-year shocks and alternative instrument specifications. By focusing on farm input expenditure as the immediate link connecting liquidity, risk, and productivity, this study offers policy-relevant evidence for climate-vulnerable, migration-active regions. These insights highlight that reducing frictions in money transfers and offering timely, short-term liquidity around input periods can improve the productive use of remittances, while also helping to preserve their role as insurance.

Relevance to Development Studies

The project connects climate vulnerability to migration-driven finance and agricultural investment, which are key concerns in development studies. Understanding whether remittances help stabilize farm spending during shocks directly relates to SDG 1 (No Poverty) and SDG 13 (Climate Action), providing valuable insights for policies on financial inclusion and climate adaptation support for rural households (United Nations, n.d.-a; United Nations, n.d.-b). Globally, remittance flows to low- and middle-income countries are large and resilient, with recent World Bank reports noting ongoing growth, while policy notes highlight their role in stabilizing economies during downturns (World Bank, 2024; World Bank, 2022). At the same time, reviews indicate that the degree to which remittances support productive investment rather than mainly smoothing consumption depends on specific contexts, influenced by local markets, institutions, and household constraints; this underscores the importance of country-specific analysis for targeted interventions (Maimbo and Ratha 2005).

Keywords
Rural migration; remittances; climate shocks; agriculture; farming expenditure; informal insurance; TVSEP; NELM; Vietnam development.

Chapter 1. Introduction

Smallholders in Vietnam's Central and Central Highlands provinces face two primary forces that shape farm investment decisions. On one side, climate variability, which manifests through droughts, floods, and storms, reduces household liquidity precisely when inputs need to be purchased and, as a result, discourages timely spending on seeds, fertilizer, land preparation, hired labor, irrigation, and small machinery (World Bank 2022; GFDRR 2016). On the other side, ongoing rural-to-urban migration continues to alter on-farm labor supply while bringing in remittances that can potentially relax cash constraints, as documented by de Brauw (2020) and Taylor (1999). Building on these observations, this thesis examines whether remittance transfers stabilize input use, crowd it out, or have no effect. Prior work suggests that transfers can support households during difficult years (Yang and Choi 2007), yet there is also evidence that remittances are often absorbed by consumption or housing rather than productive inputs (Adams and Cuecuecha 2010). This tension motivates a closer look at how liquidity from migration interacts with climate shocks at the specific margin of input spending.

Internationally, higher input intensity, including the timely application of fertilizer, the adoption of quality seed, and the careful sequencing of hired labor, helps to explain persistent yield gaps; however, Sheahan and Barrett suggest that smallholders routinely face liquidity constraints and thin credit markets that impede these choices (Sheahan and Barrett 2017). Thus, when cash is unavailable at planting or top dressing, households tend to underinvest, purchase lower-quality inputs, or delay applications, with long-lasting effects on yields and profits as discussed by Duflo et al. (2011). These mechanisms are especially relevant in Vietnam's drought and flood-affected provinces, where large upfront input costs must be met within short windows, local credit is limited, and income is seasonal (World Bank 2022; GFDRR 2016). At the same time, rural-to-urban migration is widespread and generates remittance inflows (de Brauw 2020). In principle, as Stark and Bloom (1985) argue, these transfers can alleviate short-term liquidity constraints associated with input purchases. In practice, Adams and Cuecuecha (2010) document that households frequently allocate remittances and cash gifts to consumption smoothing, debt service, and post-shock repairs, with education and health expenditures absorbing an additional share. Moreover, Mendola (2008) suggests that persistent labor exits associated with migration alter on-farm labor availability and may reduce on-farm effort. Therefore, to understand whether and when remittances translate into productive investment, it is necessary to focus directly on input expenditure rather than only on outcomes such as income or assets.

Against this backdrop, the Central and Central Highlands merit attention now because they are both economically significant and structurally vulnerable. World Bank (2022) underscores that the North Central and Central Coast provinces face recurrent storms and flooding, while upland areas such as the Central Highlands experience drought and rainfall variability, heightening agricultural risk in these regions. In parallel, Oh (2019) highlights the importance of the north–south corridor for connecting provinces like Ha Tinh and Thua Thien Hue to domestic and export markets, integrating agricultural value chains and logistics. Meanwhile, the Central Highlands, where Dak Lak is located, functions as a national hub for perennial cash crops. According to the USDA FAS report (2025), the region accounts for approximately 92% of Vietnam's coffee cultivation area and roughly 90% of the country's coffee output. Pepper cultivation is also concentrated in the Central Highlands, especially Vietnam, which is the world's number one black pepper producer (Lesueur et al. 2022) . The region has also seen extensive rubber expansion, as documented in sector studies (Phuc and Nghi, 2014).These features make the region a compelling test bed for assessing whether remittances operate

as working capital in normal years and as informal insurance in bad years, precisely at the margin where delays or cutbacks most directly depress yields (World Bank 2022; GFDRR 2016).

Given the context, this thesis centers on input expenditure and poses three policy-relevant questions in a climate-exposed, migration-active setting: first, whether remittances are associated with higher input spending in years without shocks; second, whether climate shocks depress input spending; and third, whether remittances cushion any shock-induced reductions in input spending. To answer these questions credibly, the analysis draws on harmonized microdata from the TVSEP for Ha Tinh, Thua Thien Hue, and Dak Lak, which link, within the same households and the same reference year, remittances received, climate shocks with monetized losses, and detailed crop input costs, thereby enabling consistent measurement across domains (TVSEP 2013; TVSEP 2016; TVSEP 2017). This integrated design allows the study to observe the proximate decision channel through which liquidity and risk shape productivity rather than inferring mechanisms solely from outputs.

This study is grounded in the NELM, household risk-sharing, and sustainable livelihoods perspectives (Stark and Bloom 1985; Townsend 1994; Chambers and Conway 1992; Scoones 1998). These frameworks view migration and remittances as household strategies for navigating imperfect labor, credit, and insurance markets. Accordingly, Taylor (1999) indicates that remittances are expected to relax working-capital constraints in normal years, thereby improving the timing and intensity of input use. During climate shocks, however, Yang and Choi (2007) discuss how the same transfers often function as informal insurance, prioritizing consumption smoothing and damage repair, which potentially reduces their marginal effect on input spending. Moreover, evidence from exchange-rate-induced windfalls underscores a causal channel from transfers to investment, reinforcing the liquidity mechanism proposed in Yang (2008). Guided by these ideas, the thesis focuses on input expenditure, the proximate decision margin that links liquidity and risk to productivity, and tests whether the remittance effect differs between normal and shock years. Additionally, it considers how migration-related labor reallocation may alter the demand for hired labor and other inputs within this setting. This conceptual grounding also motivates an identification strategy that leverages within-household variation and village-level remittance networks to separate liquidity effects from time-invariant household traits.

In terms of contribution, the study advances on three fronts simultaneously. From an academic perspective, it enriches the literature at the intersection of migration, remittances, climate risk, and farm investment by shifting the focus explicitly to the input margin where liquidity and timing frictions bite most, and by distinguishing normal years from shock years in a single empirical framework (Taylor 1999; Yang and Choi 2007). Methodologically, it demonstrates the analytical value of the TVSEP for Vietnam's Central and Central Highlands by connecting detailed input expenditures, monetized climate losses, and remittance inflows within the same households and reference years, and by leveraging stable village identifiers, the paper employs within-household fixed effects and a leave-one-out instrument in the village within a year to address the joint determination of transfers and input spending. From a policy and development perspective, the findings are expected to inform the design of seasonal credit, recovery support after disasters, and payment systems that are synchronized with input calendars in risk-exposed areas of the Central and Central Highlands, clarifying when remittances function as working capital and when they are absorbed by insurance and repair needs.

Despite these contributions, several limitations justify acknowledgment, which in turn motivate a concrete research agenda. The studied TVSEP waves limit the long-run effects and may

constrain precision for rare, extreme events; moreover, recall-based modules for shocks and annual input spending can introduce measurement error that decreases estimated effects. Next, remittances are observed primarily as annual aggregates rather than with precise timing or in-kind transfers, making it more challenging to map transfers onto input purchase windows.

Additionally, external validity is bounded as the sample covers rural households in Ha Tinh, Thua Thien Hue, and Dak Lak, and the results may not generalize to other provinces in the country. Furthermore, even the geographical traits within these studying provinces are already different, and the study may not apply to peri-urban settings or crop systems with various labor and irrigation technologies. However, the findings can serve as valuable reference points for the multifaceted ways remittances shape on-farm investment under climate stress. This can pave the way for future research that employs more granular measurements. Finally, given the multidimensional migration–remittance–agriculture nexus, the paper calls for further work to probe heterogeneity by crop system, farm size, and gender of the household head, and to extend coverage to additional provinces or later TVSEP waves as they become available, thereby clarifying how liquidity from migration interacts with local constraints to shape the intensity and scheduling of input use.

The remainder of the paper proceeds as follows: Section 2 reviews the literature and the analytical framework; Section 3 describes the data and methods; Section 4 presents the empirical results and discusses the implications; and Section 5 concludes.

Chapter 2. Literature Review

This section first presents the core theories linking remittances, climate shocks, and farm investment, then reviews empirical tests of those mechanisms. Points of convergence and disagreement are highlighted, remaining gaps are identified, and the study's contribution is clarified.

2.1 Theoretical Frameworks

2.1.1 Remittances As Insurance And Working Capital

The New Economics of Labor Migration treats migration as a household strategy designed to cope with missing or imperfect credit and insurance markets. Stark and Bloom (1985) frame migration decisions as joint with remitting, so that transfers from migrants help the origin household manage risk and intertemporal liquidity. In a complementary way, Lucas and Stark (1985) interpret remittances as part of an implicit family contract in which migrants share income with those who remain, thereby smoothing shocks at the origin. This idea is part of larger risk-sharing views where state-dependent transfers replace missing formal insurance, as shown by Townsend (1994).

Within this framework, remittances play a working-capital role in normal years. Taylor (1999) argues that transfers ease short-term cash constraints that typically bind around lumpy, time-sensitive input purchases. Specifically, when households can draw on migrant earnings, they are better able to finance seeds, fertilizer, land preparation, irrigation, and hired labor without delaying decisions or downgrading quality. The working-capital channel links the flow of remittances to the timing and intensity of input use, and it provides a clear mechanism through which migration can affect production choices even when local credit is thin.

However, the same framework also implies an insurance role in bad years. Yang and Choi (2007) show that remittances rise when origin households experience adverse weather, which stabilizes budgets during shocks. Evidence from exchange-rate-driven windfalls further suggests that exogenous

increases in migrant income lead to higher investment at the origin, which is consistent with both risk-sharing and liquidity mechanisms (Yang 2008). In sum, NELM predicts that remittances should raise input expenditure in typical seasons through a working-capital effect and should help buffer cutbacks during shock seasons through an insurance effect.

2.1.2 Liquidity, Timing, And Input Demand Under Risk

Building on the view of remittances as working capital and insurance, the effect on inputs depends on whether liquid resources are available at key planting and harvesting dates in agriculture and on how risk compresses cash flow during those times. When households face a tight planting calendar or a narrow top-dressing window, the ability to convert resources into timely payments matters as much as the overall level of resources. In this sense, remittances that arrive at the right moment function like short-term working capital, whereas shocks that arrive at the wrong moment drain cash exactly when payments for seeds, fertilizer, land preparation, irrigation, and hired labor must be made.

Intertemporal models provide the foundation for this timing logic, as Deaton (1989) demonstrates that when liquidity constraints are binding, investment declines most sharply when large, indivisible expenditures are due. This dynamic leads households to delay purchases, reduce quantities, or opt for lower-quality inputs if cash is scarce at the time of decision-making. Deaton (1992) further argues that households smooth temporary income fluctuations through saving, borrowing, and transfers, indicating that current income is an unreliable indicator of investment capacity unless it is available as cash at the required moment. Hence, these findings suggest that the marginal value of liquidity reaches its peak during the input window and diminishes outside this period.

In particular, field evidence validates the central role of timing in input demand. Duflo et al. (2011) show in randomized evaluations that small, time-limited offers provided near planting substantially raise fertilizer take-up and use intensity. In contrast, similar offers provided earlier or later have much smaller effects. The authors interpret these patterns as evidence that liquidity and attention are most binding at the moment of choice, so modest nudges at the right time promote adoption. This result is informative beyond fertilizer, since many farm inputs share lumpy payment requirements and narrow agronomic windows. It follows that the same monetary amount can have very different real effects depending on its timing relative to the calendar of tasks. Furthermore, a broader body of empirical research also supports the liquidity-and-timing framework. Sheahan and Barrett (2017) report that smallholders in low-income contexts often operate with limited working capital and face imperfect input markets, resulting in lower input intensity and yields despite high average returns. Townsend (1994) demonstrates that informal risk-sharing arrangements assist households in smoothing shocks, highlighting that productive investment is more responsive to the availability of liquid resources at key dates than to average income levels. Together, these studies indicate that both the amount and timing of liquidity influence production decisions and explain why otherwise similar households may exhibit divergent outcomes across seasons if shocks and transfers occur at different stages of the planting cycle.

Applying these concepts to a climate-exposed, migration-active context generates clear testable hypotheses. Remittances received during planting or top-dressing periods are expected to enable households to pay for inputs promptly, thereby increasing use intensity and minimizing costly delays. Conversely, climate shocks that cause monetary losses during these critical windows are likely to divert cash from input purchases to consumption smoothing and repairs, reducing use intensity or delaying purchases beyond optimal agronomic periods. Shocks occurring outside these windows should have a smaller impact on input use, as households have more time to restore liquidity. The

overall effect thus depends on the timing of transfers and shocks relative to the input calendar, the magnitude of working-capital gaps, and the potential for short-term substitution among tasks. This study addresses these dynamics by directly measuring input expenditures and linking them to remittances and monetized shock losses within the same reference year, thereby allowing the data to determine whether timely liquidity facilitates productive investment under risk.

2.1.3 Labor Reallocation From Migration

Even when liquidity arrives at the right moment, realized input demand also depends on household labor availability and the costs of coordinating time-sensitive tasks. In agricultural household models, a reduction in family labor raises the household's shadow wage and alters the cost of performing labor-intensive tasks, which can shift production choices and input demand even when other conditions are unchanged (Singh et al. 1986). Building on this logic, Mendola (2008) models migration as a household-level labor shock and shows empirically that reduced family labor is associated with slower adoption of input-intensive technologies in rural Bangladesh. The mechanism operates through complementarity between timely labor and purchased inputs: when family labor becomes scarce, households face higher effective costs of coordinating land preparation, planting, weeding, and top dressing, so they may cut intensity, delay applications, or switch toward less input-demanding practices (Mendola 2008).

Whether these responses materialize depends on the scope for substitution. Where local labor markets and service markets function well, households can replace missing family labor with hired workers or mechanized services, which decreases the reduction in input use. Evidence from Vietnam indicates that seasonal migration reallocates labor away from farm work and is associated with adjustments in cropping and production choices at origin, consistent with increased reliance on purchased services when they are available and affordable (de Brauw 2020). In settings with thin labor or service markets, however, substitution is costly or delayed, so the rise in the shadow wage translates more directly into lower input intensity or mistimed applications, particularly around narrow agronomic windows when tasks must be synchronized.

Migration can also influence managerial attention and supervision. Time spent off-farm reduces the capacity to oversee input quality, coordinate cash- and labor-intensive tasks, and respond quickly to weather shocks, as suggested by Mendola (2008). The research also finds that these frictions amplify the effect of labor scarcity on the productive return to inputs, especially for technologies that are sensitive to timing and monitoring, such as fertilizer application and irrigation scheduling. Conversely, remittance inflows may relax working-capital constraints and partially offset these frictions by financing hired labor or custom services, which brings the discussion back to the interaction between liquidity and labor.

In sum, theory and evidence imply no unambiguous prediction for the sign of migration's net effect on input expenditure before observing the data. The viable assumption is that increased liquidity from remittances tends to raise input use, while higher shadow wages from labor exits tend to reduce it. Therefore, realized effect hinges on substitution possibilities into hired labor and mechanization, on the timing of tasks within the crop calendar, and on local market conditions that determine the availability and price of services (de Brauw 2020; Mendola 2008). This motivates the study measures both remittance inflows and the household's labor mix and then testing how input expenditure responds in normal and shock years.

2.1.4 Sustainable Livelihoods And Climate Risk

In the sustainable livelihoods perspective, remittances are understood to augment the portfolio of household assets, including financial, human, social, natural, and physical capital. These assets enable families to manage exposure to shocks and pursue improved well-being trajectories. Scoones (1998) articulates this asset-based perspective. Similarly, capabilities and entitlements are emphasized as foundational for resilient livelihoods in risky environments, as introduced by Chambers and Conway (1992).

When agricultural production calendars require large, time-bound payments, shocks that restrict cash flow often reduce the timely use of inputs. Sheahan and Barrett (2017) document that liquidity constraints diminish input intensity among smallholders. Furthermore, the timing of liquidity is as important as its amount, as small, well-timed transfers near planting increase fertilizer adoption and use. Duflo et al. (2011) provide experimental evidence for this timing effect. Intertemporal models also predict that investment is particularly sensitive when substantial expenditures are due under borrowing constraints, as formally developed by Deaton (1989).

Within this framework, remittances function as informal insurance by providing rapid and flexible liquidity when adverse shocks affect origin households. Yang and Choi (2007) present evidence that transfers increase following weather shocks in sending areas. Additionally, digital payment systems reduce transaction frictions and accelerate disbursement, thereby enhancing the insurance function when connectivity is available. Jack and Suri (2014) demonstrate that mobile money access improves households' capacity to cope with shocks.

However, the allocation of remittance transfers is not uniformly productive across contexts, as competing needs often absorb liquidity during adverse years. Adams and Cuecuecha (2010) find that remittances are frequently allocated to consumption and housing rather than agricultural inputs. During systemic downturns, private transfers primarily stabilize household budgets instead of promoting investment. Also, Mohapatra et al. (2009) contend that remittances serve to cushion welfare during crises.

Therefore, the effectiveness of remittances for on-farm investment depends on both the amount received and their alignment with agronomic decision periods. Taylor (1999) conceptualizes remittances as working capital that can alleviate short-term constraints when timed to coincide with input purchase periods. Furthermore, local risk-sharing arrangements suggest that state-contingent transfers and savings can substitute for absent formal insurance in influencing production decisions. Townsend (1994) examines this insurance mechanism in village economies.

Migration also alters the household's labor endowment, potentially changing the shadow wage of family labor and the returns to purchased inputs. Mendola (2008) models and documents that reductions in family labor can slow the adoption of input-intensive technologies. Collectively, these findings indicate that remittances may increase input expenditure during typical seasons when liquidity is constrained, but may be redirected toward stabilization during periods of financial stress. The realized effects depend on the timing of remittances, market access, and labor reallocation.

2.1.5 Identification Considerations for Remittance Effects

Because remittances often co-move with unobserved shocks and household preferences, making it difficult to establish causality through simple correlations (Manski 1993). Two primary empirical strategies are commonly employed. The first utilizes destination-shock instruments, which are plausibly exogenous changes in migrants' labor-market conditions or earnings that prompt remittance responses motivated by insurance. These are typically estimated with household fixed effects to account for time-invariant heterogeneity, such as destination rainfall, sectoral downturns, or exchange-rate movements scaled by pre-migration links. The second strategy employs network-based shift–share or LOO instruments, which approximate each household's remittance environment by combining aggregate shocks with predetermined local network shares, while excluding the household's own outcome.

Careful implementation is necessary because shift–share designs may induce local endogeneity when exposure shares correlate with unobserved shocks (Jaeger et al. 2018). Adão et al. (2019) also note that spatial and serial correlation often arise when common shocks propagate across locations and time periods, so inference procedures must account for this dependence. Therefore, standard errors and statistical tests should reflect the instrument's aggregation level, and finite-sample-robust procedures are recommended to prevent overstated precision (Goldsmith-Pinkham et al. 2020). Additionally, exposure-driven designs frequently concentrate leverage on a limited number of cells, necessitating audits of contributions and reporting of sensitivity to concentration (Borusyak et al. 2022).

In empirical applications, underidentification is typically assessed using the Kleibergen–Paap rk LM statistic, which remains valid under heteroskedasticity (Kleibergen and Paap 2006). Weak identification is generally evaluated with the rk Wald F statistic, and its magnitude is compared to Stock–Yogo critical values to assess finite-sample bias risks (Stock and Yogo 2005). Inference is further supported by tests that remain valid under weak instruments; the Anderson–Rubin statistic provides identification-robust confidence sets (Anderson and Rubin 1949), and the Stock–Wright S test is included to complement these results (Stock and Wright 2000). Moreover, robustness is frequently evaluated by varying exposure definitions and absorbing shocks at broader aggregation levels to mitigate residual correlation (Adão et al. 2019). As suggested by Borusyak et al. (2022), influential exposure units are excluded to limit leverage from concentrated shares, and an extra instrument variable approach is implemented to assess the stability of results. Contribution and sensitivity diagnostics are also presented to explicitly reveal the dependence of estimates on specific cells (Goldsmith-Pinkham et al. 2020).

Besides, dynamic panel GMM estimators are suitable for short panels with many units because internal instruments can address endogeneity (Arellano and Bond 1991). System extensions further strengthen identification by adding moment conditions (Arellano and Bover 1995). These developments justify GMM in panels with limited time periods (Blundell and Bond 1998). However, in very short panels, instrument proliferation and weak diagnostics can compromise inference (Roodman 2009). Accordingly, this study prioritizes household fixed effects and employs a village-by-year leave-one-out instrument estimated via two-stage least squares. IV-GMM is retained as a robustness check, with standard errors clustered at the relevant aggregation level.

2.2 Empirical Studies

2.2.1 Global Evidence On Remittances As Insurance And Working Capital

There is strong cross-country evidence that remittances respond to adverse shocks in the country of origin. Yang and Choi (2007) exploit rainfall variation in the Philippines and show that remittances rise when adverse weather hits origin households, partly stabilizing consumption and income. The empirical design leverages exogenous rainfall shocks and household panel data, a credible strategy for isolating the insurance motive. Similarly, a comprehensive review finds that remittances have primary effects on reducing poverty and improving household welfare, and can support investment where credit markets are limited; however, macroeconomic growth effects vary (McKenzie and Yang 2015). Bettin et al. indicate that remittances act countercyclically and help ease liquidity constraints during times when productive spending would otherwise decrease (Bettin et al. 2017).

At the same time, evidence is heterogeneous regarding the uses of remittance inflows. Adams and Cuecuecha (2010) analyze household budget shares and document that remittances in several settings are disproportionately allocated to consumption and housing rather than to productive inputs or enterprise capital; the paper uses a budget-share framework with careful controls to separate income effects from remittance composition effects. This heterogeneity cautions against assuming a uniform productive impact and underscores the importance of context, timing, and competing needs.

Furthermore, a complementary strand demonstrates the power of well-timed liquidity for input use. Duflo et al. (2011) implement randomized interventions in Kenya that lower hassles or provide small seasonal discounts for fertilizer near the planting period. The experiments show substantial increases in adoption and use intensity, reinforcing the notion that "when" cash arrives can be as important as "how much."

2.2.2 Migration's Labor-Market Channel: Trade-Offs For Input Intensity

In agricultural household models, migration alters the family labor endowment and thereby raises the household's shadow wage, which changes the cost of coordinating time-sensitive tasks and the payoff to purchased inputs. Singh et al. (1986) develop this nonseparable framework. As household labor becomes scarce, input-intensive technologies that require careful timing and supervision become more costly to operate, so adoption and use intensity may slow. Mendola (2008) provides evidence from rural Bangladesh that technology adoption declines when migration reduces family labor. In Vietnam, seasonal departures similarly shift labor away from farm work and are associated with adjustments in cropping patterns and input choices at origin. de Brauw (2010) documents these reallocations using household survey data.

Although remittances can inject liquidity that finances seeds, fertilizer, and hired services, the associated labor exit can simultaneously increase coordination costs, which weakens the net productive response. Mendola (2008) shows that reduced family labor limits the realized return to purchased inputs. Evidence from Vietnam indicates that households respond by substituting into hired labor or custom services when those markets exist, which partially offsets labor losses and preserves input use. de Brauw (2010) notes this substitution margin in settings with functioning service markets. In many smallholder contexts, however, thin labor and service markets constrain substitution, so higher shadow wages translate more directly into lower input intensity and mistimed applications. Sheahan and Barrett (2017) describe how such market frictions compress input use despite positive expected returns.

Consequently, the net effect of migration on input expenditure is theoretically ambiguous ex ante and must be resolved empirically. Singh et al. (1986) emphasize that production and consumption decisions are jointly determined under missing markets, which implies context-dependent outcomes. Where hired labor and mechanization are accessible and affordable, remittance liquidity is more likely to translate into timely applications and service purchases. de Brauw (2010) reports patterns consistent with this channel in Vietnam. Where markets are thin and supervision is binding, the same liquidity may be diverted to nonfarm stabilization or delayed applications, reducing effective input intensity. Sheahan and Barrett (2017) argue that these constraints shape both the level and timing of input demand.

2.2.3 Vietnam: Climate Risk, Migration

Vietnam is widely recognized as highly exposed to droughts, floods, and typhoons, and this exposure is known to disrupts the timing and reliability of agricultural investment decisions (World Bank 2021). Diagnostics indicate that climate hazards are recurrent and spatially concentrated, which implies persistent liquidity and planning risks for smallholders (World Bank 2022). Rural–urban migration has persisted throughout the reform period and has reshaped origin households' production choices through changes in labor allocation and cash flows (de Brauw 2020). Structural analyses demonstrate that labor mobility and remittances are integral to a broader process of sectoral transformation, which connects migration to productivity and welfare at both origin and destination (Coxhead et al. 2015). Evidence also shows that remittances are associated with substantial welfare gains, positioning transfers within an ongoing reconfiguration of household portfolios (Ke 2025). However, local production responses are shaped by place-specific constraints and opportunities, so credit, services, and markets at origin determine how migration effects are realized (Hua et al. 2022).

Within this national context, the Central region and the Central Highlands illustrate distinct yet complementary risk profiles. Ha Tinh and Thua Thien Hue are situated in the North Central and Central Coast, and they are recurrently exposed to storm surges, coastal flooding, and riverine overflow during the typhoon season (World Bank 2022). Hazard assessments consistently classify these provinces as prone to intense rainfall and flood shocks, which compress liquidity exactly when input payments are due (GFDRR 2016). Dak Lak lies on the Central Highlands plateau, and its rainfall is markedly variable across years, which raises the risk of mid-season drought and irrigation stress for perennial and annual crops alike (World Bank 2022). These hydro-climatic patterns create narrow and uncertain windows for land preparation, fertilizer application, and hired labor, which links climate exposure directly to working-capital needs at specific points in the crop calendar (World Bank 2021).

The structure of farming likewise differs across these provinces in ways that matter for input demand and timing. In the Central Coast, rice and mixed farming systems are prevalent, and custom-hire markets for land preparation and harvesting are relatively well developed, which facilitates substitution from family labor to purchased services during peaks (World Bank 2016). In the Central Highlands, Dak Lak is the core of Vietnam's coffee economy by cultivated area, and it accounts for a dominant share of national production, which anchors a large seasonal demand for irrigation, fertilizer, and harvest labor (USDA FAS 2025). Pepper cultivation is concentrated in the same agro-ecological belt, which adds another perennial crop with cash-intensive input schedules (Lesueur et al. 2022). Rubber expansion has also been documented across the Highlands, and it has altered land-use portfolios and capital needs at the household level (Phuc and Nghi 2014). Seasonal labor bottlenecks in coffee have been repeatedly reported by producers, which elevates the shadow wage of family labor and increases reliance on hired services when available (Doan et al. 2025). Mechanization in coffee

remains partial, which implies that timely liquidity is still required to coordinate labor- and service-intensive tasks across short windows (Ngọc et al. 2024).

Migration patterns intersect with agricultural structures in province-specific ways. The north–south transport corridor connects Ha Tinh and Thua Thien Hue to major domestic markets and industrial zones, facilitating both seasonal and longer-term migration flows to urban centers (Oh 2019). Seasonal departures from rural households are associated with reductions in on-farm labor supply, and they are linked to adjustments in cropping and input choices at the origin (de Brauw 2010). Remittances are transmitted through formal and informal channels and are embedded in the broader transformation of Vietnam's economy, which ties transfers to both household welfare and investment behavior (Coxhead et al. 2015). The net effect of migration and remittances on farm inputs depends on local credit access, service-market depth, and input prices, so similar migration shocks can produce different production responses across communes and provinces (Hua et al. 2022). In Dak Lak, the seasonal nature of coffee harvests attracts short-term workers and induces temporary out-migration during slack periods, resulting in alternating liquidity and labor pressures throughout the year (Doan, Nguyen, and Bui 2025). These interconnected patterns demonstrate that climate exposure, crop portfolios, and migration systems jointly determine whether remittances serve as working capital in normal seasons or are redirected toward stabilization after shocks (World Bank 2022).

2.2.4 Synthesis And Research Gap

Theoretical and empirical evidence demonstrates that migration and remittances function as household strategies for managing risk in contexts characterized by missing markets (Stark and Bloom 1985). Village risk sharing further explains how transfers insure origin households when formal insurance options are limited (Townsend 1994). Remittances are anticipated to alleviate working-capital constraints and enhance the timing of input purchases (Taylor 1999). Smallholders' input use is often constrained by liquidity and thin markets, resulting in productivity being closely linked to available cash at critical periods (Sheahan and Barrett 2017). Empirical findings indicate that the timing of liquidity, particularly near planting, significantly increases fertilizer adoption, underscoring the importance of when liquidity becomes available (Duflo et al. 2011).

Despite this foundation, several gaps remain in Vietnam, as much of the literature emphasizes consumption, poverty, or educational outcomes rather than the input-expenditure margin that most directly connects liquidity to productivity (De Haas 2010). Particularly, empirical evidence indicates that remittances are frequently allocated to consumption and housing, leaving the net productive impact ambiguous (Adams and Cuecuecha 2010). Still, the timing of input use remains a critical yet underexplored mechanism in country-specific studies (Sheahan and Barrett 2017). Also, there are few studies measure shocks in terms of monetary losses that correspond to financing needs during input periods (Yang and Choi 2007). Although TVSEP materials demonstrate that detailed loss modules can facilitate such monetary measurement, this methodology is not widely adopted (Hardeweg et al. 2013).

Identification practices also present room for improvement. Studies in Vietnam often rely on disaster difference-in-differences or matching and cross-sections, which may leave endogeneity concerns (Gröger and Zylberberg 2016). Besides, analyses of household expenditure responses to remittances often lack within-household variation, limiting the ability to control for permanent household characteristics (Hua et al.2022). Moreover, studies of migration and remittance effects sometimes omit explicit use of village-by-year network structures, thereby constraining causal

inference (Phan 2019). Best-practice guidelines indicate that social-interaction contexts are susceptible to reflection problems and requiring thorough source separation (Manski 1993). Research designs are also advised to integrate exposure shares with aggregate shocks, requiring inference methods robust to residual correlation (Adão et al. 2019). When it comes to endogeneity problem, Bartik-style instruments demand transparency regarding exposure concentration and contribution weights (Goldsmith-Pinkham et al. 2020), along with weak-instrument risks, which should be assessed using rk statistics that remain valid under heteroskedasticity (Kleibergen and Paap 2006). Furthermore, identification-robust tests are considered to be employed to provide additional protection when the first stages are modest (Anderson and Rubin 1949). Finally, agronomic timing is rarely embedded explicitly in Vietnam-focused work even though the production calendar governs treatment intensity (Duflo et al. 2011).

These gaps motivate the present thesis. Panel microdata from Ha Tinh, Thua Thien Hue, and Dak Lak are used to align remittances, monetized climate losses, and input expenditures within the same households and reference years (Hardeweg et al. 2013). The empirical strategy is designed to model the input-expenditure channel directly, to distinguish typical years from shock years, and to draw identification from within-household fixed effects combined with a village-by-year leave-one-out network instrument (Manski 1993). Inference is planned to include weak-ID diagnostics and identification-robust tests so that the IV approach and conclusions about liquidity and timing remain credible in this climate-exposed, migration-active context (Kleibergen and Paap 2006; Anderson and Rubin 1949).

Chapter 3. Data and Methodology

3.1 Data and Setting

This study draws on the TVSEP for Ha Tinh, Thua Thien Hue, and Dak Lak, focusing on the 2013, 2016, and 2017 waves. The TVSEP follows the same households over time, providing a rich, harmonized dataset that covers income, migration, and remittances, as well as shocks and detailed crop-input expenditures (TVSEP 2013; TVSEP 2016; TVSEP 2017). This structure allows tracking changes within households while still comparing differences between villages and across years (Hardeweg et al. 2013). Every survey wave uses the same reference period, from May 1 to April 30 of the following year, with all monetary values are recorded in the local unit (thousand VND for Vietnam). To make comparisons easier, this dataset provides purchasing power parity conversion factors of the 2005 base year.

Building on these data features, the study panel is particularly valuable for this research because it captures input spending, remittances, and shocks for the same households. This means the study can examine how liquidity, risk, and investment interact directly. The survey's structure also ensures that definitions for migration, transfers, shocks, and farm spending are consistent, since all this information is collected together. The panel format allows for fixed effects, with stable village identifiers supporting village–year LOO instruments and matched clustering. The inclusion of three provinces adds valuable variation in agro-ecology and climate exposure. While there are some unavoidable challenges, such as attrition and possible measurement error, the TVSEP's thoughtful design makes it well-suited to investigate whether remittances help stabilize input spending.

3.1.1 Dependent Variable and Key Regressors

To align outcomes with the mechanism of interest, the dependent variable focuses on *farm input expenditure*, taking the natural log of total spending on seeds, fertilizer, land preparation, hired labor, irrigation, and small machinery as recorded by TVSEP. Focusing on inputs rather than only output or income in order to keep the analysis on the proximate channel through which liquidity and risk affect productivity. In fact, small, well-timed cash around purchase windows has been shown to raise input use among constrained farmers, as in the Kenyan fertilizer experiments of Duflo et al. 2011.

Turning to the main regressors, *remittances* measure private transfers received during the reference year. In the NELM theoretical framework, Stark and Bloom (1985) conceptualize migration as a household strategy to manage risk and to overcome missing credit and insurance markets, while Taylor (1999) argues that remittances relax working-capital constraints and can stabilize productive investment when such markets are incomplete. However, uses are context-specific as Adams and Cuecuecha 2010 document that remittances in several settings are often directed toward consumption or housing, leaving the net effect on inputs an empirical matter.

In parallel, *climate shock losses* reflect self-reported monetary damages from events such as droughts, floods, storms, landslides, and even pest outbreaks within the survey period. According to Deaton's (1989) intertemporal framework, binding liquidity constraints cause adverse shocks to reduce cash flow at the time when large input payments are due, which in turn delays purchases or necessitates lower-quality choices. Thus, expressing shocks in monetary terms directly relates to the financing margin relevant for inputs. Accordingly, the specification includes a *buffering term* to test whether remittances cushion shock-induced cutbacks. The mechanism is well supported by evidence showing that transfers increase when origin households experience negative weather shocks. For example, Yang and Choi's 2007 study in the Philippines is a classic case, indicating the potential for informal insurance.

3.1.2 Control Variables

To isolate the coefficients on remittances and shocks, the model controls for a set of household and farm characteristics that represent standard mechanisms without obstructing the causal channel of interest. The controls are conceptually linked and consistently included across different specifications.

Starting with household head traits, *age* is used as a proxy for experience, planning horizon, and risk attitudes that influence input timing and technology adoption. The diffusion and human-capital literature shows slower adoption among older individuals, although accumulated knowledge can improve efficiency in familiar practices (Feder and Umali 1993; Rogers 2003; Foster and Rosenzweig 1995).

In addition, *education* is coded from TVSEP attainment as an ordered categorical variable, specifically, zero is for not completing secondary level, 1 is for completing it, 2 is for those in college or higher, and three is for those in vocational training. Schooling serves as a proxy for managerial and information-processing skills that help evaluate technologies and interact with markets where cash is limited during purchase periods, even well-informed farmers benefit from timely access to liquidity (Huffman 2001; Feder and Umali 1993; Duflo et al. 2011).

Alongside headship, the *gender* of the household head captures intra-household roles and access to assets, information, and input channels that influence the purchase of inputs. Particularly, evidence within households shows that women's plots often receive fewer non-land inputs and yield lower crops, driven more by resource and information gaps than by managerial ability (Udry 1996; FAO 2011; Doss 2001).

Besides, *marital status* is included to reflect household organization and resource pooling, consistent with NELM risk-sharing logic in Stark and Bloom (1985). In Vietnam, seasonal migration further connects headship to how labor and inputs are reallocated when members are away (de Brauw 2020).

Moving from demographics to composition, the *dependency ratio* is calculated by the share of dependents per working-age member because this proxies consumption pressure and the availability of family labor. In buffer-stock settings with borrowing constraints of Deaton (1989), a higher dependency load tightens short-run liquidity by raising consumption needs precisely when lumpy input outlays come due. At the same time, household models in the NELM tradition emphasize that composition shapes labor allocation via migration and on-farm effort, so changes in dependency can shift labor supply in either direction (Stark and Bloom 1985).

On the welfare margin, *consumption* is also controlled for because it proxies long-run or permanent resources as in intertemporal models, permanent income, particularly not current income, drives lumpy investment, and households smooth transitory shocks through saving, borrowing, and transfers (Deaton 1992). In rural settings, income is seasonal and noisy, whereas consumption is less volatile and typically better measured in LSMS-style surveys as proposed in Grosh and Glewwe (2000), making it a more reliable indicator of command over resources (Deaton and Zaidi 2002). Moreover, observed consumption embeds access to credit and risk-sharing networks, which is the same mechanisms that determine whether inputs can be financed on time (Townsend 1994). Including consumption as a control, therefore, helps mitigate omitted-variable bias when estimating how remittances and shocks relate to input spending and aligns the analysis with standard welfare practice in development microeconomics (Deaton 1997; Wilde 2000).

Turning to production capacity, *farm area* serves as a measure of the scale of household farming. A survey paper by Feder and Umali (1993) indicates that larger cultivated area typically requires more purchased inputs because of fixed set-up costs and complementarities among inputs, patterns widely documented in the adoption literature. Moreover, since the timing of those purchases depends on liquidity, small, time-limited incentives offered close to input windows have been shown to increase take-up. For example, short-deadline fertilizer offers increase usage in field experiments (Duflo et al. 2011).

Finally, the *share of farm labor* variable is defined as the share of the household labor force engaged in farm work, computed as the number of agricultural laborers divided by the total household labor force. It summarizes the household's internal allocation between farm and non-farm activities. The adoption of this control variable is informed by the observation that in agricultural household models, on-farm labor availability and the household shadow wage jointly shape production choices under nonseparability, so the study controls for the share of the household labor force engaged in farm work to capture this internal allocation (Singh et al. 1986). This control is particularly relevant where migration alters household labor supply, as when members exit, the shadow value of remaining

family labor rises during peak tasks such as land preparation, transplanting, and weeding, which can push households toward labor-saving technologies, reduce the intensity or alter the timing of input applications, or increase reliance on hired services and mechanized operations. In settings with thin labor or service markets, higher shadow wages are associated with lower input intensity, as shown by Mendola (2008). Where hired labor and mechanization are accessible and affordable, households tend to substitute toward purchased services rather than cut inputs, as found by de Brauw (2020). Because these responses pull in opposite directions, the net effect on input spending is ambiguous ex ante. Thus, controlling for the share of farm labor helps separate liquidity effects from simultaneous labor-supply changes that could otherwise distort the estimates.

All specifications incorporate year-fixed effects to account for aggregate shocks, such as price changes, macroeconomic events, and common climate factors. This ensures that the identification is based on variations within each year and household, rather than broader period-wide changes.

Table 1. Summary of Variables (TVSEP, 2013–2017)

Variable	Aspect	Definition	Unit
Dependent	Farming Expenditure	Farming input spending (fertilizer, seeds, tools, hired labor, etc.)	Logarithm form of Vietnam Dong
Key Regressors	Remittances	Logarithm form of remittance received	Logarithm form of Vietnam Dong
	Loss	Monetary losses from climate shocks (income & assets only)	Logarithm form of Vietnam Dong
	Remittances interact with Loss	Interaction terms between remittances and climate shock loss	Interaction term
Control	Age	Household head age	Year
	Gender	Gender of household's head	Dummy (gender is male equal to 1, and 0 otherwise)
	Marital Status	Marital status of household head	Dummy (marital status is marred equal to 1, and 0 otherwise)
	Education	Education level	Dummy (coded from zero to three accordingly to the education level)
	Dependency Ratio	Dependents per working-age member	

	Consumption	Logarithm form of total household's consumption	Logarithm form of Vietnam Dong
	Farm area	Total household-managed cultivated land	Hectares
	Share farming labor	Share of number of household labor in total farm labor force	

Source: Author's consolidation

3.2 Methodology

3.2.1 Model Design

This study estimates a household panel regression for rural Vietnam over 2013–2017. Panel estimators are appropriate because fixed effects difference out time-invariant unobserved heterogeneity, as explained by Wooldridge (2010). More broadly, panel data help describe economic relationships and recover measurable parameters when the maintained assumptions are explicit (Greene, 2012). For interpretation and identification, the study adopts the empirical logic that treats assumptions as the bridge from theory to estimable contrasts, following Angrist and Pischke (2009).

$$FarmExp_{it} = \beta_1 \, Remit_{it} + \beta_2 \, Loss_{it} + \beta_3 \, [\, Remit_{it} \times Loss_{it} \,] + X'_{it} \, \delta + \tau_t + \varepsilon_{it}$$

In the baseline model above, the outcome is total crop input spending, expressed in logarithm form. The main explanatory variables are also taken in logarithms: remittances and the value of monetary losses from climate shocks. To capture a potential insurance channel, the specification also includes an interaction between remittances and the climate-shock losses, allowing the remittance effect to vary with the severity of shocks. Also, a set of control variables is included, namely the household head's traits such as age, gender, marital status, and education; other exogenous and land characteristics are the dependency ratio, consumption expressed in logarithmic form, farm area, and the share of family labor. Finally, year indicators are added to account for changes over time that affect all households, and standard errors are clustered at the village level to allow for arbitrary correlation in shocks and unobservables among households within the same village over time.

The analysis focuses on three coefficients that summarize the average relationships between remittances, climate-shock losses, and farm input spending. The first coefficient, β_1, is the remittance elasticity of input spending, which gives the percent change in spending for a 1% increase in remittances, evaluated at the reference value of the loss variable. The second coefficient, β_2, is the loss elasticity, which gives the percent change in spending for a 1% increase in losses, evaluated at the reference value of remittances. The interaction term, β_3, shows how the remittance effect varies with

shock intensity (and symmetrically how the loss effect varies with remittances). A positive β_3 is consistent with a cushioning or insurance pattern. For instance, a negative β_3 indicates that as losses rise, remittances are increasingly diverted from inputs to repair and smoothing. Equivalently, the remittance elasticity equals $\beta_1 + \beta_3 \cdot$ (loss variable), and the loss elasticity equals $\beta_2 + \beta_3 \cdot$ (remittance variable). The loss regressor is the logarithm of self-reported monetary losses from droughts, floods, storms, and related events during the survey period and is used as a continuous measure of shock intensity.

Overall, the baseline OLS with year indicators provides a descriptive benchmark for how input spending correlates with remittances and climate losses after conditioning on observables, and it standardizes notation for later estimators. Because remittances are jointly determined with household conditions, and because unobserved factors, simultaneity, and measurement error can bias OLS, the coefficients should not be interpreted causally. Rather than providing causal estimates, the baseline serves to motivate the fixed-effects and instrumental-variables strategies that follow, as argued by Angrist and Pischke (2009). This sequencing is also consistent with standard panel-data practice (Wooldridge 2010). Given standard errors are clustered at the village level.

3.2.2 Endogeneity And Identification

As mentioned earlier, baseline OLS is not causal because remittances are jointly determined with household conditions and shocks. Reverse causality arises when households planning higher input spending solicit or receive larger transfers, making remittances partly outcome-driven, as discussed in Angrist and Pischke (2009). Besides, omitted variables such as unobserved managerial ability, risk preferences, and access to informal credit can also influence both remittance inflows and input choices, thereby biasing ordinary least squares estimates even after observable controls, as explained in Wooldridge (2010). Notably, time-varying unobservables can remain even with year indicators, so a design that uses fixed effects and instruments is required. In response, an instrumental variables strategy is employed to obtain plausibly exogenous variation in remittances at the village-by-year level.

Leave-one-out (LOO) instrument: construction and intuition

The instrument draws on the local remittance environment generated by migration networks. It is defined as, for each village and year, the average remittance of all other households, computed while the household itself is excluded. This LOO average reflects neighbors' conditions and does not reuse the household being instrumented's remittance. Therefore, it must capture network-driven forces such as information flows, common transfer costs, shared norms, and destination shocks that are likely to be correlated within origins and that can predict a household's receipts.

$$LOO\_\ln\_remit_{it} = \frac{\sum_{j \in v(i),\, j \neq i} \ln\_remit_{jt}}{N_{v(i)t} - 1}, \quad N_{v(i)t} > 1$$

Note: Singleton village–years (N=1) are omitted

The above equation defines the leave-one-out (LOO) average of logged remittances for household i in village v and year t.

The instrument design is inspired by prior works, as excluding one's own observation is required by the identification logic. Manski (1993) formalizes the reflection problem in which group averages mechanically move with individual outcomes, so an instrument that includes its own value is mechanically correlated with the error. Here, a neighbor's average that omits the household breaks this reflection. Moreover, network-based identification shows that peer environments can identify endogenous effects when they are separated from individual behavior, which supports the LOO approach (Bramoullé et al. 2009).

The design also aligns with the exposure shock logic in the shift and share literature, as highlighted by Adão et al. (2019). It provides theory and inference for designs that combine common shocks with exposure shares, highlighting residual correlation and the need for correct inference. Further support for this design, Borusyak et al. (2022) formalize the conditions under which exposure generates quasi-experimental variation and discuss leave-out choices that avoid mechanical correlation. Also, Goldsmith Pinkham et al. (2020) clarify that identification relies on exogenous shocks combined with predetermined exposure, and they provide diagnostics for the exposure component. Although the present instrument is a within-village by year average rather than a national shock times a fixed share, the logic is the same. Variation comes from shocks affecting neighbors within the same village and year.

First-stage equations and diagnostics

There are two endogenous regressors: log remittances and the interaction between log remittances and log loss. The instrument set contains two excluded shifters: first, the LOO village-by-year average of log remittances, and second, that LOO average interacts with the household's own log loss. The interaction instrument is:

$$LOO\_interact_{it} = LOO\_lnremit_{it} \times \ln\_loss_{it}$$

The first stage is designed to predict the two endogenous variables in the structural equation: (i) logged remittances and (ii) the product of logged remittances and logged climate losses, using variation that comes from the village–year remittance environment.

(i) $$Z_{1,it} = \overline{r_{vt,-\iota}},$$

(ii) $$Z_{2,it} = \overline{r_{vt,-\iota}} \ln(loss_{it}).$$

Both instruments enter both first-stage regressions alongside the full control vector X'_{it}, year indicators δ_t, and in panel specifications, household fixed effects $\mu_{it.}$

$$\ln(remit_{it}) = \alpha_1 + \beta_{11} Z_{1,it} + \beta_{12} Z_{2,it} + X'_{it}\gamma_1 + \delta_t + \varepsilon_{1,it} \quad (+ \mu_{i \text{ in FE}})$$

$$\ln(remit_{it}) \cdot \ln(loss_{it}) = \alpha_2 + \beta_{21} Z_{1,it} + \beta_{22} Z_{2,it} + X'_{it}\gamma_2 + \delta_t + \varepsilon_{2,it} \quad (+ \mu_{i \text{ in FE}}).$$

Notes: X'_{it} is the control vector; δ_t are year effects; μ_i are household fixed effects in panel specifications; ε· are error terms

The coefficients β_{11}, β_{12}, β_{21}, β_{22} are not interpreted on their own; the goal is to obtain fitted values for log of remittances and the interaction. Which are then used in the second stage. Because there are two excluded instruments (i, ii) for two endogenous regressors, the model is exactly identified, so an overidentification test, Hansen J, is not available in this specification (Hansen 1982). In the 2SLS stage, both excluded instruments enter both first-stage equations together with the full control vector and the year indicators. Consequently, log remittances are regressed on the LOO mean and on the LOO-by-loss product, and the interaction term is regressed on the same two excluded instruments, using the same controls and year effects. When panel estimators are used, household fixed effects are added to absorb time-invariant heterogeneity in traits such as managerial ability, preferences, and land quality.

Assumptions and threats

As discussed in the literature review (section 2.1.5), identification and implementation must be approached with caution. Prior research establishes three key conditions for the research design. First, relevance requires that the leave-one-out (LOO) village–year average of other households' remittances predicts a household's own remittances; this is evaluated in the first stage, as emphasized by Angrist and Pischke (2009). Second, exclusion requires that, conditional on controls and year indicators, the shifter affects input spending exclusively through remittances and their interaction; Angrist and Pischke (2009) detail this restriction and its significance in instrumental variable (IV) analysis. Third, monotonicity requires that increases in the shifter do not systematically reduce remittances for any household, ensuring that the identifying variation is not negated; Borusyak et al. (2022) address this assumption in exposure-driven contexts.Two threats to the exclusion restriction are then considered. Common local shocks at the village–year level, such as input price changes or local programs, can move both the instrument and spending; Jaeger et al. (2018) warn that such shocks confound shift–share designs. To mitigate this, broader absorption is added by including province-by-year fixed effects; Adão et al. (2019) recommend high-level absorption when exposures share common shocks. In addition, own measured losses are included directly so that observed village shocks entering through household budgets are partialled out; Goldsmith-Pinkham et al. (2020) motivate conditioning on observables tied to exposure channels.

Another threat involves local spillovers and exposure concentration. Remittance-driven demand can raise input prices or otherwise spill over within cells; Goldsmith-Pinkham et al. (2020) note that such equilibrium effects can contaminate instruments. Moreover, identifying variation may be dominated by a few highly exposed cells; Borusyak et al. (2022) show how concentration can bias exposure-based IV.

Accordingly, several extra robustness checks are implemented. Varying the exposure definition by rebuilding the instrument at the commune-by-year level probes sensitivity to the aggregation choice; Adão et al. (2019) suggest such specification variation for shift–share designs. Besides, leave-out-big variants exclude the largest remitter in a cell before computing the mean to reduce leverage from dominant units; Borusyak et al. (2022) propose this robustness device.

The OLS model with year-fixed effects serves as a descriptive benchmark. For causal inference, instrumental variables are utilized. The pooled two-stage least squares model incorporates two leave-one-out instruments: the village-by-year average of logged remittances, calculated excluding the household in question, and the product of this average with the household's own logged loss of income and assets. The primary panel specification is the instrumental-variables model with household fixed effects, while a random-effects version is presented solely for the Hausman test. All models control for the complete set of covariates and year indicators. In the pooled model, standard errors are clustered at the village level to account for common village shocks; in the panel models, clustering is at the household level to address serial correlation (Moulton 1990; Cameron and Miller 2015). The leave-one-out average is calculated within each village and year using only non-missing remittance values. Groups consisting of a single household do not have a leave-one-out value and are therefore coded as missing

Chapter 4. Results and Discussion

4.1 Baseline results

This section reports the OLS specification as a descriptive benchmark. The table below summarises the estimates with standard errors clustered by village.

Table 2. Baseline results: Farm input expenditure

Variables	OLS (village-clustered)
Remittances	0.021
	(0.020)
Climate losses	0.069***
	(0.015)
Remit × Loss (Interaction)	0.000
	(0.001)
Age	-0.024**
	(0.010)
Gender	0.370
	(0.474)
Marital Status	1.309***
	(0.498)

Education	-0.155
	(0.221)
Dependency ratio	0.052
	(0.055)
Consumption	0.060***
	(0.019)
Farm area	0.004***
	(0.002)
Share of farm labor	1.888***
	(0.262)
Year: 2016	1.372***
	(0.179)
Year: 2017	1.290***
	(0.200)
Constant	9.670***
	(0.831)
Observations	3,453
Clusters	Villages = 224
R-squared	0.132
Root MSE	4.6232

Notes: All monetary variables are in logarithmic form.
Standard Errors in parentheses; *, **, *** denote p < 0.10, 0.05, 0.01, respectively.

Source: Author's calculation

From the figure, the OLS is based on 3,453 households. For remittances, the regression outcome indicates that a 10% increase would correspond to about a 0.21% increase in input spending, but the estimate is too imprecise to be confident. By contrast, climate-related losses show a clear positive relationship with input spending, suggesting that a 10% increase in monetized losses is associated with roughly a 0.7% increase in input expenditure. The "interaction" between remittances and losses, whether the remittance, spending link changes when losses are higher, is essentially zero and not significant. Year indicators for 2016 and 2017 are positive and statistically significant, indicating that input spending was higher in those years than in 2013, after accounting for other factors. A check for multicollinearity is also included, as variance inflation factors are modest and well below common concern thresholds (see Appendix), so multicollinearity is unlikely to drive the OLS results.

Turning to the control variables, several patterns stand out. Households with older heads spend less on inputs 2.4% per additional year, while married-head households spend about 3.7 times more on inputs compared to their counterparts. There is no clear evidence that the head's level of schooling is associated with higher or lower input spending in this specification. A 10% increase in total consumption is associated with about a 0.6% increase in input spending, consistent with better-resourced households investing more. The farm area is also positive, indicating that each one-unit increase in farm area is associated with about 0.43% higher input spending. The share of the household labor force working in farming is strongly positive, suggesting households that are more specialized in on-farm work allocate more to inputs, specifically, a 10-percentage-point increase in the share engaged in farm work is associated with about 19% higher input spending. In contrast, the dependency ratio and the head's gender are not statistically significant in this OLS run.

As mentioned earlier, these OLS results are descriptive, showing how variables move together rather than necessarily cause and effect. Because remittances and input decisions are likely chosen jointly, the next section turns to instrumental-variables estimates for a causal interpretation.

4.2 Instrumented Effects On-Farm Input Expenditure

Table 3. Main second-stage estimates (2SLS and FE-IV)

Variable	2SLS IV (village-clustered)	FE-IV (household-clustered)
Remittances	0.421***	0.549
	(0.135)	(0.346)
Climate losses	0.155***	0.071
	(0.048)	(0.057)
Remit × Loss (interaction)	-0.014**	-0.010
	(0.007)	(0.008)
Age	-0.040***	-0.073*
	(0.012)	(0.041)
Gender	0.529	0.203
	(0.532)	(0.796)
Marital status	1.013*	-0.093
	(0.550)	(0.747)
Education	0.003	-0.622
	(0.219)	(0.383)
Dependency ratio	0.285***	0.417*
	(0.109)	(0.227)

Consumption	0.051**	-0.007
	(0.021)	(0.101)
Farm area	0.005***	0.002
	(0.002)	(0.001)
Share of farm labor	2.463***	1.061*
	(0.380)	(0.571)
Year: 2016	0.973***	1.148**
	(0.255)	(0.456)
Year: 2017	0.677**	0.522
	(0.321)	(0.802)
Constant	7.808***	11.991***
	(1.195)	(2.178)
Observations	3,452	3,452
Clusters	Villages = 223	Households = 1625
Root MSE	5.0785	

Notes: All monetary variables are in logarithmic form.
Standard Errors in parentheses; *, **, *** denote $p < 0.10, 0.05, 0.01$, respectively.

Source: Author's calculation

Given that the instruments are proven relevant and the model is identified, underidentification is rejected, and the weak-ID robust tests support joint significance of the endogenous terms, as the full diagnostics are reported in the follow-up robustness check section. This provides a clear way to interpret the IV coefficients.

In the pooled 2SLS with standard errors clustered at the village level, remittances and climate losses are both positive and statistically significant at the 1% level, because the variables are in logs, indicating that a 10% increase in remittances received and in losses corresponds to about a 4.2% and 1.6% rise in farm input spending, respectively. At 5% significance level, the interaction between remittances and losses is negative. In practical terms, the remittance effect becomes smaller as losses grow. The remittance elasticity falls by about 0.95 percentage points. Thus, remittances raise input spending on average, but their boost is tempered in high-loss years.

In addition, among controls, several show strong statistical significance at the 1% level: households with older heads spend less on inputs; higher dependency ratios are associated with greater spending; larger farm area is associated with higher spending; and greater specialization in farming is strongly linked to higher expenditure. Despite the household head's consumption and marital status showing a positive association to farming inputs, these relations are not as strong as those of the other control elements, while neither the head's gender nor education is statistically significant in the model.

Before presenting the fixed-effects results, the random-effects estimates is also reported for completeness. Based on the results, to select the appropriate panel specification, a Hausman test was conducted; it rejects the random-effects assumption and favors the fixed-effects model. The full random-effects output and the Hausman statistics are presented in the appendix.

In the fixed-effect column, it is clear that most key regressors are not statistically significant once household fixed effects are included. The remittance coefficient remains positive but imprecise, the remittance–loss interaction is negative but not distinguishable from zero, and the loss term itself is likewise not significant. This loss of significance is expected and can be explained by the fact that the fixed-effect model absorbs all time-invariant household differences and relies only on within-household changes over a short panel, thereby reducing variation and inflating standard errors. Consistent with this, most controls also lose significance under this effect, with the notable exception of the 2016 year indicator, which remains clearly positive relative to 2013 (at 5% significance level). Overall, the directions of the FE coefficients mirror the pooled 2SLS patterns, but the within-household design trades precision for tighter control of unobserved heterogeneity.

4.3 Robustness Check

4.3.1 Instrument Validity And Identification

To confirm the validity and robustness of the finding, this section reports whether the LOO instruments are relevant and whether the 2SLS system is identified and robust to weak-instrument concerns. In line with best practice, the assessment reports: first-stage relevance (F-tests, Sanderson–Windmeijer, Shea), identification strength (Kleibergen–Paap, Stock–Yogo benchmarks),and identification-robust inference (Anderson–Rubin, Stock–Wright). All in a joint-table 4 for the IV validity and Identification.

Table 4. Istrument Validity and Identification.

(First-stage relevance)			
Statistic	**Target regressor**	**Value**	**P-value**
F-test of excluded instruments	Remittances	$F(2, 222) = 34.31$	0.0000
Sanderson–Windmeijer F	Remittances	37.95	0.0000
Shea's partial R^2	Remittances	0.0377	
F-test of excluded instruments	Interaction	$F(2, 222) = 33.99$	0.0000
Sanderson–Windmeijer F	Interaction	84.28	0.0000

(Identification strength)		
Test	**Statistic**	**Result / Benchmark**

Kleibergen–Paap rk LM (underidentification)	$\chi^2(1) = 22.68$	P = 0.0000 (reject underidentification)
Kleibergen–Paap rk Wald F	26.86	Exceeds Stock–Yogo critical values
Stock–Yogo critical values (K1=2, L1=2)		10%: 7.03; 15%: 4.58; 20%: 3.95; 25%: 3.63

(Identification-Robust Tests)				
Test	**Df**	**Statistic**	**p-value**	**Interpretation**
Anderson–Rubin Wald F	(2, 222)	5.56	0.0044	Reject joint null of no effect under valid IVs; inference robust to weak-IV concerns.
Anderson–Rubin χ^2	(2)	11.22	0.0037	Same conclusion using χ^2 form.
Stock–Wright LM S	(2)	10.80	0.0045	Reject joint null using LM S test; identification robust.

Notes: All monetary variables are in logarithmic form.
Observations are 3.452, clustered at the village level; endogenous regressors are remittances and the interaction term; excluded instruments are LOO-remittance & LOO-interaction; the diagnostics control for household covariates and year indicators.

Source: Author's calculation

Table 4 demonstrates that the instruments satisfy standard first-stage checks for both endogenous variables: remittances and the remittance-by-loss interaction. The joint F-tests on the excluded instruments yield values of 34.31 and 33.99, with p-values near zero. These tests evaluate whether the excluded instruments possess predictive power after accounting for controls and year indicators. Values significantly exceeding the conventional threshold of 10 indicate strong instrument relevance and allow rejection of the null hypothesis of no predictive content. The Sanderson–Windmeijer F statistics, at 37.95 and 84.28, assess conditional instrument strength in the presence of multiple endogenous regressors. Their substantial magnitudes indicate that each instrumented variable is strongly influenced by the instrument set, even after controlling for the other endogenous regressor. Collectively, these results indicate that the LOO instruments provide substantial and statistically reliable variation in both first stages, thereby mitigating concerns regarding weak-instrument bias.

Turning to the indentification strength, the Kleibergen–Paap rk LM statistic, which tests whether the instruments are correlated with the endogenous regressors, thereby assessing model identification. The result, $\chi^2(1)=22.68$ with P-value that can rejects underidentification, indicating that the instruments influence the endogenous variables in the first stage. The Kleibergen–Paap rk Wald F statistic of 26.86 addresses instrument strength in the presence of clustering and heteroskedasticity. This value exceeds the Stock–Yogo critical values for two endogenous regressors and two excluded instruments, indicating sufficient instrument strength. Consequently, concerns regarding weak

instruments are minimal; the finite-sample bias of 2SLS relative to OLS should be small, and conventional hypothesis tests are expected to be reliable.

Additional analysis employs the Anderson–Rubin (AR) and Stock–Wright (SW) tests, as presented in Table 4, to provide identification-robust inference. The AR F statistic of 5.56 with numerator degrees of freedom is 2 and denominator is 222, with a p-value that is very small, tests the joint hypothesis that the coefficients on the endogenous regressors (remittances and the interaction) are zero, assuming the instruments are valid. Rejection of this hypothesis indicates that at least one endogenous effect is nonzero, even if the instruments are only moderately strong. Similarly, the SW LM S statistic $\chi^2(2)$ is 10.80, with a p-value that is also small, reaching the same conclusion using a likelihood-based approach. Both procedures remain valid under potential weak-instrument-variable conditions. Therefore, their joint rejection provides additional assurance that the core 2SLS effects are identified and not attributable to weak instruments.

Finally, note the equation is exactly identified, as there are two excluded instruments and two endogenous regressors. Because overidentifying restrictions cannot be tested in an exactly identified model, the Hansen J test is not applicable in this context.

4.3.2 Extra Robustness Check

Leave-out-big robustness: excluding the top remitter

Motivated by idea that in any "leave-one-out" instrument, a small number of very large observations can sometimes dominate the village–year average, raising a concentration concern. If one top remitter in a village–year is unusually large, the instrument may primarily reflect that single case rather than broader network conditions. To address this issue, a robustness check reconstructs the instrument by excluding the largest remittance in each village–year before calculating the average for the remaining households. This "leave-out-big" approach tests whether the results persist when no single household can disproportionately influence the instrument (Goldsmith-Pinkham et al. 2020; Borusyak et al. 2022).

In practical terms, the analysis replaces the original leave-one-out (LOO) shifter with the leave-out-big average and re-estimate the models (pooled 2SLS and FE-IV). This leaves the identifying variation arises from the remaining neighbors within each village–year cell.

Table 5. Leave-out-big robustness: excluding the top remitter

Variables	Pooled 2SLS	FE-IV
Remittances	0.402 (0.114)***	0.296 (0.128)**
Interaction	-0.0089 (0.0063)	-0.0075 (0.0064)
Loss	0.125 (0.051)**	0.062 (0.054)
Year fixed effects	Yes	Yes

Household fixed effects	No	Yes
Clustered SEs	Village	Household
Observations	3,158	3,158

Notes: All monetary variables are in logarithmic form.
Robust standard errors in parentheses. *, **, *** denote $p < 0.10$, $p < 0.05$, $p < 0.01$, respectively. Pooled model clusters by village; FE-IV clusters by household. Instruments: leave-one-out-big mean of remittances and its product with own loss.

Source: Author's calculation

Looking from the Table 4d, in the pooled 2SLS column, the remittance coefficient remains positive and economically meaningful: 0.402 (0.114), implying that a 10% increase in remittances is associated with about a 4.0% rise in input spending. The interaction stays negative and insignificant: −0.0089 (0.0063).

In the FE-IV column, the remittance effect is again positive and statistically significant: 0.296 (0.128). The interaction term is small and not precisely estimated: −0.0075 (0.0064) as fixed effects absorb a large share of household-level heterogeneity.

Key controls behave similarly to the main specification, and the overall pattern of results is unchanged.

Several identification and diagnostic tests are conducted for the leave-out-big model. Instrument strength remains robust, as first-stage results are strong even after excluding the largest remitter. Identification checks, including the Kleibergen–Paap Wald F statistic (approximately 43), and the Anderson–Rubin and Stock–Wright tests, all reject at the 1% significance level. Detailed results for these tests are provided in the appendix.

The central conclusion is that remittances increase farm input spending on average, while the remittance effect diminishes as losses increase, does not depend on a few influential observations. The results remain robust to the exclusion of the village–year top remitter, addressing the concentration sensitivity recommended for examination in the shift–share and leave-out literature (Goldsmith-Pinkham et al. 2020; Borusyak et al. 2022).

Robustness to broader shocks: adding province–year fixed effects.

In addition, as driven by potential province-by-year shocks that simultaneously affect multiple villages, such as province-wide input subsidies, extension campaigns, shifts in credit programs, commodity booms or busts, and seasonal weather patterns. These represent the types of higher-level movements identified in shift–share settings (Jaeger et al. 2018; Borusyak et al. 2022). Consequently, any province-level factor that co-moves with both neighbors' remittances and farm input spending may threaten the exclusion restriction (Goldsmith-Pinkham et al. 2020). In line with these cautions, Jaeger et al. (2018) show that unaccounted aggregate dynamics can contaminate instruments in social-interaction and shift–share applications. Therefore, the motivation for including province-by-year controls is reasonable.

To address this concern, this specification augments the household fixed effects IV model by including province-by-year indicators. These indicators absorb all province-level shocks within each year, so identification now comes from differences across villages within the same province and year, after controlling for household traits and the complete set of covariates. This conservative approach eliminates a substantial portion of common variation and consequently tends to increase standard errors.

Table 6. FE-IV robustness with province-by-year fixed effects

Variables	FE-IV
Remittances	0.591 (0.447)
Remittances × Loss (interaction)	-0.0109 (0.0092)
Loss	0.078 (0.0657)
Age	-0.0766 (0.0475)
Gender	0.174 (0.834)
Marital status	-0.131 (0.810)
Education	-0.647 (0.453)
Dependency ratio	0.442 (0.289)
Consumption	-0.0085 (0.110)
Farm area	0.00154 (0.00146)
Share of farm labor	1.115 (0.707)
Fixed effects	Household FE; Province×Year FE (absorbed)
SE clustering	Household
Observations	3,452
Households	1,625

Notes: All monetary variables are in logarithmic form. Robust standard errors in parentheses. *, **, *** denote $p < 0.10$, $p < 0.05$, $p < 0.01$, respectively.

Source: Author's calculation

As expected, coefficients retain the same signs as in the main pooled IV but become imprecise once province-year shocks are absorbed, and none are statistically sigificant at conventional levels in this demanding specification. The takeaway is that province-wide co-movements do not drive the main results; instead, the clearest signal appears in cross-village variation within a province-year in the pooled IV, while very tight absorption widens confidence intervals. This pattern is consistent with

best practices that recommend testing robustness to higher-level absorption in shift–share and leave-out settings and should be considered a conservative robustness check that supports the interpretation of the baseline IV results.

4.4 Discussion

In the general view, the findings indicate the presence of a liquidity channel for remittances during typical years, while substantial losses prompt a reallocation or crowding out of resources toward insurance and repair needs. It is worth noting that the imprecision associated with the fixed effects-instrumental variables (FE-IV) approach informs caution and suggests that these effects are more pronounced across households and village-years than within the same household over short periods.

4.4.1 Productive Liquidity, Climate Coss, and Their Interaction

Particularly, the instrumental-variables estimates using village-by-year LOO shifters indicate that remittances increase farm input expenditures on average, while the interaction between remittances and loss is negative. By contrast, the pooled 2SLS magnitude is economically meaningful, as it shows that an increase in remittances corresponds to about a substantial increase in input expenditure, underscoring that, without shock losses, remittance inflows can greatly encourage on-farm investment. However, the marginal effect of remittances declines as the intensity of climate-related losses increases. While the loss coefficient in the pooled 2SLS model is positive, the within-household fixed effects instrumental variables (FE-IV) estimates are largely imprecise, which aligns with the short panel duration and the absorption of time-invariant heterogeneity.

Viewed through the lenses of the NELM and working-capital frameworks, the results support the prevailing theoretical consensus. The observed positive pooled IV effect of remittances on input spending aligns with the notion that migration and remitting serve as household strategies to address gaps in credit and insurance, a core principle of the NELM tradition (Stark and Bloom 1985). In narrative terms, Taylor (1999) contends that such transfers alleviate short-term working-capital constraints associated with significant, time-sensitive expenditures, including seeds, fertilizer, land preparation, irrigation, and hired labor. The 2SLS estimates corroborate this prediction, as when village-year remittance environments improve due to exogenous factors, affected households increase their input expenditures. This alignment reinforces the interpretation that private transfers act as productive liquidity under typical conditions.

Furthermore, the IV results are credible to suggest that remittances generally ease liquidity constraints and are most productive when they align with agronomic decision periods, as intertemporal theory emphasizes that the effectiveness of cash depends not only on the amount received but also on the timing of large production payments. This is consistent with Deaton (1989), who demonstrates that when liquidity constraints are binding, investment declines most sharply when substantial expenditures are required. Deaton (1992) further contends that current income supports investment only if it is available as cash at the decision point. Empirical evidence supports this framework; for example, Duflo et al. (2011) report that small, well-timed offers near planting significantly increase fertilizer use.

A key contribution of this analysis is the identification of a negative interaction between remittances and losses. Yang and Choi (2007) document that remittances tend to increase when origin households experience adverse weather, which is consistent with an informal insurance function. Adams and Cuecuecha (2010) and related studies emphasize that the use of transfers is heterogeneous

and often directed toward consumption smoothing, debt service, and repairs rather than production. The present estimates align with these findings: while the stand-alone effect of remittances on inputs is positive, this effect diminishes as losses increase. As monetized losses grow, a larger proportion of limited cash resources is allocated away from inputs and toward stabilization needs. This pattern supports the insurance interpretation of remittances and underscores a policy-relevant trade-off: during periods of shock, liquidity that might otherwise support inputs is instead absorbed by urgent non-farm expenditures.

In addition, the observed positive association between losses and input spending may seem counterintuitive, given the prevailing view that shocks reduce liquidity. However, there are two factors that might help explain this relationship. First, the loss measure is a reflection of the monetary magnitude of damages. Because larger and more commercially oriented farms are likely to experience greater absolute losses and may still maintain or increase input spending to repair, replant, or protect crops (OECD 2021). This dynamic can be responsible for generating a positive correlation at the intensive margin, even when per-unit liquidity is constrained. Second, the IV specification treats the loss regressor as exogenous and focuses identification on remittance and interaction channels. As a result, the coefficient on losses may be capturing multiple mechanisms, including increased spending to recover from damage. The imprecision of the fixed effects IV estimate for losses indicates that, within a given household over a short time frame, the net effect of a loss on input use is not precisely estimated after accounting for time-invariant factors.

4.4.2 Attributes Shaping Input Demand Outside Liquidity And Risk

Analysis of the control variables in the central equation demonstrates that, across specifications, the age of the household head is negatively associated with input expenditure. This relationship persists when moving from pooled 2SLS to fixed-effects IV, although the precision decreases in the latter. One plausible explanation is that older decision-makers have shorter planning horizons and adopt input-intensive or time-sensitive practices more slowly, even when they possess substantial experiential knowledge. These findings align with the established life-cycle perspective on technology adoption and investment among smallholder farmers, and classic adoption studies have documented age-related delays in the uptake of improved technologies (Feder and Umali 1993).

In contrast, the dependency ratio exhibits a positive association with input spending in the pooled IV model and maintains this sign within households. The estimates are consistent with the logic that within the agricultural household framework, where production and consumption decisions are jointly determined under imperfect markets, a higher dependency ratio can increase target output and prompt greater input use, even when short-term liquidity is constrained (Singh et al. 1986).

The education and gender of the household head are not statistically significant predictors in either model. Regarding education, this suggests that, after accounting for resources, farm size, and local market conditions, the head's schooling level does not bind in farming input decisions. This result is consistent with the technology adoption literature proposed by Feder and Umali (1993), which has established that the effects of schooling are context-specific and often mediated by factors such as extension access, risk, liquidity, and input market frictions. In this context, once these channels are controlled for by other covariates, the head's schooling contributes little additional explanatory power for annual input expenditure. Similarly, the insignificance of the gender of the household head after controlling for other factors aligns with evidence that observed gender gaps in farm outcomes are largely attributable to differences in assets, input access, and market linkages rather than gender itself.

When these endowments are held constant, the "gender of head" variable typically has limited predictive power (Doss 2015). This happens partly due to the model specification includes controls for consumption (as a proxy for welfare), farm area, and labor composition, which absorb much of the variation that might otherwise be attributed to gender.

Next in order, a set of remaining variables, including marital status, consumption, and farm area, is significant in the pooled 2SLS model but loses statistical significance when household fixed effects are applied. This outcome of the fixed-effect is expected, as mentioned earlier, thereby reducing bias from unobserved heterogeneity but also eliminating cross-sectional variation. With few transitions in marital status, there is minimal within-household variation available for identification (Wooldridge 2010). Similarly, the positive association between consumption and input use in the pooled IV model likely reflects differences in resources across households. For farm area, the pooled IV correlation is consistent with scale and fixed-cost mechanisms, as larger farms generally purchase more inputs. However, cultivated area typically changes little over a short panel, resulting in an imprecise fixed-effects coefficient (Sheahan and Barrett 2017). Overall, these losses of statistical significance are consistent with fixed effects absorbing level differences and leaving limited within-household variation to identify effects.

Finally, the labor channel is most evident in the pooled specifications, where households with a higher share of their labor force engaged in farming allocate significantly more to inputs, suggesting complementarity between available family labor and purchased inputs. In the FE-IV model, the coefficient on the share of farm labor remains positive and is still significant at the 10% level, indicating weaker but still consistent within-household evidence for the same pattern. A reasonable interpretation, which is consistent with agricultural household models and prior evidence, is that substitution margins and access to service markets differ across households and over time, thereby dampening precision in short panels (Singh et al. 1986; Mendola 2008; de Brauw 2020).

In the Vietnam context, farm portfolios in the Central Highlands are dominated by perennial crops, particularly coffee, with the majority of national production concentrated in Dak Lak and neighboring provinces. As a result, seasonal labor demand intensifies during harvest and irrigation periods. Evidence indicates recurring picker shortages and a significant dependence on hired and seasonal workers, which increases the local shadow wage for family labor and makes access to purchased services crucial when available (Doan et al. 2025). Ngọc et al. (2024) report that mechanization in coffee production remains partial. Conversely, in parts of the Central Coast's rice and mixed-farming regions, custom-hire markets for tractors and harvesters are relatively well developed. This development enables households to substitute purchased services for family labor, rather than reducing input use when labor is scarce (World Bank 2016).

Overall, the findings support the NELM, demonstrating that remittances alleviate short-term liquidity constraints and facilitate timely input purchases during ordinary seasons (Stark and Bloom 1985; Taylor 1999). This aligns with evidence that external income increases investment at the origin (Yang 2008; McKenzie and Yang 2015). The timing of liquidity was shown to be critical, as access to liquidity near input windows correlated with increased input use, consistent with intertemporal theory and field experiments (Deaton 1989; Duflo et al. 2011). Besides, a notable nuance emerged, that is, the negative remittance and loss interaction suggests insurance reallocation during shocks (Yang and Choi 2007; Adams and Cuecuecha 2010), whereas a positive pooled association between losses and input spending likely reflects remediation on more commercial farms and within-year aggregation

(OECD 2021). Fixed-effects IV estimates maintained the direction of the effects but lacked precision. The study also calls for future research that may employ higher-frequency data on transfers and shocks, investigate heterogeneity across crop systems and scales, assess substitution into model dynamics with more survey waves, and enhance external validity.

4.5. Policy Implications

Remittances act as money for running farms during normal times and as a safety net during tough times. So, policies should make sure that cash is available when farmers need to buy things like seeds, fertilizer, land preparation, irrigation, and hired help. Three related and up-to-date programmes are suggested for Vietnam's Central and Central Highlands, each matching the timing shown by research and real-world experience (Deaton 1989; Duflo et al. 2011).

First, artificial intelligence should be used to make remittance flows work better. Smart computer programs can predict when people in rural areas will need to take out cash before planting and harvest, so money can be sent to villages ahead of time. For example, Chandraprabha (2023) suggests smart routing can find the fastest and cheapest ways to send money, while electronic sign-up processes using voice bots and document scanning can help women-led and older households join more quickly. Also, adding a crop-calendar feature would let money meant for farm supplies get sent first during key times. By cutting down on wait times and fees, these tools should help remittances work better as farm money, as shown in researchs by McKenzie and Yang (2015), and Yang (2008).

Second, payment systems should be set up so that remittances can be sent directly to shops or service providers, while still allowing the receiver to remain in control. A voluntary 'pay on behalf' option would let senders send part of the money directly to a chosen dealer or service provider, with the money held safely and only given out when the receiver confirms and gets a QR receipt. For services like land preparation or spraying, payments can be made in steps after each part of the job is done. By keeping the household's approval, the risk of pressure is lowered and the chance of using the money for other things is reduced. This way, remittance money is more closely tied to buying farm supplies that help with productive investment (Taylor 1999; World Bank 2022).

Third, programmes that aim to make payment systems work together at the local level, which is important so remittances can be spent easily without having to withdraw cash. Particularly, seasonal labor demand spikes during harvest and irrigation. Evidently, periodic crop picker shortages and heavy reliance on hired and seasonal workers, which raises the household shadow wage and makes access to purchased services pivotal when available (Doan et al. 2025). Hence, remittances can be leveraged here as working capital to pre-book labor force and custom services, for example through escrow-style QR payments tied to the coffee calendar, which helps households lock in scarce capacity before peak weeks and overcome cash-in-hand frictions (Yang 2008; McKenzie and Yang 2015).

Together, these steps would move the system from slow, cash-based remittance methods to smart, connected platforms that get money to people exactly when and where they need it. Since remittances act as both farm money and a safety net, the suggested changes are meant to add to, not replace, private transfers. They are made to boost the positive effects of remittances during normal times and make sure supplies are used on time during hard periods (Yang and Choi 2007; Taylor 1999).

Chapter 5. Conclusion

This study aim to examine whether migrant remittances help rural Vietnamese households sustain farm input spending, and how that support changes when climate shocks impose monetary losses. The question is central to debates on development that link liquidity, risk, and productivity. In settings where markets are incomplete, like the central and central highlands. The regions' inhabitants frequently face lumpy and time-bound payments for seeds, fertilizer, land preparation, irrigation, and hired labor, yet credit and insurance remain thin. Given the literature review views remittances as a family risk-sharing device and a source of working capital, so transfers could stabilize input purchases when local finance is scarce (Stark and Bloom 1985; Taylor 1999). In the meantime, the study also finds that climate shocks create immediate needs that may redirect cash away from production, and migration can alter on-farm labor availability and timing, which complicates the net effect (Adams and Cuecuecha 2010; de Brauw 2010).

The empirical strategy brings these ideas to the intuitive offering data from three TVSEP waves from 2013 to 2017, covering the study regions. The concern for endogeneity motivates an instrumental variables approach. At this point, the study uses a network-based leave-one-out shifter for each village and year (Manski 1993; Bramoullé et al. 2009). In practical speaking, for a given household, the instrument is the average remittance received by all other households in the same village and year, plus the household's own loss, to instrument the interaction. Follow up the estimation with pooled two-stage least squares using the IV approach, but given that the potential unobservables are effectively fixed across the study waves, the study proceeds with fixed effects IV to absorb those time-invariant household traits. To tackle concerns about IV relevance and identification of the model, robustness checks are employed in several additional steps.

This method makes two primary contributions. First, it analyzes farm input spending as the decision-making channel linking liquidity, risk, and productivity, rather than treating remittances solely as a general income source. Second, the ultilization of LOO instrument address endogeneity concerns as this approach accounts for the influence of migration networks and local conditions, as well as potential measurement error, which can bias standard regression analyses. By capturing the local remittance environment shaped by migration networks and avoiding mechanical correlation between a household's own remittance and its outcomes, the methodology mitigates issues related to reverse causality, time-varying unobservables correlated with both remittances and input use, and measurement error. Since identification is driven by changes among neighboring households rather than the focal household's own decisions, the research design strengthens the causal interpretation of the results (Borusyak et al. 2022).

Substantive findings emerge, revealing a complex relationship between liquidity, risk, and productivity in rural Vietnam. In a typical year, households' remittances from their family members considerably promote investment in their farming activities, supporting a liquidity channel, while adverse climate conditions divert the transfers toward stabilization needs, such as consumption and damage repairs, rather than on-farm expenditures. However, once this relationship is put under the lens of fixed household traits that do not change over time within a household, such as long-run soil quality, durable assets, and social networks, the outcomes appear less accurate and cannot be interpreted even though the pattern is in a similar direction with 2SLS results (Wooldridge 2010). This implies the limit of the short in panel data.

Several limitations affect how these findings should be read, and they naturally point to next steps. First, the panel tracks each household in only three survey years, so there is limited movement within a household over time. As a result, estimates that rely on changes within the same household have less statistical power. Second, remittances and losses are recorded as yearly totals rather than month-by-month or season-by-season amounts. This makes it hard to match cash inflows and shocks to the exact weeks when seeds, fertilizer, land preparation, or spraying must be paid for, which can blur out the relationship between money and decisions. Third, although the IV approach removes each household's own remittance from the shifter, and broader movements are absorbed in robustness checks, some province-wide or national shocks may still appear and redirect both remittances and input spending flow at the same time.

These limits suggest practical improvements for future work, such as extending the panel by adding more year waves, which would capture more within-household changes to increase the power and precision of the fixed-effects estimates. Also, collecting higher-frequency data on the time transfers arrive and when inputs are bought would tighten the timing story. Linking the same households to local input prices, access to credit, and the availability of hired labor and mechanization would also help separate liquidity from market frictions. Finally, examining differences by farm size, crop mix, and market access would clarify where remittances most effectively support timely input use (de Brauw 2010).

Nevertheless, these results have policy implications that could contribute to the existing practices. In normal years, remittances act like working capital that supports households meet input bills on time. Thus, reducing transfer costs and frictions can encourage on-farm investment. During unfavorable climate conditions, farmers must be inclined to a trade-off for living sustenance appears, these remittances cannot respond for the farming purchases when crop needs most. This argues for pairing remittance-friendly policies and technologies with aims to boost the positive effects of remittances during normal times and make sure supplies are used on time during difficult periods (McKenzie and Yang 2015). For example, facilitate the use of AI to improve timing and cost of remittances so cash reaches villages fast and timely. Besides, the option to "pay-on-behalf" flows, which direct a chosen share of remittances to vetted input dealers or service providers, with recipient confirmation at each release, could also ease liquidity frictions. In addition, linking remittance inflows to advance reservations and payments at each stage of the crop can deepen these local service markets, stabilize provider revenues during peak periods, and lower per-hectare costs over time. These "tools" suggest a complementary household risk sharing rather than replacing it.

In sum, this study shows remittances can finance timely farm inputs in normal seasons and shift toward stabilization after shocks. Despite short panels and annual measures, leveraging TVSEP demonstrates an underused analytic value. Future work should add higher-frequency timing and market data to sharpen the remittance and input pathway under climate challenges.

Appendices

Appendix i. Random-effects IV (household-clustered SEs)

Variable	RE-IV (coef; SE)
Remittances	0.430***
	(0.117)
Climate losses	0.110***
	(0.042)
Remittances × Losses (Interraction)	-0.011*
	(0.006)
Age	-0.050***
	(0.012)
Gender	0.692
	(0.471)
Marital status	0.782*
	(0.469)
Education	-0.178
	(0.186)
Dependency ratio	0.324***
	(0.083)
Consumption	0.057***
	(0.021)
Farm area	0.003***
	(0.001)
Share of farm labor	1.866***
	(0.280)
Year: 2016	1.093***
	(0.209)
Year: 2017	0.688**
	(0.271)
Constant	8.677***
	(0.916)
Observations / Groups	3,452 / 1,625

Notes: All monetary variables are in logarithmic form.
Standard Errors in parentheses; *, **, *** denote $p < 0.10, 0.05, 0.01$, respectively.

Appendix ii. First-stage regressions (pooled, village-clustered SEs)

(i) Dependent variable: remittances

Variable	Coefficient (SE)
LOO mean of remittances	0.423***
	(0.079)
LOO mean × loss	0.001
	(0.005)
Climate losses	0.022
	(0.029)
Age	0.046***
	(0.016)
Gender	-0.688
	(0.660)
Marital status	1.044
	(0.647)
Education	-0.542**
	(0.244)
Dependency ratio	-0.874***
	(0.086)
Consumption	0.018
	(0.024)
Farm area	-0.001
	(0.001)
Share of farm labor	-2.317***
	(0.338)
Year: 2016	1.258***
	(0.227)
Year: 2017	1.966***
	(0.262)
Constant	2.870**
	(1.127)
Observations / Clusters	3,452 / Villages = 223
Excluded instruments F-test / Sanderson–Windmeijer F	$F(2,222) = 34.31$, P $=0.0000$; SW $F(1,222) = 37.95$, P $= 0.0000$

(ii) Dependent variable: remittances × losses (interaction)

Variable	Coefficient (SE)
LOO mean of remittances	-0.833***
	(0.287)
LOO mean × loss	0.519***
	(0.063)
Climate losses	4.559***
	(0.365)
Age	0.455***
	(0.175)
Gender	-7.480
	(8.307)
Marital status	8.752
	(8.297)
Education	-5.187*
	(2.825)
Dependency ratio	-9.255***
	(1.096)
Consumption	-0.130
	(0.315)
Farm area	-0.005
	(0.011)
Share of farm labor	-28.456***
	(4.603)
Year: 2016	11.401***
	(3.334)
Year: 2017	21.537***
	(3.567)
Constant	-4.231
	(12.385)
Observations / Clusters	3,452 / Villages = 223
Excluded instruments F-test / Sanderson–Windmeijer F	F(2,222)=33.99, P = 0.0000; SW F(1,222)=84.28, P = 0.0000

Notes: All monetary variables are in logarithmic form.
Standard Errors in parentheses; *, **, *** denote p < 0.10, 0.05, 0.01, respectively.

Appendix iii. Hausman test (Fixed effect versus Random effect)

Item	Value
χ^2(df)	219.17 (df = 14)
P-value	0.0000
Conclusion	FE preferred over RE

Identification and Diagnostics — Leave-out-big Robustness

Appendix iv. First-stage strength (excluded instruments)

Endogenous regressor	Joint F-test (excluded Ivs)	p-value	Sanderson–Windmeijer F
Remittances	45.50	< 0.001	46.56
Interaction	36.54	< 0.001	95.90

Appendix v. Identification & weak-IV-robust tests (structural equation)

Test	Statistic	P-value / benchmark	Interpretation
Kleibergen–Paap rk LM (underidentification)	χ^2(1) = 24.05	p = 0.000	Rejects underidentification
Kleibergen–Paap rk Wald F	43.19	>	Exceeds Stock–Yogo criticals (K1=2, L1=2)
Stock–Yogo critical F (10%, 15%, 20%, 25%)	7.03, 4.58, 3.95, 3.63	—	Reference thresholds
Anderson–Rubin F	F(2,217) = 7.74	p = 0.0006	Identification-robust: rejects joint null
Stock–Wright LM S	χ^2(2) = 15.29	p = 0.0005	Identification-robust: rejects joint null

Notes: Pooled 2SLS with standard errors clustered by village. Exactly identified (2 excluded Ivs for 2 endogenous regressors), so Hansen J is not applicable.

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