Timing lumpy investments with informal bridge loans and clunky formal loans: Evidence from Thailand

ANIL K. JAIN, ROBERT M. TOWNSEND, FAN WANG*

Abstract. This paper theoretically and empirically studies how informal credit access helps complete a borrower's choice set. First, using Thai data, we document the size and duration rigidity of formal loans and flexibility of informal loans. Second, we dynamically model a less-studied aspect of formal microfinance lending—short-term formal loans where the borrower must fully repay at maturity. We show that through bridging, short-term informal loans can extend the maturity of short-term formal loans. Third, the calibrated model suggests that bridge financing raises median household welfare by up to 2 percent, with larger gains when investment needs are especially lumpy.

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Section 1. Introduction

In recent decades, formal credit access has expanded rapidly in developing countries, often with the aim of stimulating entrepreneurial activity and facilitating investment among rural households. Yet in practice, the promise of formal finance remains constrained by rigid loan structures and limited capacity for debt rollover. At the same time, informal lenders—neighbors, relatives, local moneylenders—continue to play a pervasive role, offering flexible but often costly short-term loans. This paper explores how these two systems interact, and how informal "bridge" loans may enable households to circumvent formal loan rigidity and undertake lumpy, high-return investments.

We study these interactions through the lens of detailed financial data from Thai villages. Empirically, we document four core patterns: (i) informal and formal loans coexist within most households; (ii) formal loans are typically short-term (bullet) loans with fixed repayment schedules, while informal loans are shorter, smaller, and more varied in cost; (iii) despite the scarcity of long-term loans, large lumpy investments are made only occasionally—typically once every few years—but are common acroos households and (iv) the majority of large, lumpy investments involve interlinked sequential loans where informal loans predominantly appear to bridge the maturity gap between rigid formal loans.

Motivated by the empirical facts, we develop an intertemporal model in which a risk-averse household chooses consumption, savings, and investment over time under a binding liquidity constraint. The household can utilize formal bullet loans and a single-use informal loan that can be used to bridge formal loans. We characterize the optimal joint savings, borrowing, and investment strategies—including those involving bridge-financing—and analyze how changes in formal interest rates and access to informal credit shift the timing of lumpy investment and impact household welfare. The model highlights a simple but powerful mechanism: informal bridge loans allow households to transform a sequence of short-term formal loans into effective longer-term financing, enabling high-return investments that would otherwise be out of reach. Comparative statics and calibrated simulations show that even modest changes in credit terms—particularly formal interest rates and bridge loan fees—can meaningfully shift investment timing, borrowing behavior, and household welfare.

To illustrate the key problem for households, consider a simple example where a farmer has a productive high-return indivisible investment but no assets and no savings; for example, a tractor that does not depreciate, costs \$100, and generates a return of \$66 per year. With well-functioning credit markets, the farmer could borrow the requisite amount (\$100) and slowly repay the debt over time. With only short-term loans with no loan rollover, despite the large potential returns, the project would be supposedly infeasible. One channel to overcome this constraint—that we empirically document and explicitly model—is two consecutive one-year formal loans that are connected by a short-term informal "bridging loan." That is, even though the first lender requires full repayment before making new loans, the farmer could use an informal lender to repay the first lender—the bridge loan—and subsequently take a new loan from the first lender to repay the informal lender. In effect, converting two consecutive one-year loans from the first lender, into a single two-year loan.

Empirically, we draw on rich panel data from the Townsend Thai Monthly Survey, covering over 600 rural households across 16 villages at a monthly level from 1999 to 2009. Formal loans—from state development banks such as the BAAC and from the government's Village-fund—are structured as one-year bullet loans with fixed repayment schedules and standardized loan sizes. In contrast, informal loans—typically sourced from relatives, neighbors, or local moneylenders—exhibit substantial heterogeneity: they are shorter in duration, smaller in size, and show a wide dispersion in interest rates. These differences reflect stark asymmetries in loan design: formal finance offers lower cost but rigid terms, while informal finance offers flexibility at a premium on average.

Next, we document that investments are infrequent and lumpy. We find that the average household makes lumpy productive investments once every 7 to 10 years. The median investments are equivalent to nearly 210 percent of existing capital and up to 83 percent of annual income. Moreover, we find that the acquisition of lumpy investments are followed by substantial increases in household income—averaging a *monthly* rate of return on investment of up to 2.0 percent—suggesting that bridge loans play a critical enabling role in unlocking high-return opportunities.

We connect loans to investments and examine how households reconcile the mismatch between the rigidity of formal loans and the large, lumpy nature of productive investments. Using the monthly panel nature of the loan and investment data, we detect the timing of capital investments and match them to sequences of loans taken closely before the month of investment. We find that the majority of all investments are financed through "bridge structures," in which generally short-term informal loans intersect and overlap with two temporally disjoint but sequential formal loans. These structures allow households to roll over formal debt even when explicit rollover is prohibited, effectively extending the duration of financing beyond one year.

Building on the empirical facts, we model an infinitely-lived farmer in continuous time with a constant relative risk aversion utility function who starts with zero wealth but has a productive potential investment. Our model explores how the farmer's optimal investment decision, consumption, time to invest, and utility change as we alter the credit options available. Specifically, the farmer earns a constant wage and can increase income by investing in a project, which requires a large non-depreciating capital investment that generate a positive flow of returns. We assume that the farmer starts with zero wealth and can finance investment with loans and through a relatively poor savings technology. We make the empirically-based key modeling assumption that the farmer can only borrow for one year at a time and must fully repay before taking a new loan from a formal lender. We assume the informal lender is willing to offer a one-time "bridging' loan, for some fee per dollar of loan. This bridging loan has short maturity and helps to repay an existing formal loan and can be repaid with a subsequent new formal loan. The farmer's optimal investment strategy becomes one of three key feasible strategies: first, formal and informal loans combined with savings; second, formal loans with savings; and three, savings only.

To calculate the potential welfare gain from bridge financing, we calibrate our model to using our empirical findings from Thailand. Considering the median value for lumpy investment size, return on investment, formal interest rate, and informal borrowing cost, and drawing preference parameters from the literature, we estimate welfare consequences of financing strategies by computing consumption equivalent variation (CEV) welfare gains for different financing contracts under different formal and informal loan costs. We find that, at the baseline formal interest rate of 6 percent, a single formal loan already lifts lifetime welfare by roughly 1 percent of wages relative to self-funding; adding an informal rollover (bridge finance) boosts that gain to about 2 percent—a substantial boost to the agent's welfare. These findings underscore the importance of repayment flexibility and the complementarities between formal and informal credit in expanding financial access in rural economies.

Subsection 1.1. **Literature.** The specific features that we observe in informal and formal loans in Thailand are found in other developing countries. Many lending institutions, including both development banks as well as micro-finance lenders, often offer only relative inflexible annualized loans (Morduch 1999; Conning and Udry 2007; Banerjee, Karlan, and Zinman 2015). Despite the fact that rigidity of formal loans is widely noted by policymakers and practitioners, to our knowledge, there are no existing models that explicitly incorporate these rigidity as frictions preventing households from making timely capital investments, and no existing literature or models that directly incorporate the role of flexible informal credit in complementing these rigid formal loan choices. In this paper, we take the rigidity of formal and flexibility of informal loans as given and expand a model with exogenous incomplete consumption, savings and borrowing choices to accommodate loan rigidity through the lens of optimal investment timing decisions problem. The empirical aspects of our paper extends Sripakdeevong and Townsend (2022), which also categorizes empirical bridging linkages across formal and informal loans but do not link loans to investments. While the context differs, our research also echos themes from the literature on trade credit where more flexible informal loans in the form of trade credits offered by non-financial institutions could bridge formal financing gaps (Petersen and Rajan 1997; Giannetti, Burkart, and Ellingsen 2011).

While there is a large theoretical and empirical literature on financial deepening and the effects of micro-credit loans in developing areas (Greenwood and Jovanovic 1990; Banerjee 2013; Kaboski and Townsend 2011; Breza and Kinnan 2021; Buera, Kaboski, and Shin 2021) as well as a long standing and global evidence of the strong presence of informal credit markets in developing areas (Udry 1990; Siamwalla et al. 1990; Morduch 1999), most models of financial access tend to focus on how access to loans impact occupational choices for entrepreneurs without distinguishing between how formal and informal credit markets interact in investments financing. Models that consider heterogeneous financial regimes in village settings often do so by jointly considering income, consumption and investment time series without explicit considerations of the formal and informal credit market choices that translate between these balance sheet streams (Karaivanov and Townsend 2014; Kinnan 2022). Models that do distinguish between formal and informal borrowing often do so in static or two period environments (Gine 2011; Karaivanov and Kessler 2018) and rely on variations in transaction costs and collateral bounds to justify the coexistence of formal and informal options (Gine 2011; Banerjee et al. 2017; Wang 2022). In these settings, informal loans either act as substitutes for formal loans or complement formal loans which are quantity constrained due to collateral requirements.

Given the commonly recognized rigidity in formal loans, a key area of financial innovation in recent years has revolved around increasing the flexibility of formal (microfinance) loans with mounting evidence for positive effects from increasing flexibility in loan repayment terms. For example, Field et al. (2013), using a randomized-control trial that varied loan contracts, find evidence that classic microfinance loan leads to lower investment in illiquid, high-return investments. Aragón, Karaivanov, and Krishnaswamy (2020) find that, using a randomized-control trial that varied loan contracts, loans with more flexible arrangements increased small business profits by facilitating larger investments. Additionally, in terms of liquidity, Karlan and Zinman (2008) find that microfinance loan demand is far more responsive to loan maturity than interest rates. Given the observed high returns to capital among small-scale entrepreneurs (Liu and Roth 2022), the rigidity of formal loans, in conjunction of lumpiness of investments, could be one of the key obstacles reducing the effectiveness of the microfinance push on realizing more wide-spread entrepreneurial gains.

Section 2. Data and Background

We analyze a panel dataset of village households in Thailand. The data provides key empirical facts that motivate our model, and we calibrate the model using this household-level evidence. Thailand offers an excellent setting for studying the interaction between formal and informal credit markets. Thai villages have traditionally supported vibrant informal credit networks (Siamwalla et al. 1990), while formal credit has been supplied by experienced state development banks, most notably the Bank for Agriculture and Agricultural Cooperatives (BAAC). The central government has actively financed the expansion of these development banks and subsidized their operations. As a result, BAAC, like other development banks globally, has historically offered below-market interest rates that are more uniform than those typically provided by commercial banks. In addition, BAAC has traditionally required full repayment of both interest and principal on its loans, as mandated by law (Maurer, Khadka, and Seibel 2000).

In recent years, the government made improving rural informal borrowing conditions a central priority and introduced a set of programs to achieve this goal. The most prominent initiative was the Million Baht Village Fund program (Boonperm, Haughton, and Khandker 2013), which provided every village in Thailand with one million baht in lending capacity. Loans from this program were generally uniform in size and carried identical interest rates. Funds were disbursed via accounts at the BAAC, which also provided logistical support for managing the loans. These loans are generally referred to as "village fund loans." Unlike traditional BAAC loans, Village-fund loans typically had weaker enforcement of repayment requirements and sometimes implicitly permitted loan rollovers. This is partly because loan administration was delegated to village committees rather than the BAAC (Phongpaichit and Baker 2004).

We use the 1999 to 2009 waves of the Townsend Thai Monthly Survey to study how informal choices help to complete the more rigid formal financial options available to households. This dataset is particularly well-suited for analyzing interactions between formal and informal borrowing, as it includes extensive household-level financial data for approximately 650 households across 16 villages in Thailand (Samphantharak and Townsend 2009).[1] Half of the villages are located in the wealthier Central region, while the other half are in the poorer Northeastern region. Households in the survey typically consist of multiple generations and operate a range of household businesses and farms. For each household, the dataset provides detailed monthly records of financial transactions

1. There were 684 unique households in the 1999 wave. Of these, 606 households have complete credit market participation information for all survey years from 1999 to 2009. These households span 16 villages, with between 33 and 44 households observed over the 11-year period in each village. In total, 304 households are from two Northeastern provinces, while 302 households are from two Central provinces.

throughout the survey period, including loan amounts and interest rates for both formal and informal borrowing.

Subsection 2.1. **Loan terms.** We find substantial differences between more rigid formal loans and more flexible informal loans in terms of loan duration, size, and interest rates. Formal loans are predominantly one-year contracts, tend to be larger and more uniform in size, and carry relatively homogeneous and low interest rates. In contrast, informal loans typically have shorter maturities, are smaller and more varied in size, and exhibit both higher average interest rates and greater rate dispersion. Aggregating across provinces and survey years, we present key empirical contrasts in Table 1 and Figures 1, 2, and 3, which compare the duration, size, and interest rates of formal, quasi-formal, and informal loans.[2]

In our analysis, we classify both BAAC and Village-Fund loans as formal, reflecting their more rigid institutional structures. Loans from local moneylenders, neighbors, relatives, and other individual lenders are classified as informal, reflecting their more flexible terms. Loans from village agricultural cooperatives and production groups—locally based organizations with cross-regional ties—are classified as quasi-formal.

A striking feature of formal loans in our empirical setting is their uniform maturity structure: nearly all BAAC and Village-fund loans are due in approximately one year. As shown in column 2 of Table 1, the 20th to 95th percentiles of the formal loan maturity distribution range narrowly from 11 to 13 months. In contrast, informal loans have much shorter and more dispersed maturities, with a median term of just 3 months and only reaching 10 months at the 80th percentile. On average, formal loans are due in just under 13 months—more than twice the average maturity of informal loans, which is just under 6 months. Quasi-formal loans fall between these two extremes: roughly one-third are due in less than 11 months, while 45 percent mature between 11 and 13 months. The largely non-overlapping nature of these maturity distributions is illustrated in Figure 1.

Formal loans offer a relatively rigid menu of fixed loan sizes, in contrast to the smaller and more finely graduated sizes of informal loans. Village-fund loans, for instance, are highly discretized: approximately 90 percent fall between 5,000 and 30,000 baht, in increments of 5,000 baht. BAAC loans exhibit greater variation, but they too are generally issued in 5,000 baht intervals.[3] These institutional constraints are reflected in the distribution of loan sizes: the 5th, 6th, and 7th deciles of formal loan sizes are all exactly 20,000 baht, as shown in column 4 of Table 1.

2. Appendix Figures D.2, D.3, and D.4 provide additional graphical detail, breaking out loan terms by lender category within our broader classifications.

3. The discretization of formal loan sizes is a common feature of development bank lending. From the perspective of managers at national branches, offering a standardized menu of loan options may reduce administrative complexity and lower operational costs relative to tailoring loans to individual borrowers.

While some informal loans are comparable in size to the largest BAAC loans, the vast majority are much smaller. Specifically, comparing columns 5 and 7 of Table 1, we find that at the 30th and 60th percentiles, formal loans are at least five times and twice as large, respectively, as informal loans. The size distributions of formal and informal loans only converge above the 90th percentile. On average, informal loans are just 71 percent the size of formal loans and display no repeated values across deciles, reflecting their relatively more continuous and negotiable nature. In terms of size distribution, quasi-formal loans more closely resemble informal loans. These differences are further illustrated in Figure 2, which plots intersecting log loan size distributions across lender groups.

Interest rates on informal loans exhibit both a higher mean and wider dispersion compared to formal loans. Village-fund loans typically charge uniform interest rates within a given location and time period. For example, at the inception of the Village-fund program, nearly all such loans carried an annual interest rate of 6 percent, while BAAC loans charged 8 percent annually. Aggregating across time, column 8 of Table 1 shows that formal loans have a median monthly interest rate of 0.50%, a narrow interquartile range of 0.46% to 0.67%, and less than a one percentage point spread between the 5th and 95th percentiles.

In contrast, as shown in column 9, informal loans display much greater heterogeneity. While 44% of informal loans report a zero percent interest rate,[4] the average monthly interest rate is 2.36%—substantially higher than the 0.80% average for formal loans. Above the median, the gap between informal and formal monthly interest rates widens from 1.5 percentage points to over 5 percentage points. Quasi-formal loans straddle the two categories: their interest rates resemble those of informal loans below the median and those of formal loans above the median. These broader patterns across lender types are mirrored within the eight main lender categories, whose interest rate distributions are shown in Figure 3.

In addition to loan loan duration, loan size, and loan interest rates. Prior research using the same data has shown that both formal and informal loans have high rate of repayment. Wang (2022) finds that 97 percent of formal loans principals and 95 percent of informal loan principals are repaid within three months of their due dates.

Subsection 2.2. **Investment.** We identify investments by tracking the capital holding of a household and identifying single or consecutive months in which there are jumps

4. We use interest rates reported by households. Ostensibly zero-interest informal loans may require non-pecuniary compensation in the form of goods or services.

in asset holdings.[5] The data include four asset types: agricultural (including livestock), business, land, and household assets. We consider agricultural and business assets as the primary productive assets. Increases in land assets may generate additional production income, but can also be tied to durable consumption and speculation. Household assets are not considered productive. Investments are identified for each asset type individually and across three combined categories: the sum of (1) agricultural and business assets, of (2) agricultural, business, and land assets, and of (3) all four asset types, including household assets. The first two combined categories serve as our primary measures of assets and investments.

In Table 2, we present summary statistics which show that investments happen for most households, but at low frequency. Considering the asset time series that combines agricultural and business assets, we find that 93.2% of households had periods with positive assets during the 160 survey months. We find that 11.0% of households did not make any investments during the 160 months of the survey, 30.4% of households made one investment, 27.8% made two investments, 18.3% made three investments, and the remaining 12.5% made more than three investments. These results are shown in column 5 of Table 2. On average, across all households, 0.15 investments are made per year. In columns of Table 2, we consider alternative definitions of investments and find more occurrences agricultural investments compared to business investments. Overall, our findings here echo the results from Kaboski and Townsend (2011), which finds that 12 percent of households from the 64 villages in the Townsend Thai Annual Survey make lumpy farm and business assets investments each year.

In Table 3, we show that investments are generally large relative to existing asset and income levels. With investment as the unit of observation, we present the relative sizes of investments with respect to the levels of assets in the month preceding the investment as well as the income (revenue minus costs) of the household-firm from the 12 months preceding the month of investment. We first focus on agricultural and business investments. In column 4, we find that productive asset investments are substantial in relative size to existing asset levels. Specifically, at 209%, the median investment to preceding month asset ratio more than doubles the preceding month's asset level, and the interquartile range is between 62% and 1387%, meaning that about 75% of investments increased the combined agricultural and business assets level by more than half. In column 8, we summarize the productive investment to income ratio, considering self-employed productive income from agricultural (including cultivation, livestock, and shrimp and fish) and business sources,

5. We present in Appendix Figure D.1 capital-asset time series and the identification of investment timing for two illustrative households. We compute deviation in assets month by month, and consider jumps as positive differences that exceed a high positive standard deviation threshold. We compute household- and asset-combination specific standard deviation based on monthly asset differences from the household panel.

excluding income from labor and other sources. We find that the median investment to past 12 months total income ratio is about 66%, with the interquartile range between 21% and 327%. We also consider land. Land constitutes a large potential component of productive assets, but the acquisition of additional land might not be relevant for income generation. Column 5 shows that that even considering land, investment to asset ratio remains large with a median ratio of 10% and 3rd quartile ratio of 40%. Column 9 shows that considering land, the median investment to self-employed income ratio reaches 83%, with the interquartile range between 25% and 516%.

Section 3. Linking investments to loans

Subsection 3.1. **Time-linked investments with loans.** We use investment timing information jointly with the timing of the starting and ending dates of loans to identify all loans that are taken out in close proximity to the start of an investment month and repaid after the investment in assets has been made. Specifically, we identify all loans that are taken out between τ months before ($\tau = 6$ for the primary specification) and up to the month in which an investment was initiated; additionally, these loans must be due after the investment has been made.

We consider loans identified in this fashion as loans that could provide financing for the investment made within the τ window.[6] Specifically, let $\underset{\sim}{m}_{\text{inv}}$ and $\tilde{m}_{\text{inv}}$ be the starting and ending month of an investment made by a household. Let $\underset{\sim}{m}_a$ and $\tilde{m}_a$ be the month in which loan a made by the household originates and the month in which it is fully repaid, respectively. Let L be the total number of loans taken out by the household during the span of survey been considered, each investment by the household has a set of "investment-linked" loans L^A:

$$L^A(\tau) = \left\{ a \in \{1, \ldots, L\} \mid \;\; \underset{\sim}{m}_{\text{inv}} - \tau \leq \underset{\sim}{m}_a \leq \underset{\sim}{m}_{\text{inv}} \text{ and } \tilde{m}_{\text{inv}} < \tilde{m}_a \;\; \right\}. \tag{1}$$

L^A might contain the index for multiple loans, obtained from the same or multiple types of lenders. When that is the case, we interpret the household as jointly using multiple loan sources to support financing the initial investment, perhaps complementing loans from different sources given borrowing constraints on each, acting as top-up loans (Gine 2011). If L^A is empty, the investment is not loan-linked.

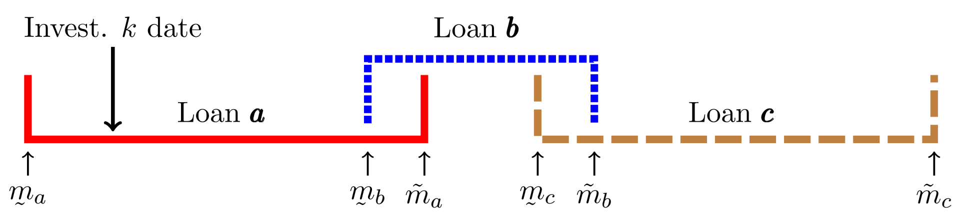
We take Eq. (1) to the panel data and link investments to loans. To allow for time before investment and after, we consider investments made between month 15 and month 145 within the 160 months panel. Additionally, given that households might also

6. It is possible that these newly initiated loans are marked by households as servicing other needs besides financing new investments, but the new loan is a net addition to the cash-on-hand available that would enable investment.

take loans for non-investment purposes, to reduce spurious linkages, we consider only investments that exceed 10,000 baht in drawing investment to loan linkages. For the rest of Section 3, we impose these restrictions on the investment sample. Given the sample, we consider the share of investments that are linked to loans within different τ-sized backward windows. Considering investments in agricultural and business assets, when $\tau = 0$, 36.7% of the investments are loan-linked. When $\tau = 3$, 61.5% of the investments are loan-linked. When $\tau = 6$, 72.1% of the investments are loan-linked. These shares significantly exceed those expected if investments occurred in random months.[7]

Subsection 3.2. **Time-link investments with loan hooks and bridges.** The features of rigid formal loans documented prior provide space for "bridge" loans. A borrower could ease her pending liquidity crunch by borrowing from a flexible bridge lender to help cover bullet debt obligations, and then borrow again from the same or an alternative bullet loan provider to repay the bridge debt and effectively achieve longer-term financing for a portion of the initial investment. To analyze these potential bridged investment to loan linkages, we define sets of loans that are "hooked" and "bridged" to the investment-linked set L^A loans.

For a household, loans a, b, and c form a set of investment-linked bridge loans, if loan a is linked to a particular investment, loans a and b as well as loans b and c are "hooked" together, and the end date of loan a is prior to the start date of loan c.



Specifically, the start and end dates for loans a and b follow this sequence: $\underset{\sim}{m}_a < \underset{\sim}{m}_b \leq \tilde{m}_a \leq \tilde{m}_b$. Similarly, the start and end dates for loans b and c follow this sequence: $\underset{\sim}{m}_b \leq \underset{\sim}{m}_c \leq \tilde{m}_b < \tilde{m}_c$. The end date for loans a and start date for c follow this sequence: $\tilde{m}_a \leq \underset{\sim}{m}_c$. The inequalities in these orderings accommodate limited granularity in the temporal unit of observation—when data is observed monthly, we can not distinguish loan timing sequences within the month. For the household, the set of bridge loans linked

7. In total, there were 15,880 household-months in which new loans were initiated out of a total of 114,318 household-months. If loans were randomly timed across household-months, there would be a 13.9% chance that loans are initiated in any household-month. Appendix Figure D.5 shows that the actual share of investments that are loan linked is significantly higher than the share that would be randomly linked across backward τ windows. As τ extends backward further, the chance that a investment is loan linked approaches 1 by construction.

to a particular investment are:

$$\mathcal{B} = \left\{ (a,b,c) \mid a \in L^A, b \in L^B(a) \text{ and } c \in L^C(a,b) \right\} . \tag{2}$$

$L^B(a)$ contains loans that are "hooked" to an investment via loan $a \in L^A$, and $L^C(a,b)$ contains loans that are "bridge-linked" to the investment via loans a and b.[8]

Building on the investment-loan linkages constructed following Eq. (1), we construct time-linked investment-loan bridges following Eq. (2). Table 4 presents the share of investments by different investment-loan linkage types. Results using the benchmark 6 months backward investment-loan window are shown.[9] Focusing on investments based on agricultural and business assets, we find that 27.9% of investments are "no-loan" investments, with $L^A = \varnothing$. 16.4% of investments are "initial loan set only" investments, with $L^B(a) = \varnothing$ for all $a \in L^A \neq \varnothing$. 6.8% of percent of investments are "hooked loans only" investments, with $L^C(a,b) = \varnothing$ for all (a,b) such that $a \in L^A \neq \varnothing$ and $b \in L^B(a) \neq \varnothing$. 48.6% of investments are "bridge-linked" investments, with non-empty $\mathcal{B}$, and these bridge-linked investments account for more than two thirds (68%) of all loan-linked investments.

Furthermore, focusing on the subset of bridge-linked agricultural and business investments, we find that 7.6% of bridge-linked investments have loan bridges with a single lender. In these cases, the triply-linked loans tend to be all from the Village-fund. Additionally, 8.0% of the bridge-linked investments have loan bridges involving both formal lenders (BAAC and Village-fund). The remaining 84.4% of bridge-linked investments contain loan bridges involving both formal and informal (including quasiformal) bridge components. Finally, among these investments with joint formal and informal investment loan bridges, 57.3% contain loan bridges with formal–informal–formal linkages—for a particular investment made by a household, there exists $(a,b,c) \in \mathcal{B}$ such that loans a and c are borrowed from the BAAC or Village-fund, and loan b comes from an informal or quasiformal lender.

Subsection 3.3. Duration and size of investment-linked loan bridges. In this section, we show the duration overlap across loan segments as well as the relative size of investments and loans within investment-loan bridges. For duration, we compare four time (months) segments summarized in Table 5. First, we compute *bridge-duration*, which is equal to the overall month gap between the start of the loan a and the end of loan c for each investment-linked loan-bridge. The median bridge-duration is 26 months. Second, we

8. In Appendix B, we define loan sets L^A, $L^B(a)$, and $L^C(a,b)$ formally and illustrate types of investment-linked bridge loans.

9. Results using a 3 month backward investment-loan window is shown in similar and shown in Appendix Table D.1.

compute *start-end-duration*, which is equal to the sum of the month gap between the start of loan a to the start of loan b and the month gap between the end of loan b to the end of loan c. The median start-end-duration is 16 months. Third, we compute *overlap-duration*, which is equal to the sum of the number of months in which loan a overlaps with loan b and the number of months in which loan c overlaps with loan b. The median overlap-duration is 7 months. Fourth, we compute *gap-duration*, which is equal to the number of months between the end of loan a and the start of loan c. The median gap-duration is 3 months for all investment-loan bridges and 2 months for those with formal-informal–formal linkages.

Jointly, we find that for the durations of the median investment-linked loan bridge, the bridging loan b originates around 3 months before annual loan a is due and is repaid around 3 months after annual loan c originates, and loan b provides bridging for about 2 to 3 months over the gap between loan a and loan c. There is substantial heterogeneity in loan bridge durations. At the first quartile of investment-linked loan bridge, the bridging is tightened with the overlap-duration falling to 3 to 4 months and the gap-duration falling to 0 month. At the third quartile, the bridging widens with overlap-duration increasing to 11 months, gap-duration increasing to 6 to 7 months, and the overall bridge-duration widening to 34 months. Across quartiles, investment-loan bridges with formal-informal–formal have slightly tighter bridging. Overall, the duration statistics on investment-linked loan bridges provide evidence that households use temporally inter-connected overlapping loans to extend the maturity of otherwise shorter-duration loans.

For size, we compare three relative investment and loan size statistics summarized in Table 6. First, we compute the *loan-a-to-investment ratio*, which is equal to the the principals of a loans divided by the size of investment. Second, we compute the *loan-b-to-a ratio*, which is equal to the ratio of the principal of linked loan b to the principals of a loans. Third, we compute the *loan-c-to-a ratio*, which is equal to the ratio of the principal of linked loan c to the principals of a loans. Jointly, at the median, we find that sufficient loans originate near the start of investment to finance the majority (median loan-a-to-investment ratios exceed 50%) of the financial needs of the lumpy investments. Around one third (median loan-b-to-a ratios are around 30%) of the initial loans are covered with a bridge loan, and a loan of up to half of the initial loan (median loan-c-to-a ratios are around 50%) size is taken out after the bridge-loan facilitated repayment of initial loans.

There are substantial heterogeneities in the loan-a-to-investment ratio. At the first quartile, the ratios remain large at greater than 20%. At the third quartile, the ratios exceed 100%. Total a loan principals can exceed investments because our time-based investment-loan linking strategy picks up all household loans. Given budget fungibility, the loans could be financing investments along with household expenditures for education, health, and other consumption items. Similarly, more expansive definitions of assets/investments across columns of Table 6 lead to a fall in the loan-a-to-investment ratio.

There are also substantial heterogeneities in the loan-b-to-a and loan-c-to-a ratios. At the first quartile, the loan-b-to-a ratios are around 10% and loan-c-to-a ratios are around 15%. The median and below results indicate that for the majority of investments, the timely repayment of loan a principals do not predominantly rely on bridging loans. Households are presumably using returns from investments to support most of the investment-loan repayments.

At the top panel of Table 6, at the third quartile, we find that the loan-b-to-c and loan-c-to-a ratios are both at around 100% among all investment-loan bridges. This show that cross-lender evergreening is present as some households rollover loans of the same size across lenders. Interestingly, among bridges with formal–informal–formal linkages in the lower panel of Table 6, at the third quartile, while the loan-b-to-a ratios are lower at around 60%, we still find 100% loan-c-to-a ratios. There could be excess loan c borrowing due to the clunkiness of formal loans: formal loans are chosen from a limited menu of sizes and repayment requires up-sizing.

Subsection 3.4. **Investments and changes in income.** We now compare two time-matched marginal changes: investment size and income change. Investment size is the difference in assets before and after the months in which an investment is made as discussed in Section 2.2. Income change is the difference between the average monthly income in the 12 months after and before the months of investment. The magnitude of the positive association between the size of investment and the size of income changes provides a measure for return on investment. In Table 7, we present estimates considering all sources of income or only self-employed productive income, and considering productive assets without and jointly with land. We also consider village and survey month fixed effects Our within household time-differencing assures that estimates are not due to correlations in cross-sectional levels, the inclusion month fixed effects difference out secular income growth trends, and the inclusion of village fixed effects difference out village-level factors that might impact investments and income.

We find a strong positive relationship between investment size and household income changes. From column 3 of Table 7, controlling for both village and survey month fixed effects, we find that, on average, investments are associated with 1.3 percent increase in average monthly income in the 12 months after compared to the 12 month before the date of the investment. Without the time and location fixed effects, we find a similar rate of return of 2.0 percent from column 1. Rates of return are about 5 to 20 percent smaller in magnitude when we consider only self-employed productive income. When we also consider land in assets, estimated rate of returns are between about 45 to 5 percent smaller, with larger gaps when all incomes are considered.

Estimates are stronger considering all income plausibly because efficiency gains induced by investments frees up time for some household members to earn more labor income. Estimates are weaker considering land jointly plausibly because some land purchases were made for consumption, storage, and speculative, rather than income generating purposes. Importantly, all estimated average rates of return excluding land exceed 1.0 percent, which is the 90th percentile of BAAC and Village-fund interest rates. Additionally, all return estimates from Table 7 are significantly higher than the 0.5 percent median monthly BAAC and Village-fund borrowing interest rate (see Table 1).

We present additional estimation results in the Appendix. As a placebo test, in Appendix Table D.2, we regress income changes on investments considering only changes in household assets. We do not find any significant effects of household asset changes on household income. As a robustness check, in Appendix Table D.3, we relax the calendar month and investment size restrictions imposed throughout Section 3 to facilitate finding investment-loan linkages and find similar rates of returns using the full sample of investments.

Our findings here relate to existing research that have found high returns to investments in village economies (Mel, McKenzie, and Woodruff 2008; Beaman et al. 2023). Our estimates here do not provide production function estimates on the returns to exogenous increases in capital, holding other inputs constant. Our return estimates are jointly determined by increases in investment, concurrent changes in other inputs, and productivity shocks known to the household at the time of investment. High realized average investment returns relative to the cost of capital from formal lenders is evidence for potential credit market inefficiencies, arising possibly due to limited long-term loan options.

Section 4. Model

Motivated by the empirical facts, in this section we develop a parsimonious model that brings out the value of bridge financing when an individual faces a single, large-scale, high-return investment but is liquidity constrained. We show how formal and informal financing can co-exist and complement each other. In Section 5, we consider possible extensions to the model such as allowing more bridge loans and investment.

We model an infinitely-lived farmer in continuous time with a constant relative risk aversion utility function who starts with zero wealth but has a productive potential investment, that requires I units of capital. Our model explores how the farmer's optimal investment decision, consumption, time to invest, and utility change as we alter the credit options available.

We proceed first by outlining the farmer's utility function, income, saving options and the possible credit options from the formal and informal lender.

Subsection 4.1. **Farmer utility.** The farmer has a standard constant relative risk aversion (CRRA) utility function with discount rate, ρ, and coefficient of relative risk aversion, σ:

$$U(c) = \int_{t=0}^{\infty} u\left(c\left(t\right)\right) e^{-\rho t} dt = \int_{t=0}^{\infty} \frac{\left(c\left(t\right)\right)^{1-\sigma}}{1-\sigma} e^{-\rho t} dt \ . \tag{3}$$

Subsection 4.2. **Farmer income and investment.** The farmer earns a wage rate of w. The farmer can invest in a large project, which requires I units of capital (the price of capital is normalized to 1) and the capital does not depreciate. To ensure the investment is 'lumpy,' we assume that the cost of this investment, I, is strictly larger than the farmer's wage rate, w. If the farmer invests I units of capital in this project, the project has a rate of return of i, otherwise the return is zero.[10] Since, we assume that the farmer's capital does not depreciate, the farmer's holding of capital at time t, $K(t)$, is simply equal to the cumulative amount of investment, k, invested in the project by time t:

$$K\left(t\right) = \int_{s=0}^{t} k\left(s\right)\ ds \ . \tag{4}$$

Subsection 4.3. **Farmer saving.** We assume that the farmer starts with zero wealth and the farmer can save income over time to build wealth and potentially finance their project. We assume that the farmer has access to some relatively poor savings technology that earns a return of $\underline{r}$, where we assume that the return of this technology is strictly less than the farmer's discount rate (that is, $\underline{r} < \rho$). We refer to savings via this technology as the farmer's liquid asset and denote it as $a\left(t\right)$.

A crucial assumption in our model is that the farmer has a positive cashflow constraint specifically, the farmer has non-negative liquid assets therefore combining that the farmer starts with zero wealth, this becomes:

$$a_0 = 0 \text{ and } a_t \geq 0 \quad \forall\, t \tag{5}$$

Taking the farmer's potential investment income and savings income together, the farmer's total income stream can be written as the sum of wages (w), investment income (if the farmer has invested), and the return from liquid assets ($\underline{r}a\left(t\right)$), written as:

$$Income\left(t\right) = w + i \cdot \mathbb{1}_{\{K(t)\geq I\}} + \underline{r} \cdot a\left(t\right) \ , \tag{6}$$

10. We assume that the farmer retains the wage return even after investing, as such, i can also be considered the net additional return from investing in the project.

where $\mathbb{1}_{\{K(t)\geq I\}}$ is an indicator function for whether the farmer has invested at least I in the project at time t in the project.

Taking the farmer's income, saving, and investment decisions together, the change in the farmer's liquid asset holdings, $\dot{a}$, will be equal to income ($w+i\cdot\mathbb{1}_{\{K(t)\geq I\}}-c(t)$), plus return on savings, ($\underline{r}\cdot a$), minus the sum of consumption, ($c(t)$), and capital investment, ($k(t)$) and formally written as:

$$\dot{a} = \underbrace{w + i\cdot\mathbb{1}_{\{K(t)\geq I\}} + \underline{r}\cdot a(t)}_{\text{Income}} - \underbrace{c(t)}_{\text{Consumption}} - \underbrace{k(t)}_{\text{Investment}}. \tag{7}$$

Subsection 4.4. **Formal lender.** The farmer can borrow from a formal lender. The formal lender is willing to lend the farmer an unlimited amount, but requires the farmer to repay the full loan (including interest) at the loan maturity date (we assume that the farmer has an enforcement technology to ensure the farmer repays). We assume the formal lender offers loans with a maturity of one year and charges an interest rate r, which is strictly greater than the farmer's discount rate (that is, $r > \rho$). Finally, we assume that the farmer cannot take additional formal loans if there is any outstanding debt to the formal lender.

The key modeling assumptions for the formal lender is that the farmer can only borrow for one year at a time and must fully repay before taking a new loan. This assumption is consistent with the empirical evidence in the previous section. Moreover, it can be rationalized by ineffective and excessive banking regulation in developing economies, especially for public sector or developments banks, that distorts bank incentives and cause them to be excessively cautious in their lending (for example, see Banerjee, Cole, and Duflo (2004)).

We define $D^F(t,s)$ the amount of total debt outstanding from the farmer to the formal lender at time t which matures at time s and $L^F(t)$ the net payment of the lender to the farmer at time t, that is, a positive value for $L^F(t)$ denotes the farmer is borrowing from the lender, and a negative value denotes that the farmer is repaying the lender.

In line with our assumptions, we place three conditions on the stock and flow of lending. First, the farmer cannot have negative debt to the formal lender (equation 8).

$$D^F(t,s) \geq 0 \quad \forall t, s \tag{8}$$

Second, the farmer must fully repay the formal loan one year after taking the loan, the maturity of the loan (equation 9).

$$\text{If } L^F(t) > 0, \text{ then } L^F(t+1) = -L^F(t)exp(r) \tag{9}$$

Third, the farmer cannot take more formal debt prior to fully repaying any existing formal debt (Equation 10).

$$L^F(t) \geq 0 \text{ iff there } \exists \text{ a positive } \epsilon \text{ s.t. } D^F(u,s) = 0 \quad \forall u \in [t-\epsilon, t) \& \forall s \tag{10}$$

Subsection 4.5. **Informal Lender.** We assume the informal lender is willing to offer a "bridging' loan, for a fee of f per dollar. This bridging loan has a very short maturity period such that if the farmer takes a informal loan at time t, the loan is due to be repaid at time $t+\varepsilon$, where ε is very small. For modeling convenience, we assume that the informal lender is only willing to offer one informal loan ever. Similar, to the notation for formal credit, we define $D^I(t)$ the amount of total debt outstanding from the farmer to the informal lender at time t and $L^I(t)$ the net payment of the lender to the farmer at time t.

We can write the three conditions on the informal debt as: first, the farmer must repay the informal debt (equation 11), second, the farmer can only use the informal lender once (equation 12), and finally the farmer cannot have negative debt to the informal lender (equation 13).

$$\text{If } L^I(t) > 0 \text{ then there must exist some small } \varepsilon \text{ s.t. } L^I(t) \cdot f + L^I(t+\varepsilon) = 0 \tag{11}$$

$$\text{If } L^I(t) > 0 \text{ for some } t\text{, then forall } s > t,\ L^I(t) \leq 0 \tag{12}$$

$$D^I(t) \geq 0 \tag{13}$$

Therefore, we can now rewrite the farmer's liquid asset holdings with formal and informal borrowing as:

$$\dot{a} = \underbrace{w + i \cdot \mathbb{1}_{\{K(t) \geq I\}} + \underline{r}a(t)}_{\text{Income}} \quad \underbrace{-c(t) - k(t)}_{\text{Consumption and Investment}} \quad + \underbrace{L^F(t) + L^I(t)}_{\text{Loan payments}} \tag{14}$$

Subsection 4.6. **Farmer's problem.** We can now write the farmer's problem as:

$$V(c) = \max_{\{c(t),k(t),L^F(t),L^I(t)\}_{t=0}^{\infty}} \int_{t=0}^{\infty} \frac{c(t)^{1-\sigma}}{1-\sigma} e^{-\rho t} dt \tag{15}$$

$$\text{s.t. equations (4) and (5), and equations (8) to (14) are satisfied}$$

Subsection 4.7. **Farmer's optimal choices.** The farmer's feasible choice set for consumption ($c(t)$), capital investment ($k(t)$), formal loan ($L^F(t)$) and informal borrowing ($L^I(t)$) is incredibly large. However, we show that the farmer's has two possible optimal strategies (with the optimal choice depending on the model environment's parameters).

Specifically, Proposition 4.1 states that the farmer's optimal strategy is either "No investment" (that is, consume the wage in all periods) or "Investment" (where the farmer invests in the project using some combination of saving, and formal and informal borrowing).

To build intuition for the farmer's optimal strategy, note that with CRRA preferences, the farmer seeks to smooth consumption over time, subject to liquidity constraints. This preference structure implies that the optimal consumption path can be characterized by the standard Euler equation, modified to account for binding liquidity constraints. In a frictionless credit market, the farmer would borrow the full investment amount upfront and repay smoothly over time. However, given the presence of rigid loan structures and a lumpy investment, the farmer must ensure that liquidity constraints are satisfied at every point in time. These constraints are particularly likely to bind around periods of investment or loan repayment.

As a result, the consumption path exhibits four distinct phases, defined relative to the time of investment, T_I: a pre-investment phase ($0 \leq t < T_I$); repayment of the first formal loan ($T_I \leq t < T_I + 1$); repayment of the second formal loan ($T_I + 1 \leq t < T_I + 2$); and a debt-free period ($t \geq T_I + 2$). The potential for binding liquidity constraints at each transition point gives rise to discontinuities or kinks in consumption, which we explore in detail below.

We start by stating the optimal strategy and then explain the intuition in greater detail. The proof is in Appendix (A).

Proposition 4.1. *The farmer's optimal strategy satisfies one of the following:*

- *No Investment, s_1: The farmer does not invest, save, or borrow. The farmer consumes their wage immediately throughout:*

$$s_1 = \left\{c(t) = w, \quad k(t) = L^F(t) = L^I(t) = 0, \quad \forall t\right\}.$$

- *Investment, s_2: The farmer saves until T_I, and subsequently both invests using formal and informal loans, repays in phases over $[T_I, T_I + 2]$, and consumes the wages and return to capital thereafter (w+i). The optimal consumption path is:*

$$c(t) = \begin{cases} c_0\, e^{m\,(T_I - t)}, & 0 \leq t < T_I, \\ \min(c_1\, e^{m\,(T_I+1-t)}, w + i), & T_I \leq t \leq T_I + 1, \\ \min(c_2\, e^{m\,(T_I+2-t)}, w + i), & T_{I+1} \leq t \leq T_I + 2, \\ w + i, & t \geq T_I + 2. \end{cases}$$

where $m = \frac{\rho - \underline{r}}{\sigma} > 0$*, and the parameters* $c_0, c_1, c_2 > 0$ *and the date* T_I *(timing of investment) is determined endogenously.*

Although the "investment" strategy may appear intricate, it actually subsumes three key feasible strategies: first, formal and informal loans combined with savings; second, formal loans with savings; and three, savings only. For instance, when the informal-loan fee approaches infinity, the strategy collapses to taking a single formal loan ($c_2 = w + i$); when the formal interest rate becomes prohibitive, it collapses to fully self-funded investment with no borrowing ($c_1 = c_2 = w + i$).

Moreover, to understand more of the farmer's optimal consumption path, because the farmer can always opt for an arbitrarily small loan, the optimal consumption path must satisfy the cash-flow constraint at every instant, which introduces the restriction that consumption must be less than or equal to $w + i$ during the period T_I and $T_I + 2$.

To build intuition for the consumption path, Figure 4 traces a representative consumption trajectory when the farmer finances the project with a bridge loan.[11] In this example the investment takes place a little after two years, and all debt is repaid exactly two years later. We discuss the key consumption phases next.

Pre-investment. Consumption starts at roughly 60% of income ($c_0 = 0.6$ with $w = 1$) and drifts downward because the discount rate ρ exceeds the low return $\underline{r}$ available on savings.

Repayment years. During each year of repayment the slope of consumption is unchanged—the farmer is still equating the marginal utility loss from saving with the poor return on liquid assets. If early repayment were allowed, the curve would tilt upward, reflecting the higher formal interest rate.[12]

Although the slope is identical across the two repayment phases, the starting level is not: consumption at the onset of the second loan (c_2) exceeds that at the onset of the first (c_1). The second loan is effectively more expensive because it carries both the formal interest rate and a rollover fee, so the farmer allows herself a slightly higher consumption level to maintain lifetime utility.

Post-repayment. Once all obligations are cleared ($t \geq T_I + 2$), consumption jumps to the full income stream, $w + i$.

11. Parameter set: $\sigma = 1.2$, $\rho = 0.04$, $\underline{r} = 0.01$, $r = 0.05$, $f = 1.08$, $w = 1$, $i = 0.4$, $I = 2.4$.

12. With discretionary early repayment, the farmer would accelerate payments to arbitrage the gap between r and ρ.

Section 5. Results

Subsection 5.1. Optimal strategy. To gain intuition for our model, Figure 5 illustrates how the farmer's optimal financing strategy varies with the annual formal interest rate r (x-axis) and the one-off rollover fee f charged by the bridge lender (y-axis).[13] Specifically, the farmer will choose one of three possible strategies for the given interest rates and fee: bridging loans (purple), mostly a single formal loan (green), and mostly self-funded (olive).[14] When both r and f are modest, the farmer finds it optimal to take two consecutive one-year formal loans and to cover the interim rollover with an informal bridge loan (purple region). As the bridge-loan fee rises, the informal instrument becomes prohibitively expensive relies on a single formal loan instead (green region). If the formal interest rate itself becomes high enough prompting the farmer to finance the investment entirely out of internal savings (olive region).[15] Thus, cheaper credit supports full bridge financing, moderate rollover fees push the farmer toward a single formal loan, and very high interest rates make self-funding the dominant option.

This figure demonstrates three interesting results. First, as expected, more expensive bridge loans discourage their use, nudging households toward pure formal borrowing. Second, higher formal rates push the farmer away from both formal credit and bridge financing, ultimately causing the farmer to fund the investment them-self through savings. Finally, as the interest rate rises, the farmer is less likely to borrow from the informal lender *even if the informal loan fee does not change*. The intuition for this result follows from the overall cost of borrowing becomes higher so the farmer is less willing to borrow.

Subsection 5.2. Characteristics of the farmer's optimal strategy. To examine the characteristics of the farmer's optimal strategy, Figures 6 and 7 show the farmer's optimal time to invest and financing strategy for different interest rates (x-axis) and informal fees (y-axis).

Figure 6 shows that, consistent with intuition, higher financing costs cause the farmer to delay investment. When financing is cheap—both the bridge-loan fee f and the formal interest rate r are low (bottom-left of the panel)—the farmer taps all available credit and invests almost immediately, roughly after 0.2 years. Once borrowing costs are high enough, the farmer first drops the bridge loan and eventually forgoes formal credit

13. Each colored region identifies the strategy that maximizes lifetime utility when $\sigma = 1.2$, $\rho = 0.04$, $\underline{r} = 0.01$, $w = 1$, $i = 0.4$, and $I = 1.4$.

14. As described in the previous section, the farmer's optimal strategy of using the bridge loan financing is always the weakly dominant strategy, therefore to illustrate the economic strategies, we rely on indicating formal loan only and self-funding when informal borrowing and formal borrowing are relatively small, respectively.

15. Because the choice between self-funding and forgoing the investment is independent of both r and f, only the self-funded region appears in the diagram.

altogether; beyond that threshold the time to invest levels off rather than continuing to increase. Moreover, the relative elasticity of the different financing costs is shown dramatically shown with the time to invest being much more sensitive to changes in the formal interest rate than the informal borrowing fee. This result follows because the formal interest rate effects two loans (the first and second formal loan), whereas, the fee, in effect only effects a single bridging loan.

Figure 7 reinforces the results from Figure 6. When credit is cheap the first loan nearly covers the entire investment. Because bridging is inexpensive, the farmer spreads repayment evenly over two years, so the second loan is about half the size of the first. Moving *up* the f-axis, rollover becomes costly; the second loan contracts sharply and, in anticipation, the first loan also shrinks. A parallel pattern appears along the x-axis: higher formal rates prompt the farmer to cut back on both the initial and follow-up loans. In short, tighter credit—whether through a higher interest rate or a steeper rollover fee—dims the appeal of large upfront borrowing and pushes the farmer toward smaller loan sizes and investing later.

Subsection 5.3. **Welfare analysis.** Choosing among financing contracts is ultimately about *when* and *how much* households consume, not just the headline interest rate. Static comparisons therefore miss the utility cost of sharp consumption swings. We translate differences in each contract's entire path into a single, cardinal metric measured in units of consumption-equivalent variation (CEV). In our setting, CEV measures changes in the constant wage that makes the household indifferent to a different contract. Because CEV is expressed in "percent of permanent wages," it can be averaged across heterogeneous borrowers and used directly in policy analysis.

Therefore, to calculate the potential welfare gain from bridge financing, we calibrate our model for farmer welfare with the empirical findings. Specifically, we use the median return to capital of around 22 percent per year (we previously found that household income rose by up to around 2 percent of investment per month following an investment), an informal fee of 2.3 percent (since the median informal loan is 3 months and charges a monthly fee of 0.7 percent), and formal interest rate of 6.1 percent (the median interest rate in our sample). Moreover, we found that the median investment was up to 80 percent of household income. Prior literature on risk preferences in developing countries have estimated risk aversion to be between 0.8 and 1.5, so we choose a value of 1.2 for our baseline estimates. Using these parameters, we can estimate different welfare gains for different financing contracts.

Figure 8 plots CEV welfare for different formal interest rates r and reveals two clear patterns for the *median* household. First, at the baseline formal interest rate of 6 percent, a single formal loan already lifts lifetime welfare by roughly 1 percent of wages relative to self-funding; adding an informal rollover (bridge finance) boosts that gain to about 2 percent—a substantial boost to the agent's welfare. Second, the bridge-loan premium remains positive throughout the entire range we examine: even when the formal interest, r, reaches 12 percent the incremental benefit is still close to 0.25 percent of wages. Hence, so long as formal credit is available and the rollover fee stays near its benchmark, bridge financing is strictly welfare-improving for the typical borrower.

It is important to emphasize that our welfare calculations reflect the median household undertaking an investment in our sample. However, there is substantial heterogeneity in both project size and returns. For example, households at the 75th percentile invested nearly 1,000 percent of their existing capital and up to 500 percent of their previous year's income (see Table 3). To demonstrate how the potential welfare gains vary with investment size—while holding the return on investment constant (that is, maintaining a fixed ratio of i/I)—Figure 9 plots CEV under the four financing regimes as a function of project scale.

The key takeaway from Figure 9 is that the farmer's welfare increases with the size of the investment under all financing strategies. This takeaway is intuitive, since the return on investment (i/I) exceeds the farmer's discount rate, larger projects yield higher absolute returns. A second observation is that the incremental welfare gain from bridge financing—relative to other contracts—also rises with project size. This reflects the fact that when the benefits to investing are larger, the ability to smooth consumption and invest earlier becomes increasingly valuable.

Furthermore, if we were to extend the model to incorporate preferences with a minimum consumption threshold—such as Stone-Geary utility—the welfare gains from bridge financing would be even greater. In such settings, households have limited ability to smooth consumption through saving alone, thereby increasing the value of credit access.[16]

Section 6. Extensions to the model

To make the intuition for our results clear, the baseline model is deliberately stylized. Nonetheless, it can be generalized in several instructive directions, each with meaningful welfare implications. We sketch three below—multiple bridge-loans, uncertainty, and asymmetric information.

For tractability, the baseline model permits the farmer to take at most one informal bridge loan, which effectively caps the combined maturity of formal debt at two years (each bridge loan connects a pair of consecutive one-year formal loans). Relaxing this assumption is straightforward and is consistent with the evidence presented earlier. If the farmer can

16. For example, the standard CRRA utility function could be modified as follows: $U(c(t)) = \frac{(c(t)-\bar{c})^{1-\sigma}}{1-\sigma}$, for $c(t) > \bar{c}$.

roll the formal debt over time with multiple bridge loans, the welfare benefits would rise even further. Specifically, the repeated bridging lets the farmer repay debt over several years, invest sooner, and smooth consumption more effectively than in the single-bridge benchmark.

Our model could also be extended to examine the effect of uncertainty on the farmer's and lenders' decisions. To be precise, in our model, the outcome of the farmer's investment is deterministic but that could be extended into a risky outcome. In such a scenario, it is likely that the welfare estimates that we have calculated over-estimate the welfare gain from bridge facilities, because with risk-averse agents, the gain from higher but riskier income would be lower.

A final possible extension to our model would be to formalize *why* formal lenders do not offer long-term contracts. In our model, we have constrained that formal lenders only offer loans with a tenor of one year (consistent with the empirical evidence). However, there could be an economic rationale for this restriction. For instance, formal lenders may be unable monitor borrowers (such as in the models by Townsend (1979), Banerjee and Newman (1993), and Holmstrom and Tirole (1997)) but local informal lenders can. Therefore, in that scenario, it is possible that formal lenders are optimally offering short-term contracts to constrain the farmer's investment choice or to force farmer's to find other sources of funding from lenders with more complete information.

Section 7. Conclusion

Over the past few decades, formal financial services have expanded rapidly in developing countries. Yet for rural households, the structure of formal credit—particularly the widespread use of short-term bullet loans—remains poorly aligned with the financing needs of high-return but lumpy investments. This paper evaluates how such rigid loan structures interact with flexible, informal credit options, and explores the welfare and investment implications of these interactions.

Empirically, we draw on detailed panel data from Thai villages to document the coexistence of formal and informal loans, the rigidity of formal credit, and the prevalence of bridging behavior. In particular, linking investments and loans together based timing overlaps, our empirical analysis shows that the majority of investments are linked to loans, the majority of these loans are triply–bridge–linked, and the majority of these bridges include formal–informal–formal loan linkages. Additionally, within investment-linked loan bridges, formal loans tend to be longer in duration and informal-bridging tend to be short in duration. Furthermore, bridging covers a significant portion of repayments for the initial loans, which support the financing of a large share of the investments in productive assets.

Motivated by the data, we develop a continuous-time model in which households make intertemporal consumption, saving, and investment decisions under liquidity constraints and rigid formal borrowing terms. Capturing key aspects of empirical investment and loan linkages, the model allows for short informal bridge loans that can be used to roll over formal bullet loans that partially finance lumpy investments, effectively extending repayment durations. We characterize the household's optimal strategy, including the timing of investment and debt repayment, and quantify how the availability of informal bridging credit shapes these choices.

We calibrate the model to household-specific data from the Thai sample and use it to estimate the welfare effects of different credit regimes. The analysis shows that informal loans meaningfully complement rigid formal credit—enabling earlier investment, smoother consumption, and significant gains in lifetime utility. At median parameter values, access to bridge financing raises welfare, in terms of consumption-equivalent variation, by roughly two percent of wages relative to formal credit alone. Moreover, these gains are even larger when investment needs are especially lumpy or when preferences impose a minimum consumption threshold.

Finally, the paper highlights the policy implications of loan design. Improving access to formal finance is not just about expanding credit volumes or reducing rates—it also requires relaxing rigid repayment structures. In settings where long-term contracts are difficult to enforce, flexible informal credit can help reduce market incompleteness. Policies that improve integration across formal and informal credit sources—or that adapt formal loans to better match household needs—can have large welfare benefits by enabling timely, high-return investment.

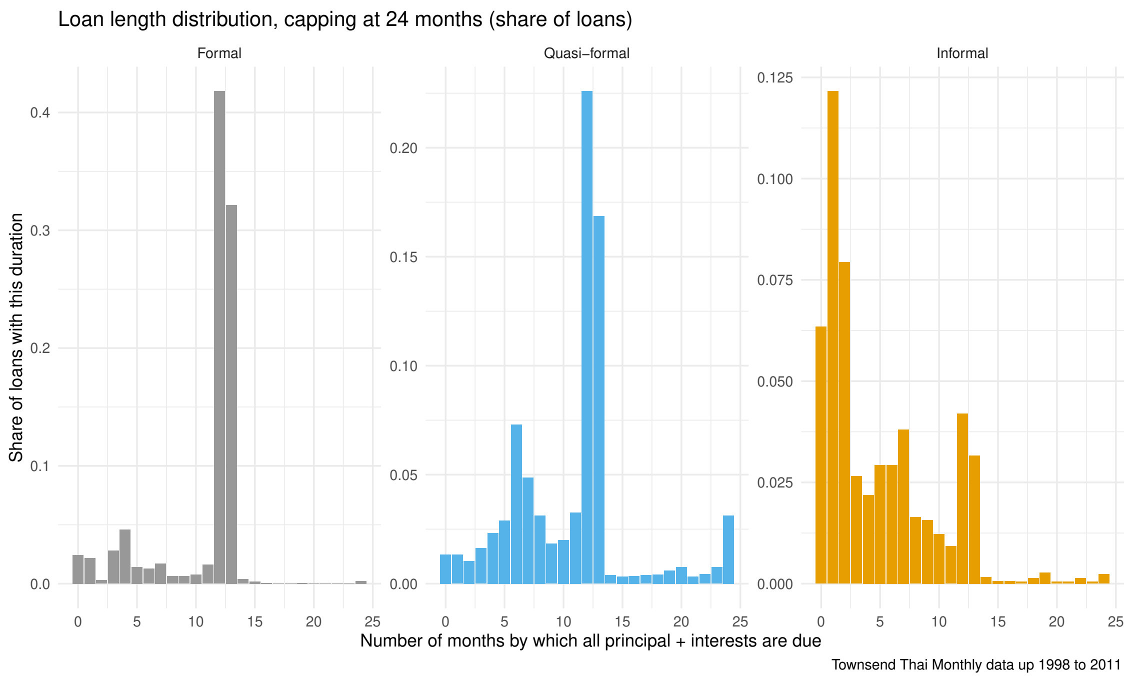


Fig. 1. Loan duration distribution
We show the loan duration (in months) distribution across formal, quasi-formal and informal loans. See discussions in Section 2.1.

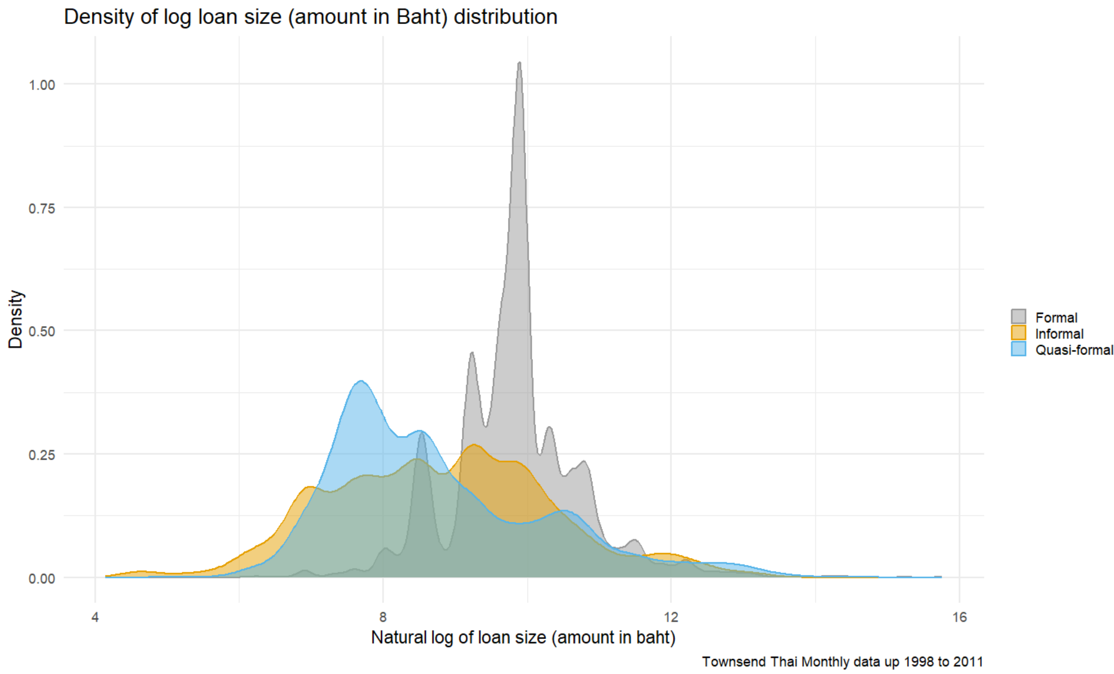


Fig. 2. Loan size distribution
We show the loan size (in log of baht) distribution across formal, quasi-formal and informal loans. See discussions in Section 2.1.

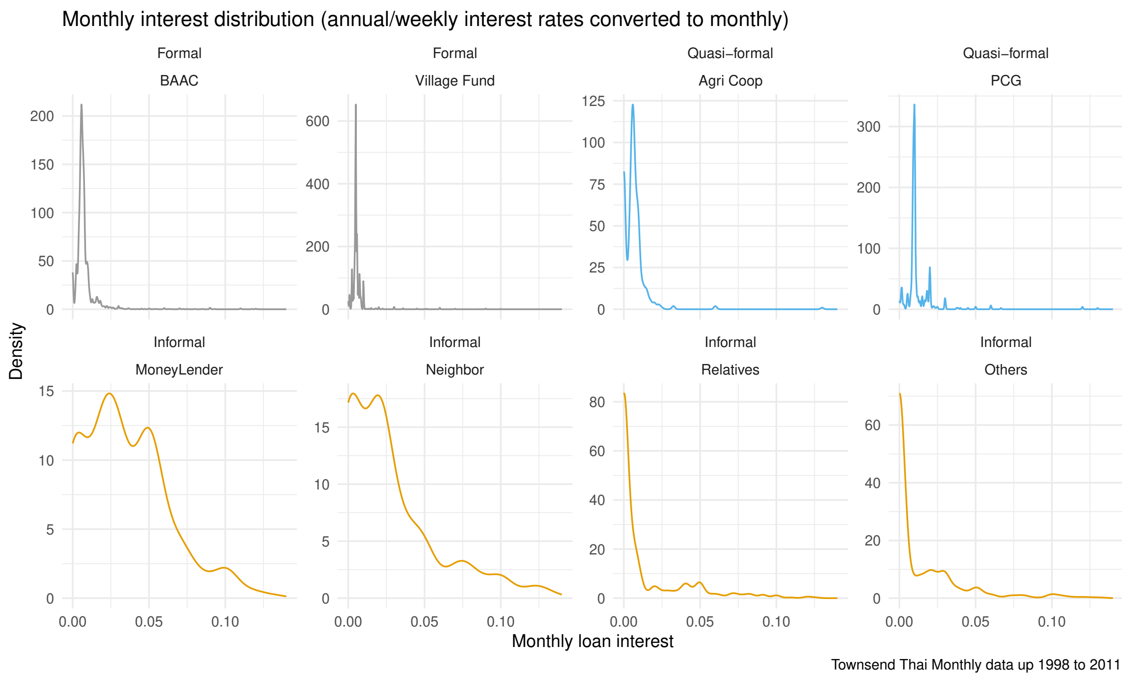


Fig. 3. Loan interest rate distribution
We show the loan interest rate (monthly) distribution across formal, quasi-formal and informal loans. See discussions in Section 2.1.

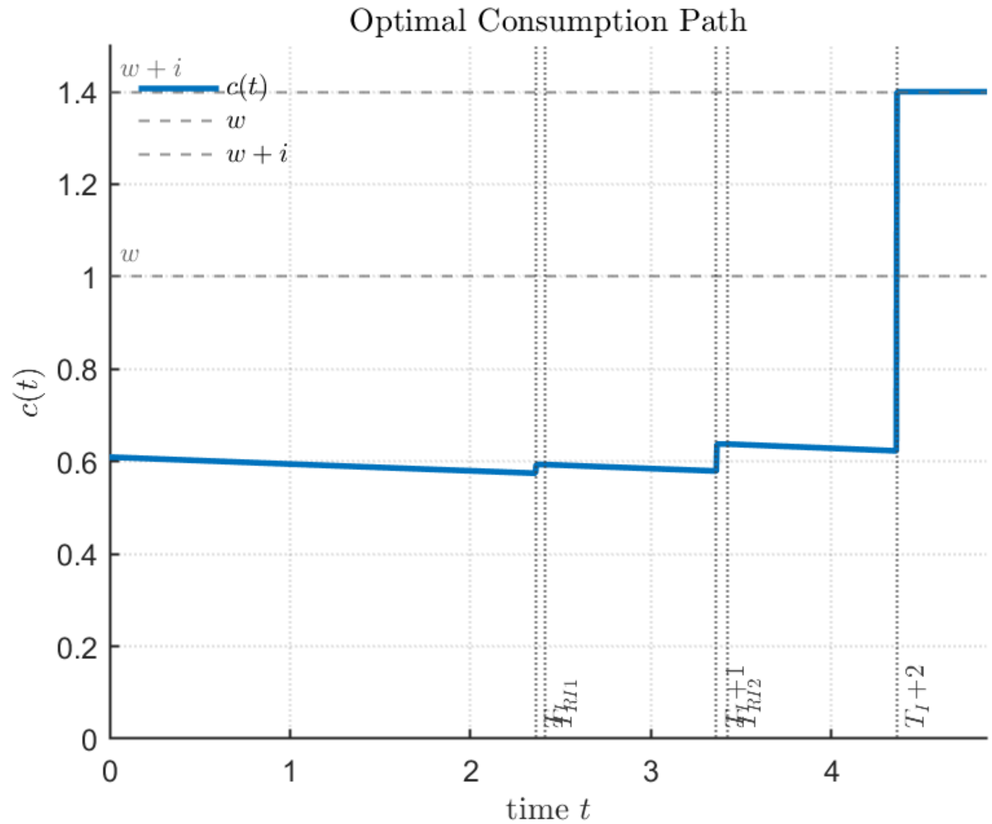


Fig. 4. Consumption path using informal and bridge loans.
This figure shows the farmer's optimal consumption path where the farmer uses the formal and bridge loans for some parameters. The parameter set used is $\sigma = 1.2,\ \rho = 0.04,\ \underline{r} = 0.01,\ r = 0.05\ f = 1.023\ w = 1,\ i = 0.4,\ I = 2.4$. To start, the farmer consumes about 60 percent of their income ($c_0 = 0.6$ and $w = 1$). The first vertical dashed line marks the timing of investment and the origination of the first formal loan, The second vertical dashed line marks when the bridge loan is used and the second formal loan originates. The third vertical dashed line marks when the second loan is fully repaid. The consumption path moves up on an upward ladder with the initial step duration and the successive step steepness determined by the share of investments financed via savings, via the first loan, and via the bridged second loan.

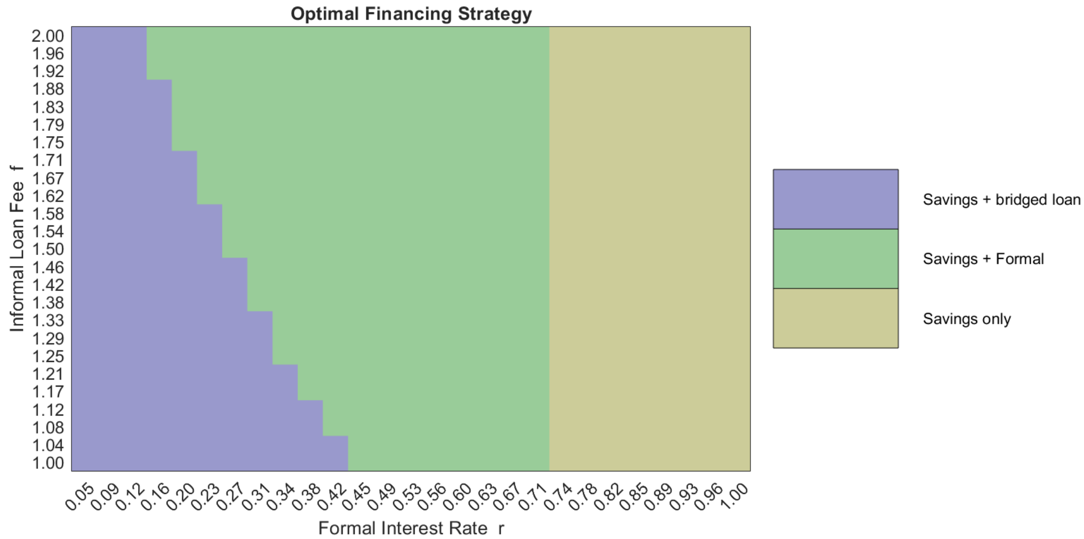


Fig. 5. Comparative statics: Optimal Strategy.
This panel maps the farmer's preferred financing strategy across the two key price variables: the annual interest rate on formal loans (r, horizontal axis) and the one-off fee charged by the informal bridge lender (f, vertical axis). Each colored region marks the strategy that maximises household welfare under the baseline parameter set $\sigma = 1.2,\ \rho = 0.04,\ \underline{r} = 0.01,\ w = 1,\ i = 0.4,\ I = 1.4.$
Purple area: Savings plus bridged loans. When both r and f are moderate, the farmer chooses two consecutive one-year formal loans and finances the interim rollover with an informal bridge loan.
Green area: Savings plus borrowing from only formal lenders. As the bridge-loan fee rises, the informal instrument becomes unattractive. Beyond a threshold (indicated here by bridge borrowing falling below 20 percent of the farmer's annual wages) the farmer relies solely on the formal lender.
Olive area: Savings only. At sufficiently high formal rates, even the first formal loan becomes negligible (below 20 percent of wages), and the farmer prefers to use internal savings to finance the investment.
Two broad patterns emerge. First, costlier bridge loans discourage their use, nudging households toward pure formal borrowing. Second, higher formal rates push the farmer away from both formal credit and bridge financing, ultimately causing the farmer to fund the investment them-self through savings.
Note that because the farmer's choice between self-funding and not investing is independent of both the formal interest rate and the bridge-loan fee, the diagram can display only one of these strategies with non-zero area.

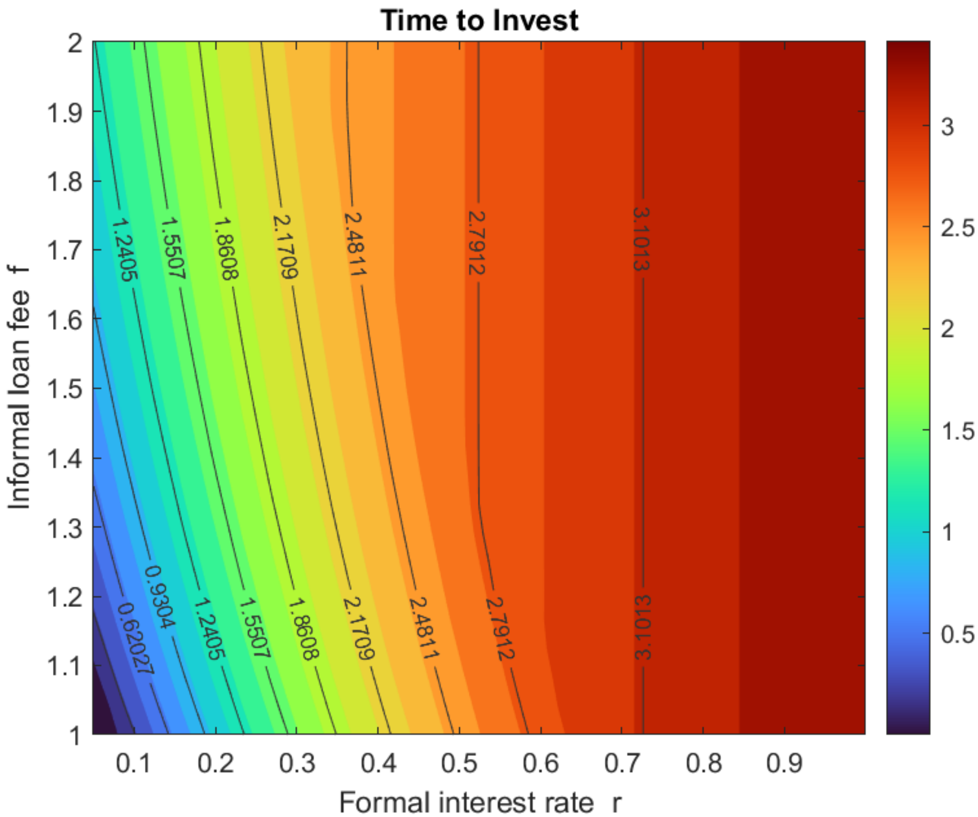


Fig. 6. Comparative statics: Time to invest.
This panel maps the farmer's time to investment (in years) across the two key price variables: the annual interest rate on formal loans (r, horizontal axis) and the one-off fee charged by the informal bridge lender (f, vertical axis). Each region denotes the time to invest that maximizes household welfare under the baseline parameter set $\sigma = 1.2,\ \rho = 0.04,\ \underline{r} = 0.01,\ w = 1,\ i = 0.4,\ I = 1.4$.
When financing is cheap—both the bridge-loan fee f and the formal interest rate r are low (bottom-left of the panel)—the farmer taps all available credit and invests almost immediately, roughly after 0.2 years. As either f or r rises, external funds become more expensive, and the optimal investment date is pushed farther into the future. Once borrowing costs are high enough, the farmer first drops the bridge loan and eventually forgoes formal credit altogether; beyond that threshold the time to invest levels off rather than continuing to increase. For instance, if the farmer self-funds the investment, the project takes over 3 years to finance.

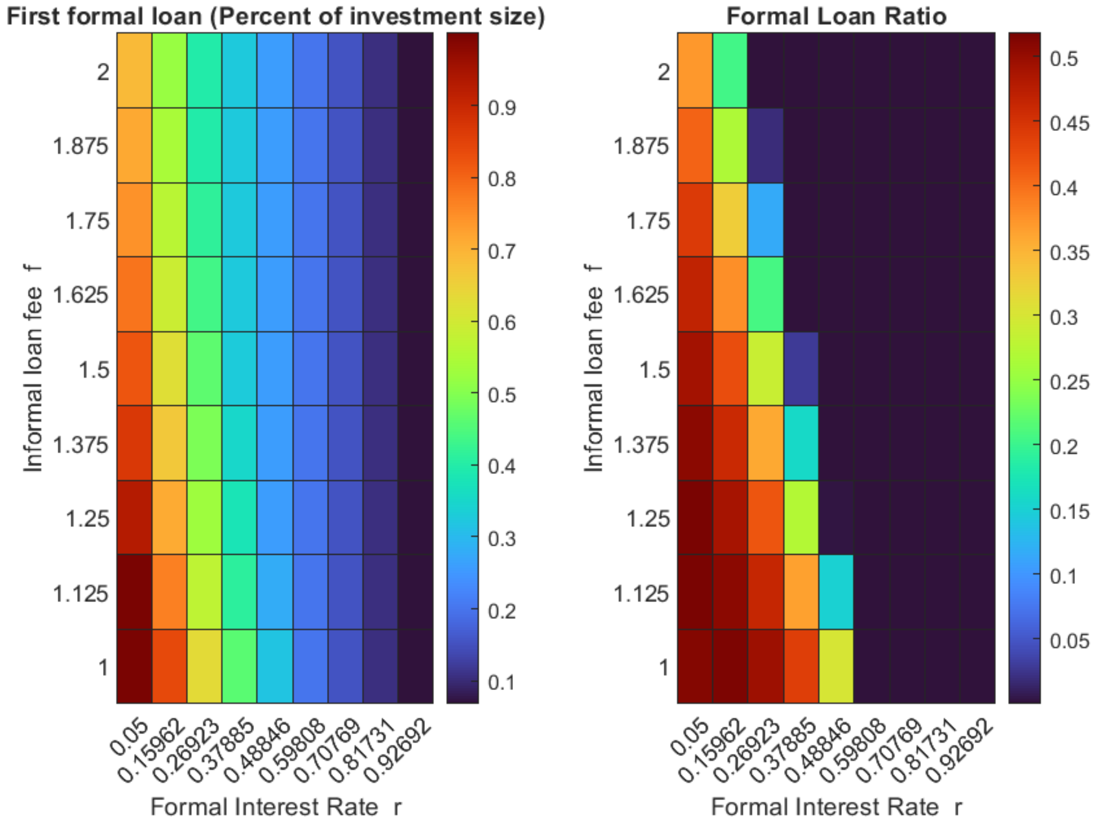


Fig. 7. Comparative statics: Financing.
This panel traces how the farmer adjusts formal borrowing as credit terms change. The left panel reports the size of the *first* formal loan as a share of the investment; the right panel shows the *second* loan as a share of the first. Both panels are indexed by the two price variables: the annual formal interest rate r (horizontal axis) and the one-off rollover fee f charged by the bridge lender (vertical axis). Shaded regions in the background mark the relative size of the loan that maximises lifetime utility under the baseline parameters $\sigma = 1.2$, $\rho = 0.04$, $\underline{r} = 0.01$, $w = 1$, $i = 0.4$, $I = 1.4$.
When credit is cheap—low r and low f in the bottom-left corner—the first loan nearly covers the entire investment. Because bridging is inexpensive, the farmer spreads repayment evenly over two years, so the second loan is about half the size of the first. Moving *up* the f-axis, rollover becomes costly; the second loan contracts sharply and, in anticipation, the first loan also shrinks. A parallel pattern appears along the x-axis: higher formal rates prompt the farmer to cut back on both the initial and follow-up loans. In short, tighter credit—whether through a higher interest rate or a steeper rollover fee—dims the appeal of large upfront borrowing and pushes the farmer toward smaller loan sizes.

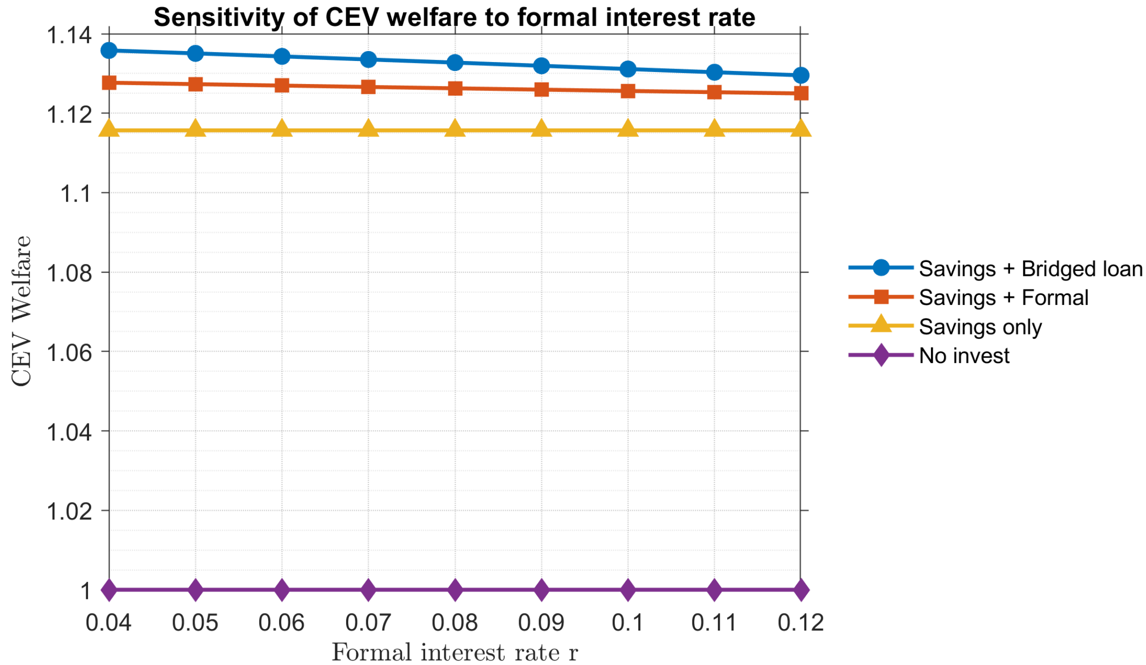


Fig. 8. Welfare under alternative financing arrangements.
The chart plots the consumption-equivalent variation (CEV) in lifetime utility for four contracts—two consecutive formal loans bridged by an informal rollover (blue), a single formal loan only (red), self-funded investment (yellow), and no investment (purple)—as the formal interest rate r varies. For each contract, the CEV is the constant wage that leaves the household indifferent between that wage and the contract's full consumption path; higher curves therefore represent greater welfare. Baseline parameters: $\sigma = 1.2,\ \rho = 0.04,\ \underline{r} = 0.01,\ w = 1,\ I = 0.82,\ i = 0.18,\ f = 1.023$
Two patterns emerge. First, for most interest-rate values, access to external finance is strictly welfare-improving: at r = 6%, formal borrowing raises the CEV by roughly 1 percent relative to self-funding. Second, adding bridge finance delivers an additional gain—about 1 percent of wages at the same rate—by allowing earlier investment and smoother consumption. As you would expect, as r rises, the welfare gains from bridge financing and formal lending fall.

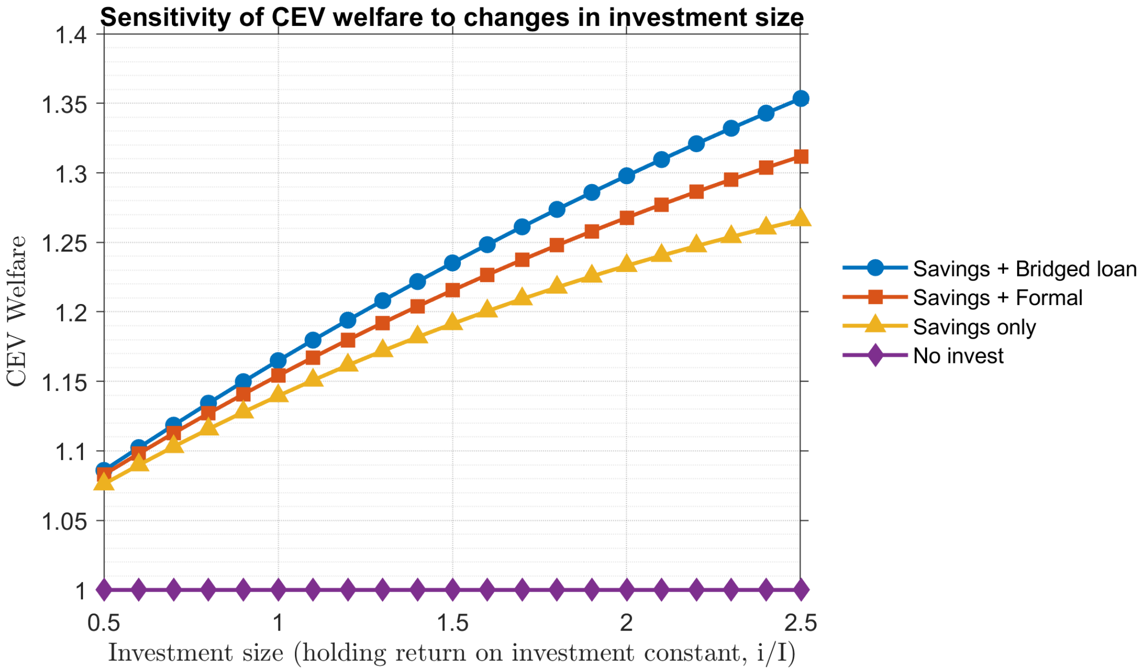


Fig. 9. Welfare under alternative financing arrangements.
The chart plots the consumption-equivalent variation (CEV) in lifetime utility for four contracts—two consecutive formal loans bridged by an informal rollover (blue), a single formal loan only (red), self-funded investment (yellow), and no investment (purple)—as the size of the investment (I) rises while holding the return on the investment constant (that is i/I). For each contract, the CEV is the constant wage that leaves the household indifferent between that wage and the contract's full consumption path; higher curves therefore represent greater welfare. Baseline parameters: $\sigma = 1.2,\ \rho = 0.04,\ \underline{r} = 0.01,\ w = 1,\ i/I = 0.22,\ r = 0.06\ f = 1.023$

Two patterns emerge. First, as the size of the investment rises (given that the return from the project is constant), across all the investment strategies, the farmer's welfare rises. Second, the additional gain from bridge financing versus other contracts is increasing in the investment size.

Table 1. Duration, size, and interest rates of loans.

Percentiles	Duration (months)			Size (baht)			Interest (monthly)		
	Formal	Quasi-formal	Informal	Formal	Quasi-formal	Informal	Formal	Quasi-formal	Informal
Below median deciles									
5	3.0	3.0	0.0	5,000	1,000	630	0.23%	0.00%	0.00%
10	4.0	5.0	0.0	5,000	1,400	1,000	0.31%	0.00%	0.00%
20	11.0	7.0	1.0	10,000	2,000	1,800	0.46%	0.00%	0.00%
30	12.0	10.0	1.0	13,000	2,380	2,700	0.46%	0.00%	0.00%
40	12.0	12.0	2.0	16,000	3,000	5,000	0.50%	0.33%	0.00%
Quartiles									
25	12.0	8.0	1.0	11,000	2,000	2,000	0.46%	0.00%	0.00%
50	12.0	12.0	3.0	20,000	5,000	6,000	0.50%	0.45%	0.71%
75	13.0	13.0	8.0	30,000	15,000	20,000	0.67%	1.00%	3.00%
Above median deciles									
60	12.0	12.0	5.0	20,000	6,000	10,000	0.58%	0.69%	2.00%
70	13.0	13.0	7.0	20,000	10,000	15,000	0.62%	0.92%	2.62%
80	13.0	18.0	10.0	30,000	23,520	20,000	0.75%	1.00%	4.00%
90	13.0	26.0	13.0	50,000	50,000	45,000	1.00%	1.85%	6.25%
95	13.0	60.0	13.0	90,000	108,750	110,000	1.27%	3.00%	9.23%
Mean									
mean	12.8	15.5	5.8	31,876	27,271	22,628	0.80%	0.86%	2.36%

Note: The distribution of loan duration (in month), loan size (in baht), and loan interest rates (monthly) across lender types. Due to their rigidity, we classify BAAC and Village-fund loans as relatively as formal loans. Due to their relative flexibility, we classify loans from local moneylenders, neighbor, relatives, and other local and individual lenders as informal loans. We classify loans from village agricultural coops and production cooperative groups, which are locally-based organizations with cross-region networks, as quasi-formal. There were 64 commercial loans observed in the sample (in contrast to 3396 BAAC loans), and they are excluded from the analysis. See discussions in Section 2.1.

Table 2. Number of investments made by households.

# of investments	Investments based on individual assets categories: Agricultural assets	Business assets	Land assets	Household assets	Investments based on combined assets categories: Agricultural and business assets	Agri., biz, and land assets	Agri., biz, land, and hh assets
Share of households with different number of investments							
0	13.6%	79.7%	24.5%	2.3%	11.0%	13.6%	5.0%
1	27.6%	14.0%	32.5%	22.6%	30.4%	29.7%	20.6%
2	29.4%	4.5%	17.5%	29.4%	27.8%	26.0%	23.4%
3	17.2%	1.0%	10.2%	23.9%	18.3%	14.4%	24.5%
4	8.6%	0.5%	5.2%	13.6%	8.0%	10.1%	15.6%
5	2.4%	0.2%	3.7%	5.2%	3.2%	4.1%	7.0%
6	1.1%	0.2%	2.6%	2.3%	1.3%	1.8%	2.4%
7	0.0%	0.0%	2.6%	0.6%	0.0%	0.2%	1.3%
8+	0.0%	0.0%	1.1%	0.2%	0.0%	0.2%	0.2%
Mean number of investments per year							
	0.14	0.02	0.14	0.19	0.15	0.15	0.20

Note: The table shows the distribution of number of investments made by households during 160 months of the panel sample period. There are four underlying asset types in the data, agricultural assets (including livestock), business assets, land assets, and household assets. We identify investments based "jumps" in the asset time-series for each of the four asset types and summarize the results in columns 2 to 5. Additionally, we identify investments based on three combined assets definitions, considering respectively "jumps" in the sum of agricultural and business assets, the sum of agricultural, business and land assets, and the sum of agricultural, business, land, and household assets. Columns 6, 7, and 8 summarize results based on these aggregate asset definitions. See discussions in Section 2.2.

Table 3. Ratio of investment to prior month assets and prior 12 months income.

	Fraction of investment to existing assets				**Fraction of investment to prior year's income**			
Numerator: Investment definitions	Agricultural	Business	Agricultural and business	Agricultural, business, and land	Agricultural and business	Agricultural, business, and land	Agricultural and business	Agricultural, business, and land
Denominator: Assets or income	Agricultural and business assets			Agricultural, business, and land assets	All income		Self-employed income	
Bottom decile								
5	14.1%	3.1%	18.0%	0.3%	0.9%	1.3%	3.6%	4.6%
10	22.7%	4.9%	27.4%	0.7%	2.2%	2.7%	7.1%	8.7%
15	31.0%	9.5%	36.6%	1.1%	3.6%	4.3%	11.3%	13.0%
Quartiles								
25	52.9%	18.9%	62.2%	2.3%	7.4%	9.1%	20.5%	24.8%
50	180.6%	68.5%	209.2%	9.7%	24.6%	33.0%	66.2%	82.5%
75	1,088.4%	940.3%	1,386.6%	39.7%	66.1%	92.8%	326.8%	515.9%
Top decile								
85	6,801.1%	6,748.2%	10,380.3%	120.1%	120.5%	184.9%	12,500.0%	9,427.0%
90	Inf%	75,634.7%	Inf%	273.9%	194.2%	339.2%	Inf%	Inf%
95	Inf%	Inf%	Inf%	1,472.2%	626.8%	1,147.2%	Inf%	Inf%

Note: In this table, considering investments identified under alternative asset definitions, we present the relative sizes of investments with respect to the levels of capital in the month preceding the investment as well as the income (revenue minus costs) of the household-firm from the 12 months preceding the month of investment. Self-employed income in columns 6 and 7 considers income from agricultural (including cultivation, livestock, and shrimp and fish) and business sources. All income in columns 8 and 9 includes self-employed income and also income from labor and other sources. At the upper quantiles in columns 2, 3, 4, 8, and 9, the table shows positive infinity at top quantiles. Infinities arise when an investment occurs in a household with zero levels of prior asset holding or prior income. Additionally, we set the investment to income ratio to positive infinity when income is negative (due to higher costs than revenue). See discussions in Section 2.2.

Table 4. Number (#) and percent (%) of investments by credit arrangements.

	Alternative investment definitions					
	Agricultural and business assets investments		Agricultural, business, and land assets investments		Agricultural, business, land, and household assets investments	
	#	%	#	%	#	%
Investments *not* time-linked to loan bridges						
Invest. *not* time-linked any loans	205	27.9%	244	29.6%	426	29.7%
Invest. time-linked to *standalone* loans (set A loans only)	121	16.4%	132	16.0%	271	18.9%
Invest. time-linked to *"hooked"* loans (set A and B loans only)	50	6.8%	57	6.9%	111	7.7%
Investments time-linked to *only* formal *or only* informal loan bridges						
Single lender type only investment-loan bridge	27	3.7%	26	3.2%	60	4.2%
Multiple formal lenders investment-loan bridge	29	3.9%	31	3.8%	41	2.9%
Multiple informal lender types investment-loan bridge	2	0.0%	2	0.0%	6	0.0%
Investments time-linked to *joint* formal *and* informal investment-loan bridges						
Contains *formal—informal—formal* loan bridges	173	23.5%	186	22.6%	293	20.4%
Do not contain formal—informal—formal loan bridges, but includes *informal links* in bridges	129	17.5%	145	17.6%	228	15.9%

Note: The number and share of investments linked to different types of loan structures, considering different investment definitions across columns, and using 6 months investment-loan backward window ($\tau = 6$). See Appendix Table D.1 for results based on 3 months backward window. To allow for time before investment and after, we consider investments made between month 15 and month 145 within the 160 months panel. Additionally, to reduce spurious linkages, we consider only investments that exceed 10,000 baht in drawing investment to loan linkages. See discussions in Section 3.2.

TABLE 5. The durations (months) of overlapping loan-bridge segments in time-linked investment-loan bridges.

	Loan bridges linked to agricultural and business assets investments				**Loan bridges linked to agricultural, business, and land assets investments**			
	Bridge duration	Start-end duration	Overlap duration	Gap duration	Bridge duration	Start-end duration	Overlap duration	Gap duration
	Start of loan a to end of loan c	*a + c dura. excluding b overlap*	*Loans a + c overlap with loan b*	*b dura. excluding a or c overlap*	*Start of loan a to end of loan c*	*a + c dura. excluding b overlap*	*Loans a + c overlap with loan b*	*b dura. excluding a or c overlap*
All investment-loan bridges								
Quartiles (number of months)								
25	23	12	3.5	0	23	12	3	0
50	26	16	7	3	26	16	7	3
75	34	21	11	6	34	21	11	7
Invest-loan bridges with formal-informal-formal linkages								
Quartiles (number of months)								
25	23	12	4	0	23	12	3	0
50	26	16	7	2	26	16	7	2
75	34	21	11	6	34	22	11	6

Note: In the table, we consider investment-loan bridges in the top panel, and the subset of investment-loan bridges with formal–informal–formal linkages in the bottom panel. In columns 2 and 6, we show *bridge-duration*, which is equal to the overall month gap between the start of the loan a and the end of loan c for each investment-linked loan-bridge. In columns 3 and 7, we show *start-end-duration*, which is equal to the sum of the month gap between the start of loan a to the start of loan b and the month gap between the end of loan b to the end of loan c. In columns 4 and 8, we show *overlap-duration*, which is equal to the sum of the number of months in which loan a overlaps with loan b and the number of months in which loan c overlaps with loan b. In columns 5 and 9, we compute *gap-duration*, which is equal to the number of months between the end of loan a and the start of loan c. In columns 2 to 5, we consider productive asset definitions without land. Results correspond to investment-linked loan bridges from the lower panels of columns 1 and 2 in Table 4. We include land in columns 6 to 9, and results correspond to investment-linked loan bridges from the lower panels of columns 3 and 4 in Table 4. See discussions in Section 3.3.

TABLE 6. The relative size of loans to investments and loans to loans in time-linked investment-loan bridges.

	Loan bridges linked to agricultural and business assets investments			Loan bridges linked to agricultural, business, and land assets investments			Loan bridges linked to agri., business, land, and household assets investments		
Numerator	a loans principals	b loan principals	c loan principals	a loans principals	b loan principals	c loan principals	a loans principals	b loan principals	c loan principals
Denominator	Investment size	a loans principals		Investment size	a loans principals		Investment size	a loans principals	
All investment-loan bridges									
Quartiles (fractions shown as percentages)									
25	29%	10%	16%	22%	11%	17%	19%	11%	14%
50	83%	30%	50%	66%	32%	50%	54%	29%	44%
75	173%	100%	100%	131%	100%	100%	103%	90%	100%
Invest-loan bridges with formal-informal-formal linkages									
Quartiles (fractions shown as percentages)									
25	44%	8%	16%	32%	8%	16%	27%	8%	14%
50	95%	17%	40%	76%	20%	40%	66%	19%	40%
75	181%	55%	97%	144%	67%	97%	131%	59%	100%

Note: The relative size of investment and loans in investment-loan bridges. In the table, we consider investment-loan bridges in the top panel, and the subset of investment-loan bridges with formal–informal–formal linkages in the bottom panel. In columns 2, 5, and 8, we show the *loan-a-to-investment ratio*, which is equal to the the principals of a loans divided by the size of investment. In columns 3, 6, and 9, we show the *loan-b-to-a ratio*, which is equal to the ratio of the principal of linked loan b to the principals of a loans. In columns 3, 6, and 9, we compute the *loan-c-to-a ratio*, which is equal to the ratio of the principal of linked loan c to the principals of a loans, linked via loan b. In columns 2 to 4, we consider productive asset definitions without land. Results correspond to investment-linked loan bridges from the lower panels of columns 1 and 2 in Table 4. We include land in columns 5 to 7, and results correspond to investment-linked loan bridges from the lower panels of columns 3 and 4 in Table 4. We include land and household assets in columns 8 to 10, and results correspond to investment-linked loan bridges from the lower panels of columns 5 and 6 in Table 4. See discussions in Section 3.3.

TABLE 7. Changes in 12 months average monthly income before and after the investment month and the size of investment.

	Outcome: pre-post investment monthly income gap					
	All income			Self-employed income		
	(1)	(2)	(3)	(4)	(5)	(6)
Productive assets (business, agricultural, and livestock assets) investments						
Investment (pre-post asset difference)	0.0201	0.0120	0.0130	0.0161	0.0114	0.0119
	(0.0064)	(0.0072)	(0.0074)	(0.0061)	(0.0069)	(0.0071)
R^2	0.013	0.218	0.268	0.009	0.208	0.254
Observations	720	720	720	720	720	720
Productive assets including land investments						
Investment (pre-post asset difference)	0.0114	0.0090	0.0099	0.0134	0.0108	0.0110
	(0.0036)	(0.0040)	(0.0041)	(0.0027)	(0.0029)	(0.0030)
R^2	0.012	0.184	0.208	0.030	0.211	0.225
Observations	805	805	805	805	805	805
Survey-month FE	No	Yes	Yes	No	Yes	Yes
Village FE	No	No	Yes	No	No	Yes

Note: Standard errors in parenthesis. Table reports coefficient from regressing the difference in average monthly income (revenue minus costs) from 12 months preceding and after the investment month on the size of investments. Investment size is the difference in asset before and after investment. In the upper panel, we show results using productive assets without land. In the lower panel, we include land. In columns (1) and (4) of, we regress changes in income on the size of investments without controls. We control for survey month fixed effects in column (2) and (5), and both survey month and village fixed effects in column (3) and (6). In columns (1) to (3) we consider all sources of income, and we consider only self-employed productive income from agricultural (including livestock, fish and shrimp) and business sources in columns (4) to (6). Placebo results considering household assets only are included in Appendix Table D.2. Consistent with the results in Tables 4, 5, and 6, the sample here considers only investments that exceed 10,000 baht and that were made between month 15 and month 145. In Appendix Table D.3, we provide estimates when these sampling restrictions are relaxed. To avoid outlier contamination, we exclude the top 1 percentile of the investment changes from the estimation sample. See discussions in Section 3.4.

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ONLINE APPENDIX

Timing lumpy investments with informal bridge loans and clunky formal loans: Evidence from Thailand

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Appendix A. Proofs

Subsection A.1. **Proof of Proposition 4.1.** To be completed.

Sketch of proof: The proof of proposition 4.1 follows from a proof by elimination.

Lemma A.1. *If the farmer makes an investment at time t, it will always be equal to $k(t) = I$. After making an investment, the farmer will not make any further investments.*

This result follows because any investment less than I has zero output and the farmer has the opportunity cost of investing in the safe, low-return, technology that has a return of $\underline{r}$, which is strictly greater than zero. Further, the farmer's investment in total capital (K_t) would never strictly exceed I units of capital, because more than I units of capital is costly and has no benefits to the farmer.

Lemma A.2. *If the farmer uses a formal loan, the farmer will only borrow to repay existing informal debt or invest in the lumpy investment.*

This results follows because both the farmer's discount rate (ρ) and the return on the poor savings technology ($\underline{r}$) are strictly less than the interest rate on formal loans (r). Therefore, the farmer would never benefit from taking a loan for consumption purposes. Recall that in our model, we require that the farmer fully repays the formal loan before taking an another formal loan.

Lemma A.3. *If the farmer uses an informal loan, the informal loan will only be used to 'bridge' two formal loans.*

This result follows because the informal loan has almost an infinite interest rate (there's a fee, f, for a loan of maturity of length ε, where ε is very small). Therefore, similar to the result for formal loans, the lender will only use the informal loan to repay maturing (formal) debt. The farmer will never use informal loans to invest in the lumpy investment because informal loans charge a higher interest rate than formal loans nor for consumption purposes since the interest rate is much higher than their discount rate. Conversely, if the farmer takes a second formal loan, it must be to repay the informal loan.

Lemma A.4. *Never Invest: Assume the farmer does not invest, then the farmer's consumption and liquid assets will satisfy the following conditions:*

$$c(t) = w \quad \forall t \tag{A.1}$$

$$a(t) = 0 \quad \forall t \tag{A.2}$$

This result follows from the farmer having a CRRA utility function (so the farmer prefers to smooth consumption). Specifically, we know from Lemmas (A.2) and (A.3) that the farmer will not borrow if the farmer does not invest. Therefore, since the return on the poor savings technology is less than the farmer's discount rate, the farmer would prefer to consume their wage income in all periods and not save. Formally, we can state the farmer's maximization problem from equation (15) simplifies to:

$$V(c) = \max_{\{c(t)\}_{t=0}^{\infty}} \int_{t=0}^{\infty} \frac{c\left(t\right)^{1-\sigma}}{1-\sigma} e^{-\rho t} dt \tag{A.3}$$

$$\text{s.t.}$$

$$a(0) = 0 \text{ and } a\left(t\right) \geq 0 \tag{A.4}$$

$$\dot{a} = w - c(t) + \underline{r} \cdot a \tag{A.5}$$

And since the interest rate on savings is strictly less than the discount rate ($\underline{r} < \rho$), the solution to this problem is given by equations (A.1) and (A.2).

Lemma A.5. *If the farmer invests, the farmer's consumption path is as follows: Investment,* s_2*: The farmer saves until* T_I*, and subsequently invests using formal and informal loans, repays in phases over* $[T_I, T_I+2]$*, and consumes the wages and return to capital thereafter (w+i). The optimal consumption path is:*

$$c(t) = \begin{cases} c_0\, e^{-m\,(t-T_I)}, & 0 \leq t < T_I, \\ \bar{c}_1, & T_I \leq t < T_{RI1}, \\ c_1\, e^{m\,(T_I+1-t)}, & T_{RI1} \leq t \leq T_I+1, \\ \bar{c}_2, & T_I+1 < t < T_{RI2}, \\ c_2\, e^{m\,(T_I+2-t)}, & T_{RI2} \leq t \leq T_I+2, \\ w+i, & t \geq T_I+2. \end{cases}$$

where $m = \frac{\rho-r}{\sigma} > 0$*, and the parameters* $c_0, \bar{c}_1, c_1, \bar{c}_2, c_2 > 0$ *and the dates* T_{RI1}*,* T_{RI2} *and* T_I *are determined endogenously.*

To solve this problem, it is easier to show the solution for the more general case where a farmer uses both the formal and informal loans. Subsequently, we show that using solely formal credit or no credit to invest are special cases of this more general case. The proof follows from backward induction.

From lemma (A.1), if the farmer invests, it will be only be in one time period, so let's define that time period as $t = T_{\mathrm{I}}$. Therefore, capital investment must follow the following process:

$$k^s(t) = \begin{cases} 0 & \text{if } t \neq T_{\mathrm{I}} \\ I & \text{if } t = T_{\mathrm{I}} \end{cases}$$

To start let's break the farmer's problem into four distinct phases. As explained in Lemma (A.2), if the farmer borrows, the farmer will only borrow to invest so this must also occur at time T_I. The farmer takes an informal loan at time T_I+1, which is used to fully repay the initial formal loan at its due date. The farmer then takes another formal loan immediately at time T_I+1 to repay the informal loan. Finally, the farmer repays the second formal loan at its due date T_I+2. Therefore, the four phases are: before investment ($t < T_I$), while repaying the first formal loan ($T_I < t < T_I+1$), and after repaying the first formal loan but before the final loan ($T_I+1 < t < T_I+2$) and after repaying all debt ($t > T_I+2$).

For $t > T_I + 2$: For the same logic in lemma (A.4), after investing and repaying all debt, the farmer will consume all their income, that is:

$$c(t) = w + i \quad \forall t > T_I + 2 \tag{A.6}$$

For $T_I + 1 < t < T_I + 2$: If the farmer has invested and taken a second formal loan of size $LF2$ at time $T_I + 1$ which matures at $T_I + 2$, the farmer will solve the following problem at time $T_I + 1$:

$$V(c) = \max_{\{c(t)\}_{t=T_I+1}^{\infty}} \int_{t=T_I+1}^{\infty} \frac{c\,(t)^{1-\sigma}}{1-\sigma} e^{-\rho t} dt \tag{A.7}$$

s.t.

$$a(T_I + 1) = 0 \text{ and } a\,(t) \geq 0 \tag{A.8}$$

$$a(T_I + 2^-) = exp(r)LF2 \tag{A.9}$$

$$\dot{a} = w + i - c(t) + \underline{r}a(t) \quad \forall t \in (T_I + 1, T_I + 2) \tag{A.10}$$

Since we know that c(t) is equal to $w + i$ for all t greater than $T_I + 2$, this problem simplifies to:

$$V(c) = \max_{\{c(t)\}_{t=T_I+1}^{T_I+2}} \int_{t=T_I+1}^{T_I+2} \frac{c\,(t)^{1-\sigma}}{1-\sigma} e^{-\rho t} dt \tag{A.11}$$

s.t.

$$exp(r)LF2 = exp(\underline{r}) \int_0^1 (w + i - c(s + T_I + 1))e^{-\underline{r}s}\, ds \tag{A.12}$$

$$c(t) < w + i \tag{A.13}$$

Given the CRRA preferences, the solution to this problem is that consumption path will follow:

Let $m := \frac{r-\rho}{\sigma}$. Then:

$$c(t) = \begin{cases} c_2 \cdot e^{m(t-T_I-1)}, & \text{if } c_2 \cdot e^{m(t-T_I-1)} < w + i \\ w + i, & \text{otherwise} \end{cases} \qquad \text{for } t \in [T_I + 1,\ T_I + 2]$$

Where the region $c(t) = w + i$ is solely to ensure that the farmer's consumption path remains constrained by the liquidity constraints and c_2 is chosen such that equation A.12 (the budget constraint) is satisfied.

For $T_I < t < T_I + 1$: If the farmer invests at time T_I, takes a formal loan of size $LF1$ at time T_I which matures at $T_I + 1$, an informal loan of size LI at time $T_I + 1^-$, the farmer will solve the following problem at time T_I:

$$V(c) = max_{\{c(t)\}_{t=T_I}^{T_I+1}} \int_{t=T_I}^{T_I+1} \frac{c\,(t)^{1-\sigma}}{1-\sigma} e^{-\rho t} dt \tag{A.14}$$

s.t.

$$a(T_I) = 0 \text{ and } a\,(t) \geq 0 \tag{A.15}$$

$$a(T_I + 1^-) + L^I = exp(r)LF1 \tag{A.16}$$

$$\dot{a} = w + i - c(t) + \underline{r}a(t) \quad \forall t \in (T_I, T_I + 1) \tag{A.17}$$

Similar to the earlier problem, for given loans of size $LF1$ and LI, this problem can be written as:

$$V(c) = \max_{\{c(t)\}_{t=T_I}^{T_I+1}} \int_{t=T_I}^{T_I+1} \frac{c\,(t)^{1-\sigma}}{1-\sigma} e^{-\rho t} dt \tag{A.18}$$

s.t.

$$exp(r)LF1 = exp(\underline{r}) \int_0^1 (w + i - c(s + T_I))e^{-\underline{r}s}\, ds + LI \tag{A.19}$$

$$c(t) < w + i \tag{A.20}$$

As before, given the CRRA preferences, the solution to this problem is that consumption path will follow:

Let $m := \frac{r-\rho}{\sigma}$. Then:

$$c(t) = \begin{cases} c_1 \cdot e^{m(t-T_I)}, & \text{if } c_1 \cdot e^{m(t-T_I)} < w + i \\ w + i, & \text{otherwise} \end{cases} \qquad \text{for } t \in [T_I,\ T_I + 1]$$

For $t < T_I$: If the farmer invests at time T_I using a formal loan of size LF1, then the farmer's problem is simply:

$$V(c) = \max_{\{c(t)\}_{t=0}^{T_I}} \int_{t=0}^{T_I} \frac{c(t)^{1-\sigma}}{1-\sigma} e^{-\rho t} dt \tag{A.21}$$

s.t.

$$a(0) = 0 \text{ and } a(t) \geq 0 \tag{A.22}$$

$$\dot{a} = w - c(t) + \underline{r} \cdot a \quad \forall t < T_I \tag{A.23}$$

$$a(T_I^-) + LF1 = I \tag{A.24}$$

For a given LF1 and and T_I and given the CRRA preferences, the solution to this problem is that consumption path will follow[A.17]:

Let $m := \frac{r-\rho}{\sigma}$. Then:

$$c(t) = c_0 \cdot e^{m(t-T_I)}, \quad \text{for } t \in [0,\ T_I)$$

Therefore, we can now state the farmer's problem, if investing, as:

A.1.1. *Farmer's problem if investing.* Define the choice variable:

$$x = \left(c_0,\, c_1,\, c_2,\, T_I,\, LF1,\, LF2,\, L^I\right)$$

where:

- c_0 Consumption at $t = 0$ $(0 < c_0 < w)$
- c_1 Consumption *just before* $t = T_I + 1$ $(0 < c_1 < w + i)$
- c_2 Consumption *just before* $t = T_I + 2$ $(0 < c_2 < w + i)$
- T_I Investment time
- $LF1$ Formal loan drawn at $t = T_I$
- L^I Informal loan drawn at $t = T_I + 1^-$
- $LF2$ Second formal loan drawn at $t = T_I + 1$

A.17. If the farmer is investing, it is never optimal for the farmer to be constrained by the income stream, that is the farmer should always save a little to start so we do not need a "min" function in writing the farmer's optimal consumption for $t < T_I$

Objective.

$$\max_x \; V = \int_0^{T_I+2} \frac{c(t)^{1-\sigma}}{1-\sigma} e^{-\rho t}\, dt + \int_{T_I+2}^{\infty} \frac{(w+i)^{1-\sigma}}{1-\sigma} e^{-\rho t}\, dt$$
$$= \int_0^{T_I+2} \frac{c(t)^{1-\sigma}}{1-\sigma} e^{-\rho t}\, dt \; + \; \frac{(w+i)^{1-\sigma}}{(1-\sigma)\,\rho} e^{-\rho\,(T_I+2)}.$$

Budget constraints.

(B1)
$$\int_0^{T_I} (w - c(t))\, e^{\underline{r}\,(T_I - t)}\, dt \; + \; LF1 = I,$$

(B2)
$$\int_{T_I}^{T_I+1} (w + i - c(t))\, e^{\underline{r}\,(T_I+1-t)}\, dt \; + \; L^I = LF1\, e^r,$$

(B3)
$$f\, L^I = LF2,$$

(B4)
$$\int_{T_I+1}^{T_I+2} (w + i - c(t))\, e^{\underline{r}\,(T_I+2-t)}\, dt = LF2\, e^r.$$

Consumption path.

$$c(t) = \begin{cases} c_0\, e^{m\,(T_I - t)}, & 0 \le t < T_I, \\ \min(c_1\, e^{m\,(T_I+1-t)}, w+i), & T_I \le t \le T_I + 1, \\ \min(c_2\, e^{m\,(T_I+2-t)}, w+i), & T_{I+1} \le t \le T_I + 2, \\ w + i, & t \ge T_I + 2. \end{cases}$$

where $m := \frac{r-\rho}{\sigma}$..

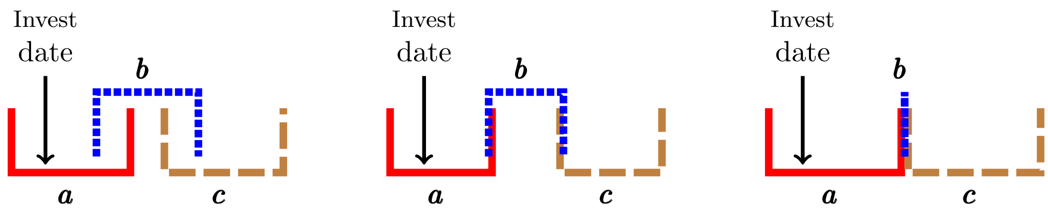
Feasibility conditions.

$$c_0, c_1, c_2 \ge 0$$
$$LF1, LF2, L^I > 0,$$
$$c(t) \le w \;\; (t < T_I).$$

This problem can be solved with numerical methods.

Appendix B. Additional Data Definition and Construction (online)

Subsection B.1. **Defining investment-linked loan hooks and bridges.** Building on the discussions in Section 3.2 of the main text, here we define loan sets $L^A_{j,k}(\tau)$, $L^B_{j,k}(a)$, and $L^C_{j,k}(a,b)$ and illustrate types of investment-k-linked bridge loans. For added precision, in this section, we redefine L^A from Eq. (1) and $\mathcal{B}_{j,k}(\tau)$ from Eq. (2) with additional notations for household j, investment k, and investment-loan windows τ.



(a) Loans a and b as well as loans b and c are "loosely-hooked" to each other—bridge loan b originates before a is due and b is due after c originates.

(b) The loans are "tightly–hooked"—bridge loan b originates when a is due and b is repaid when c originates.

(c) The "bridge" is lengthless—the bridge loan b originates and is repaid in the same unit of time that a is repaid and c originates.

Fig. B.1. We illustrate in three panels the origination and repayment timelines for three types of investment-linked bridge loans allowed by Eq. (B.5). Investment-linked loan a is shown in solid-red, bridge-loan b is shown in dotted-blue, and third loan c is shown in dashed-brown. The left and right vertical bounding edges for each loan illustrates origination and due dates (months) for each loan, and the horizontal span for each loan illustrates loan duration. A black arrow points to the date when the investment is made, which is within τ-window of loan a as defined in Equation (1).

Let $m^{\mathrm{I},s}_{j,k}$ and $m^{\mathrm{I},e}_{j,k}$ be the starting and ending month of the kth investment made by household j; superscript I denotes investments. Let $m^{\mathrm{L},s}_{j,a}$ and $m^{\mathrm{L},e}_{j,a}$ be the month in which loan a made by household j was first initiated and the month in which it is fully repaid, respectively; superscript L denotes loans. Let L_j be the total number of loans taken out by household j during the span of survey been considered, each investment k by household j has a set of "investment-linked" loans $L^A_{j,k}(\tau)$:

$$\text{(B.1)} \qquad L^A_{j,k}(\tau) = \Big\{ a \in \{1, \ldots, L_j\} \mid \ m^{\mathrm{I},s}_{j,k} - \tau \le m^{\mathrm{L},s}_{j,a} \le m^{\mathrm{I},s}_{j,k} \text{ and } m^{\mathrm{I},e}_{j,k} < m^{\mathrm{L},e}_{j,a} \ \Big\} .$$

Loan set $L^B_{j,k}(a)$ loans that are "hooked" to investment k via loan a from loan $L^A_{j,k}(\tau)$. Specifically, loan $b \in L^B_{j,k}(a)$ is taken out by household j after loan a has *originated* and before or in the month in which loan a is *due*, and loan b is repaid after or in the month in which loan a is *due*:

$$\text{(B.2)} \qquad L^B_{j,k}(a) = \left\{ b \in \{1,\ldots,L_j\} \setminus L^A_{j,k}(\tau) \;\middle|\; \begin{array}{c} m^{\mathrm{L},s}_{j,a} < m^{\mathrm{L},s}_{j,b} \leq m^{\mathrm{L},e}_{j,a} \\ \text{and } m^{\mathrm{L},e}_{j,a} \leq m^{\mathrm{L},e}_{j,b} \end{array} \right\} \text{ for } a \in L^A_{j,k}(\tau)\ .$$

For household j, the set of investment-k-linked hooked loans are:

$$\text{(B.3)} \qquad \mathrm{HOOK}_{j,k}(\tau) = \left\{ (a,b) \mid a \in L^A_{j,k}(\tau) \text{ and } b \in L^B_{j,k}(a) \right\}\ .$$

We define loan set $L^C_{j,k}(a,b)$ as containing loans that are "bridge-linked" to investment k via sets $L^B_{j,k}(a)$ and $L^A_{j,k}(\tau)$ loans. Specifically, the origination date of loan $c \in L^C_{j,k}(a,b)$ satisfies three conditions: Loan c originates after or in the same month that loan a is *due*, after or in the same month that loan b *originates*, and before or in the same month that loan b is *due*. Additionally, the due month for loan c must come after the *due* date of loan b:

$$\text{(B.4)} \qquad \begin{array}{c} L^C_{j,k}(a,b) = \left\{ c \in \{1,\ldots,L_j\} \setminus \left(L^A_{j,k}(\tau) \cup L^B_{j,k}(a)\right) \;\middle|\; \begin{array}{c} m^{\mathrm{L},e}_{j,a} \leq m^{\mathrm{L},s}_{j,c}\ , \\ m^{\mathrm{L},s}_{j,b} \leq m^{\mathrm{L},s}_{j,c} \leq m^{\mathrm{L},e}_{j,b}\ , \\ \text{and } m^{\mathrm{L},e}_{j,b} < m^{\mathrm{L},e}_{j,c} \end{array} \right\} \\ \text{for } b \in L^B_{j,k}(a) \text{ and } a \in L^A_{j,k}(\tau)\ . \end{array}$$

For household j, the set of investment-k-linked bridge loans are:

$$\text{(B.5)} \qquad \mathcal{B}_{j,k}(\tau) = \left\{ (a,b,c) \mid a \in L^A_{j,k}(\tau), b \in L^B_{j,k}(a) \text{ and } c \in L^C_{j,k}(a,b) \right\}\ .$$

Eq. (B.5) allows for three types of "bridges" as visualized in Figure B.1. In Panel (a), the loans are "loosely-hooked"—the bridging loan is taken out before the due date of the first loan and repaid after the origination date of the third loan. Conforming to Eqs. (B.1), (B.2) and (B.4), the investment, loan origination, and loan due dates are such that: $m^{\mathrm{L},s}_{j,a} < m^{\mathrm{I},s}_{j,k} < m^{\mathrm{L},s}_{j,b} < m^{\mathrm{L},e}_{j,a} < m^{\mathrm{L},s}_{j,c} < m^{\mathrm{L},e}_{j,b} < m^{\mathrm{L},e}_{j,c}$. In Panel (b), the loans are "tightly-hooks"—the bridging loan is taken out in the same month the first loan is due and repaid in the same month that the third loan originates, with $m^{\mathrm{L},s}_{j,a} < m^{\mathrm{I},s}_{j,k} < m^{\mathrm{L},s}_{j,b} = m^{\mathrm{L},e}_{j,a} < m^{\mathrm{L},s}_{j,c} = m^{\mathrm{L},e}_{j,b} < m^{\mathrm{L},e}_{j,c}$. In Panel (c), the "bridge" is length-less—the bridge loan originates and is repaid in the same month, with $m^{\mathrm{L},s}_{j,a} < m^{\mathrm{I},s}_{j,k} < m^{\mathrm{L},s}_{j,b} = m^{\mathrm{L},e}_{j,a} = m^{\mathrm{L},s}_{j,c} = m^{\mathrm{L},e}_{j,b} < m^{\mathrm{L},e}_{j,c}$.

Presumably, to function as parts of a loan-bridge, loan b is taken out at a time prior to when loan a is due, and loan c is taken out before loan b is repaid. But temporal unit of observation in surveys, which is month in our empirical data, is unlikely allow allow for sufficiently fine temporal granularity to distinguish the orders of these events.

Subsection B.2. **Inter-loan gaps and loan hooks and bridges definition.**

B.2.1. *Loan hooks.* we identify all within-individual loans that have overlaps, and create a file where the unit of observation is each binary combination of overlapping loans for each household. loans that overlap are "hooked", with a loan that is in the upper hook position, and the paired loan in the bottom hook position.

for each within household paired loan we compute the three gaps:

- `gl`: top left - bottom left
- `gm`: bottom left - top right
- `gr`: top right - bottom right

where "top left" refers to the start date of the first loan, and "bottom right" refers to the end date of the second loan. consideration all possible combinations of loan pairings, two loans are hooked only when all three gaps are positive or non-zero:

- $gl > 0$: the bottom loan is taken out after the top loan.
- $gm \geq 0$: the top loan is not due yet or just due when the bottom loan is taken out.
- $gr > 0$: the bottom loan is due after the top loan is due.

during this process, we also identify loan pairs that have identical timing, these are loan pairs where $gl = gr = 0$. for these loans, $gm + 1 > 0$ is the length (including start and end) of both loans. if $gm = 0$, we have two paired loans that both start and end in the same month. furthermore, we check on whether the hooked loans are provided by the same lender. we document the same of loan hooks that are:

- top and bottom hook from the same lender.
- top and bottom hook have duplicative start and end times: $gl = gr = 0$
- top and bottom hook both start and end in one month: $gm = gl = gr = 0$

B.2.2. *Loan bridges.* A loan bridge consists of three components, left-bank loan (loan A), bridge loan (loan B), and right-bank loan (loan C).

We compute three sets of three gaps.

1. Gaps between left-bank and bridge loans:
    - `G12L`: start of B - start of A
    - `G12M`: end of A - start of B
    - `G12R`: end of B - end of A
2. Gaps between left-bank and bridge loans:
    - `G23L`: start of C - start of B
    - `G23M`: end of B - start of C
    - `G23R`: end of C - end of B
3. Within-loan gap, duration of each lona:

- `GW1`: loan A gap
- `GW2`: loan B gap
- `GW3`: loan C gap

In addition, we compute river, abutment and approach widths. Jointly there are 12 bridge related widths statistics for each loan ridge.

1. River width (`GRV`) = `G12R` - `G23M` = `G23L` - `G12M`
2. Abutment width (`GAB`) = `G12M` + `G23M`
   - Left-abutment width = `G12M`
   - Right-abutment width = `G23M`
3. Approach width (`GAP`) = `G12L` + `G23R`
   - Left-approach width = `G12L`
   - Right-approach width = `G23R`

Having computed these statistics, two most basic requirements are:

1. Must be positive: $GRV > 0$, which means brige A must end in a month prior to the start of bridge C.
2. Middle loan must not be longer than loans A and B: $\min(GW1, GW3) > GW2$, note that $GW2 > GRV$.
3. we define typical bridge as satisfying additionally these conditions: $\min(GW1, GW3) \geq 11 > GW2$

Appendix C. Additional Empirical Results (online)

Subsection C.1. Coterminous formal and informal loans. In Appendix Figure D.6, we present information on the overlaps between formal and informal loans. Appendix Figure D.7 shows the household-specific shares of months in which there are any loans outstanding. Here, to simplify the consideration of conditional probabilities, we group the quasi-formal loans jointly with the informal loans. We consider, for each household month, whether the household has a formal loan outstanding, an informal loan outstanding, or both. For each household, conditional on the months in which there are outstanding informal loans, we count the number of months in which there are concurrently also outstanding formal loans. We then compute the household-specific probability of having formal loans conditional on having informal loans. Following the reverse procedure, we also compute the household-specific probability of having informal loans conditional on having formal loans. Aggregating across households, we arrive at the cross-household distributions of formal and informal conditional probabilities, which are presented in Figure D.6.

If informal loans are used, at least by some households, as bridge loans to rollover formal loans, we might expect the chance of seeing a formal loan during months in which there are informal loans to be high for these households. First, in one scenario, formal loans would be outstanding during the entire duration of an informal loan: an informal bridge loan is taken out close to the last month in which a formal loan is outstanding, a new formal loan is taken out immediately after the prior one is repaid with the help of the bridge loan, and soon after the issuance of the new formal loan, the informal bridge loan is repaid. Corresponding to this possibility, in Figure D.6, following the blue solid line, we observe a high concentration of households close to having 100% for their household-specific $P(\text{Formal} = 1|\text{Informal} = 1)$ conditional probabilities. Second, households with high $P(\text{Formal} = 1|\text{Informal} = 1)$ but not as close to 100% could be using informal loans as bridge loans but have time gaps between when the prior formal loan is repaid and when the new formal loan is issued, which would lead to the household having some months in which an informal loan is not accompanied by a formal loan. Third, given the observed diversity of informal loans, there could also be households that use informal loans for non-bridging purposes, and these might explain the small concentration of $P(\text{Formal} = 1|\text{Informal} = 1)$ around zero.

In contrast, in the bridge loan scenario, given that formal loans have substantial longer average duration, one would expect there to be many months—in between the issuance and repaid dates of formal loans—in which formal loans are outstanding without yet-unneeded informal bridge loans. We find evidence for this in Figure D.6: the $P(\text{Informal} = 1|\text{Formal} = 1)$ distribution is relatively uniform, indicating that many households predominantly have months in which there are formal loans but no informal loans.

Subsection C.2. **Additional results on investment-linked loan hooks and bridges.** Table 4 in the main text presents the share of investments by different investment-loan linkage types for 6 months backward investment-loan window. In Appendix Table D.1, we present results for 3 months backward investment-loan window. Across the columns of Table D.1, we consider different definitions of assets-investments.

In Table D.1, we find that "no-loan" investments increases to 38.5 percent of all investments, which is larger than the 27.9 percent from Table 4. For proportions of types of loans among investment-linked loans, Table D.1 shows that 67 percent of loan-linked investments having bridge-loans and 82 percent of bridge-linked investments having both formal and informal components. These statistics are similar to results from Table 4.

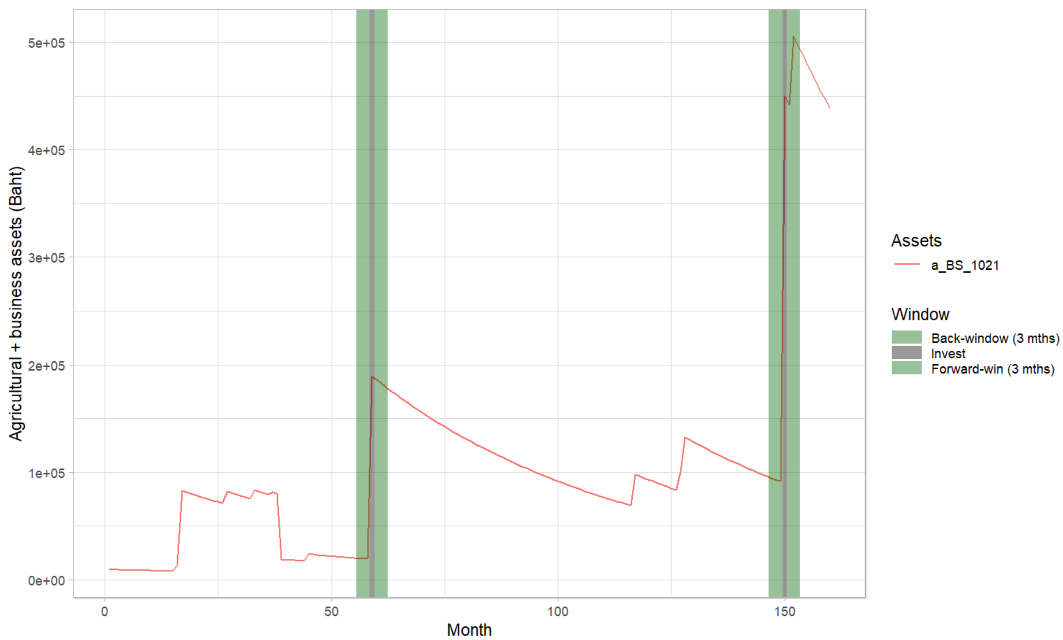
Additionally, Panel (B) of Appendix Figure D.5 shows that when we further contract the backward investment-loan window to $\tau = 0$, bridge-linked investments remains dominant, accounting for 59% of all loan-linked investments.

Subsection C.3. **Additional results on investments and changes in incomes.** In the main text, we present Table 7 and discuss the relationship between investments and changes in income by comparing changes in average monthly incomes in the 12 months after and before the months of investment.

In contrast to Table 7, which uses investments based on productive assets, Appendix Table D.2 uses investments computed based on changes in household assets, as a placebo test. While all estimates for rates of return are positive, they are significantly smaller in magnitudes than estimates in Table 7 and not significant except in the lower panel for column 4. The positive direction of all estimates indicate that a subset of household asset purchases, plausibly those that improve information acquisition and reduce transportation costs, might be partially productivity enhancing.

In Section 3 and for Tables 7 and D.2, to facilitate building investment-loan bridges, we only considered investments larger than 10,000 baht that were made between survey month 15 and month 145. In Appendix Table D.3, we relax these assumptions and consider investments from across the 160 months and of any size. We compute average monthly income from up to 12 month before and after the date of investment. Here, from the larger sample of investments, we find very similar results as in Table 7. In particular, controlling for both village and survey month fixed effects, we find that, on average, the fuller sample of investments are associated with 1.4 percent increase in average monthly income in the 12 months after compared to the 12 month before the date of the investment. Without the time and location fixed effects, we find a similar rate of return of 1.7 percent from column 1.

(a) Illustrative household example 1



(b) Illustrative household example 2

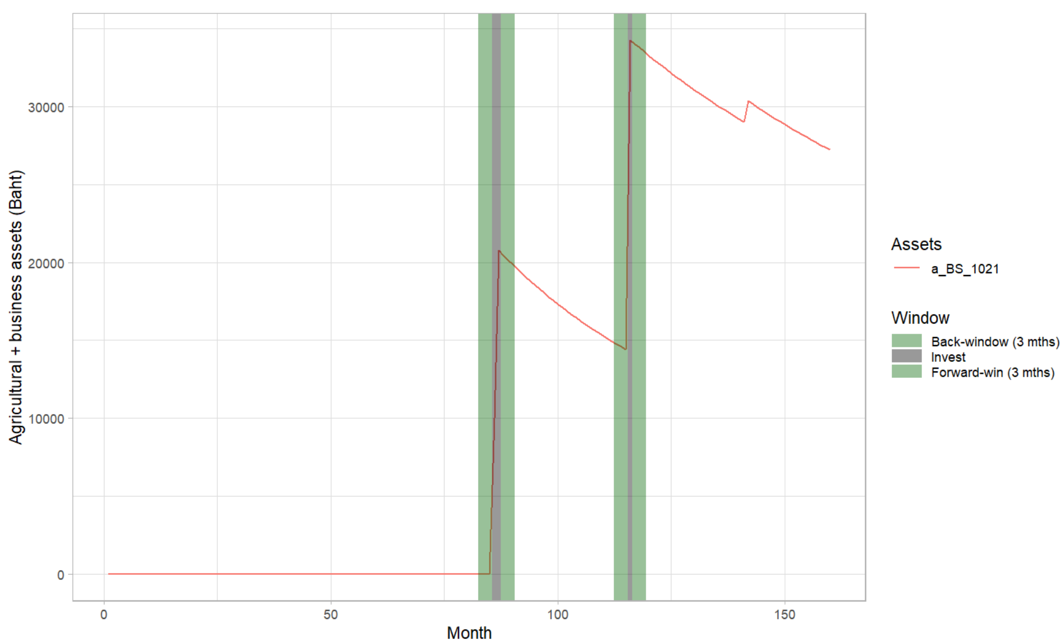
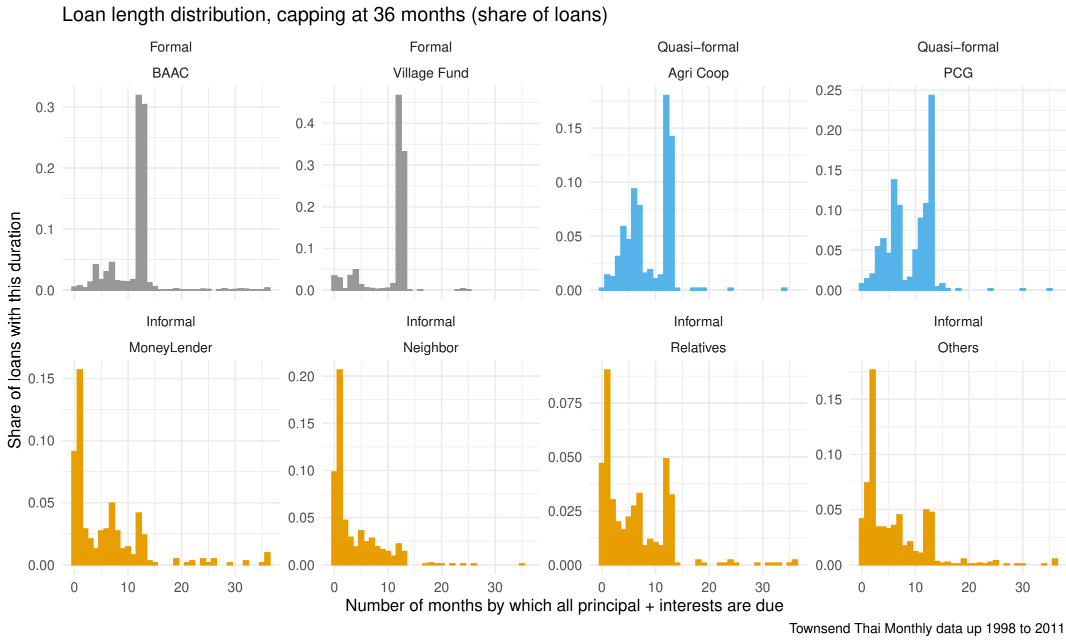


Fig. D.1. Identifying investments (shifts in capital-assets).

(a) Shares



(b) Number of Loans

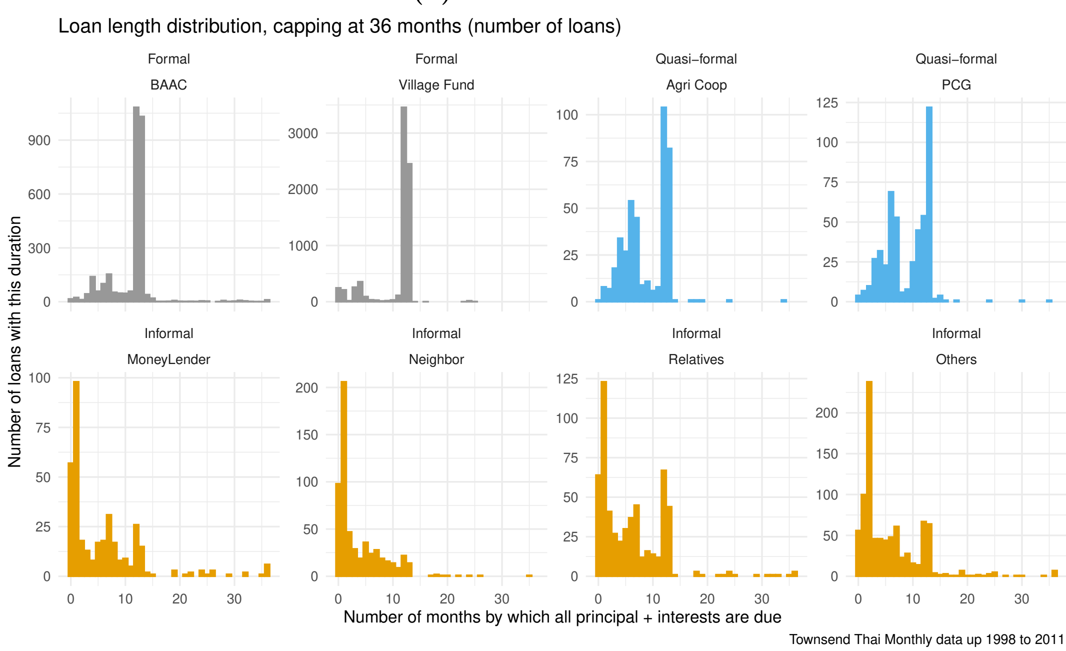


Fig. D.2. Length of loan distribution, across eight key lender types.

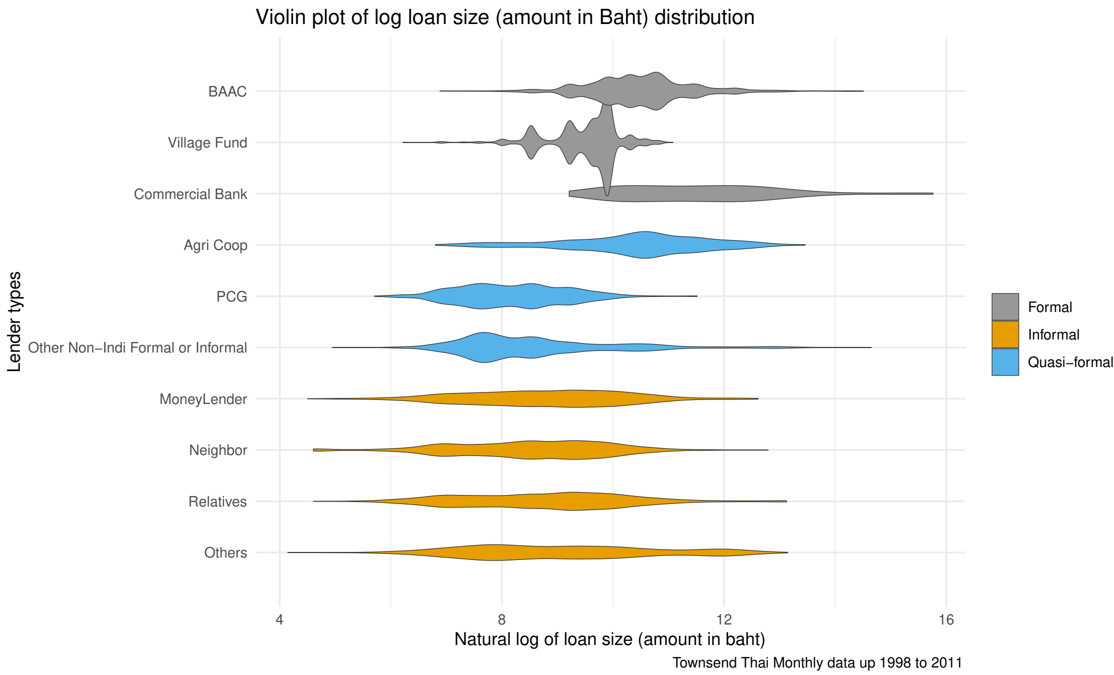


Fig. D.3. Loan size distribution across all lender types

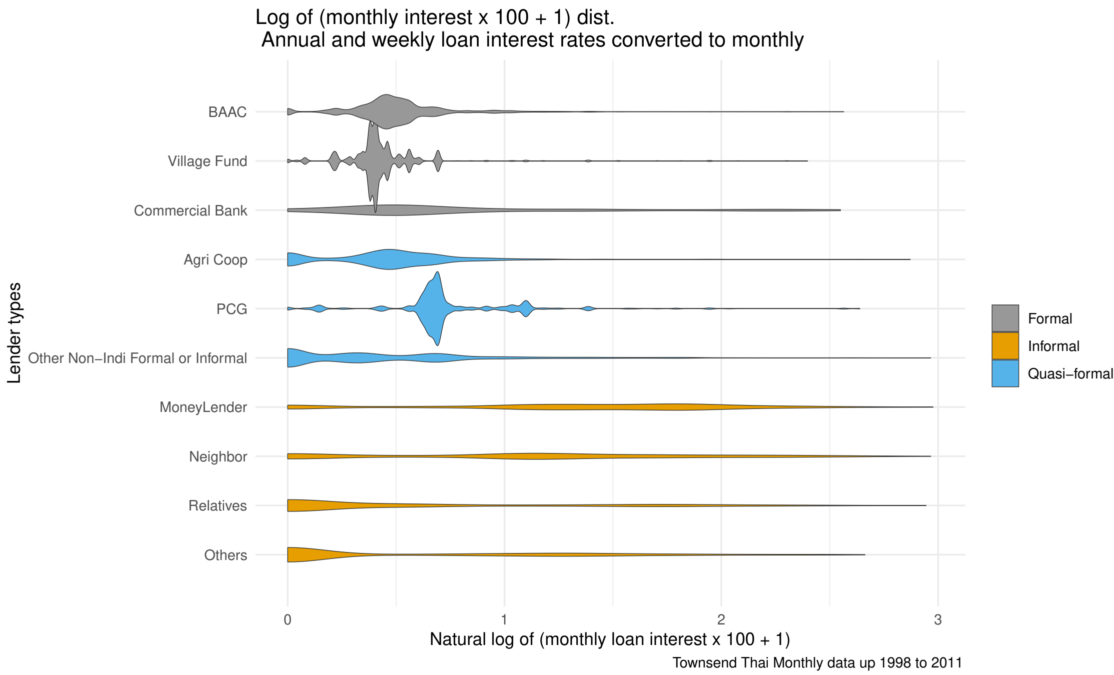
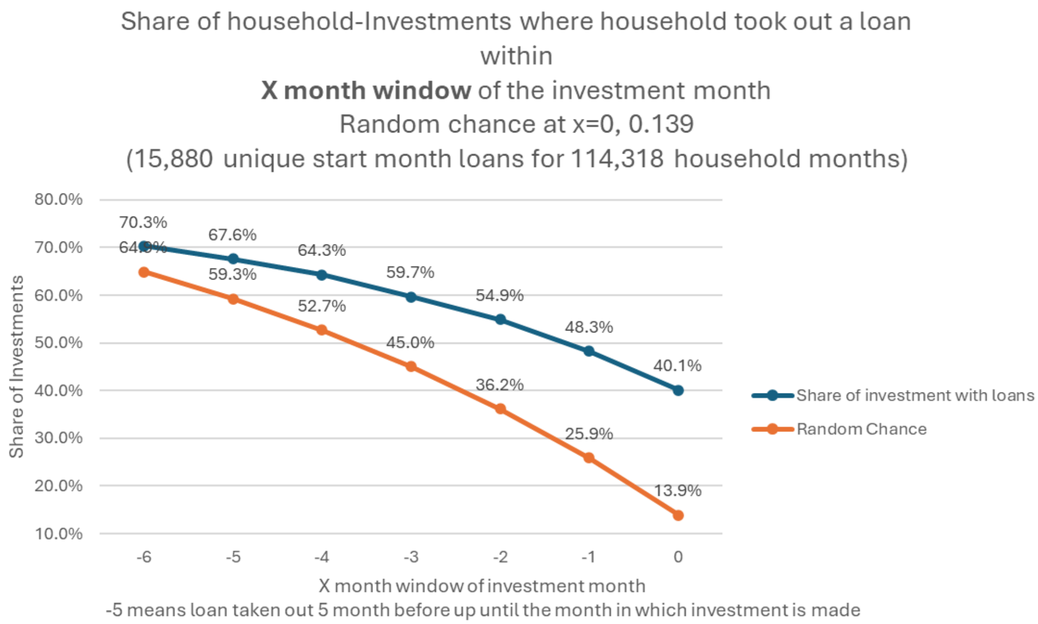


Fig. D.4. Loan interest rates distribution across all lender types

(a) Share of investments with loans



(b) Share of bridged-loans among investments with loans

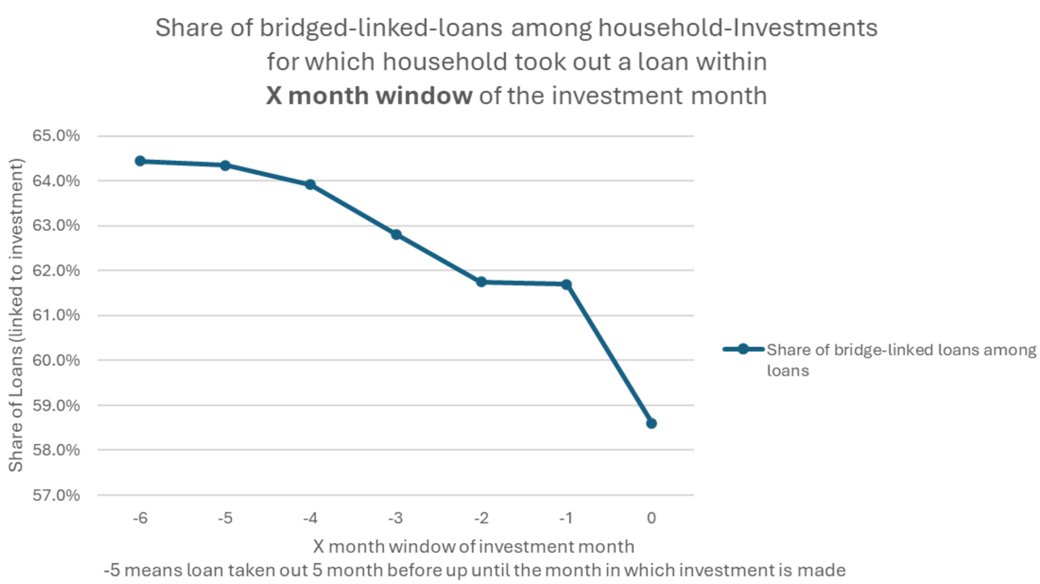


Fig. D.5. Loan and bridge-loan linkages to investments considering investments based on all assets including land and household assets.

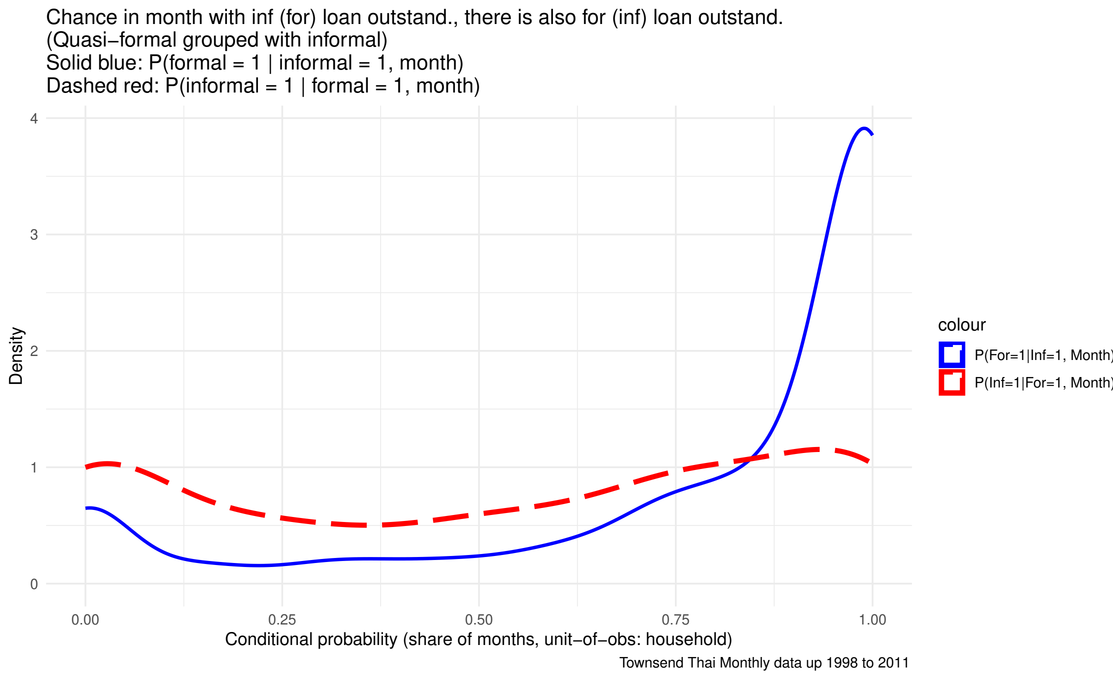


Fig. D.6. Household-specific conditional loan overlap distribution
For each household, we consider the months in which there are informal loans outstanding, and then we count the presence of outstanding formal loans during these informal loan months. This is the household-specific conditional probability of having a formal loan in a month in which the household has formal loans. We also consider the reverse household-specific conditional probability of having informal loans outstanding in months in which a household has formal loans outstanding. Aggregating across households, we present the distribution of these two conditional probabilities.

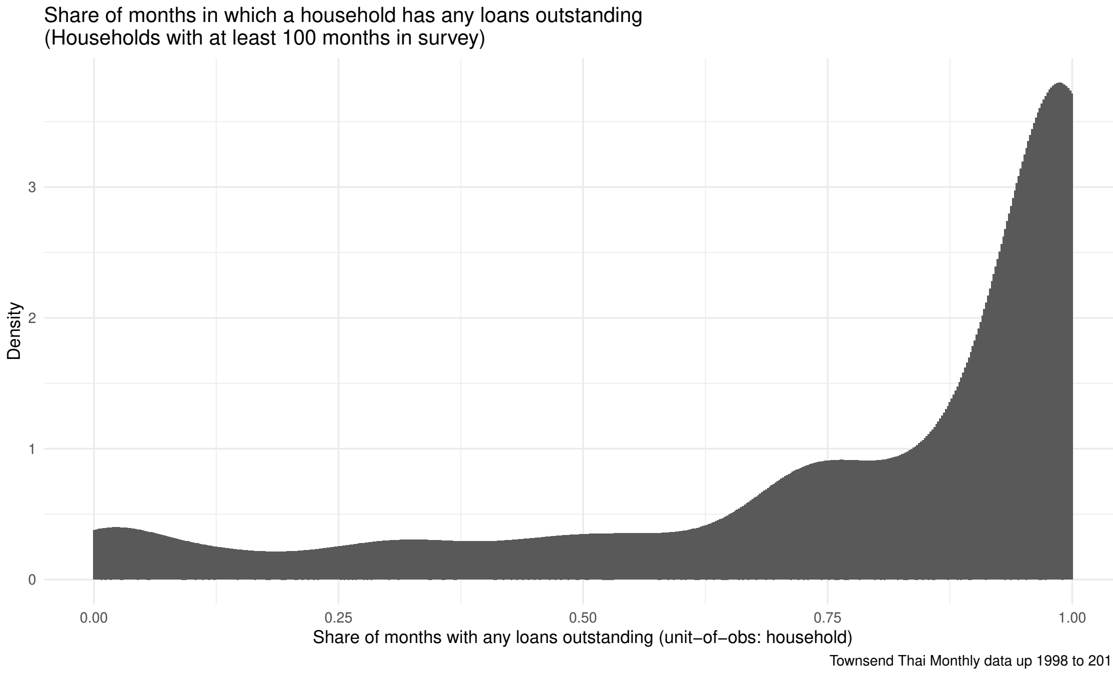


Fig. D.7. Distribution of household-specific share of months with loans

Table D.1. Number (#) and percent (%) of investments by credit arrangements (3 month investment-loan backward window).

	Alternative investment definitions					
	Agricultural and business assets investments		Agricultural, business, and land assets investments		Agricultural, business, land, and household assets investments	
	#	%	#	%	#	%
Investments *not* time-linked to loan bridges						
Invest. *not* time-linked any loans	283	38.5%	333	40.5%	578	40.3%
Invest. time-linked to *standalone* loans (set A loans only)	108	14.7%	133	16.2%	262	18.2%
Invest. time-linked to *"hooked"* loans (set A and B loans only)	42	5.7%	47	5.7%	88	6.1%
Investments time-linked to *only* formal *or only* informal loan bridges						
Single lender type only investment-loan bridge	28	3.8%	25	3.0%	49	3.4%
Multiple formal lenders investment-loan bridge	25	3.4%	22	2.7%	30	2.1%
Multiple informal lender types investment-loan bridge	2	0.0%	1	0.0%	5	0.0%
Investments time-linked to *joint* formal *and* informal investment-loan bridges						
Contains *formal—informal—formal* loan bridges	136	18.5%	131	15.9%	205	14.3%
Do not contain formal—informal—formal loan bridges, but includes *informal links* in bridges	112	15.2%	131	15.9%	219	15.3%

Note: The number and share of investments linked to different types of loan structures, considering different investment definitions across columns, and using 3 months investment-loan backward window ($\tau = 3$). See Table 4 for results based on 6 months backward window. To allow for time before investment and after, we consider investments made between month 15 and month 145 within the 160 months panel. Additionally, to reduce spurious linkages, we consider only investments that exceed 10,000 baht in drawing investment to loan linkages. See discussions in Section 3.2 and Appendix Section C.2.

TABLE D.2. Placebo: Changes in 12 months average monthly income before and after investment month and the size of investment, considering household assets.

	Outcome: pre-post investment monthly income gap					
	All income			Self-employed income		
	(1)	(2)	(3)	(4)	(5)	(6)
Household assets investments						
Investment (pre-post asset difference)	0.0038	0.0050	0.0058	0.0001	0.0023	0.0033
	(0.0044)	(0.0048)	(0.0049)	(0.0040)	(0.0044)	(0.0045)
R^2	0.001	0.096	0.104	0.000	0.094	0.103
Observations	1216	1216	1216	1216	1216	1216
All assets (productive assets, land, and household assets) investments						
Investment (pre-post asset difference)	0.0043	0.0035	0.0041	0.0049	0.0032	0.0032
	(0.0027)	(0.0029)	(0.0030)	(0.0021)	(0.0022)	(0.0023)
R^2	0.002	0.088	0.110	0.004	0.098	0.116
Observations	1406	1406	1406	1406	1406	1406
Survey-month FE	No	Yes	Yes	No	Yes	Yes
Village FE	No	No	Yes	No	No	Yes

Note: Standard errors in parenthesis. Table reports coefficient from regressing the difference in average monthly income from 12 months preceding and after the investment month on the size of investments. We compute investments for each asset definition separately. Investment size is the difference in asset before and after investment. In columns 2 and 5, we control for all survey month fixed effects; in columns 4 and 6, we control for survey month and village fixed effects. In contrast to Table 7, which uses investments based on productive assets, the results here use investments computed based on changes in household assets, which are not productivity enhancing, as a placebo test. See discussions in Section 3.4 and Appendix Section C.3.

TABLE D.3. Full investment sample: Changes in 12 months average monthly income before and after investment month and the size of investment.

	Outcome: pre-post investment monthly income gap					
	All income			Self-employed income		
	(1)	(2)	(3)	(4)	(5)	(6)
Productive assets (business, agricultural, and livestock assets) investments						
Investment (pre-post asset difference)	0.0168	0.0147	0.0138	0.0135	0.0117	0.0103
	(0.0053)	(0.0058)	(0.0061)	(0.0049)	(0.0054)	(0.0056)
R^2	0.008	0.145	0.158	0.006	0.137	0.149
Observations	1181	1181	1181	1181	1181	1181
Productive assets including land investments						
Investment (pre-post asset difference)	0.0079	0.0066	0.0070	0.0091	0.0085	0.0081
	(0.0036)	(0.0038)	(0.0090)	(0.0096)	(0.0052)	(0.0056)
R^2	0.005	0.131	0.150	0.013	0.151	0.165
Observations	1184	1184	1184	1184	1184	1184
Survey-month FE	No	Yes	Yes	No	Yes	Yes
Village FE	No	No	Yes	No	No	Yes

Note: Standard errors in parenthesis. Table reports coefficient from regressing the difference in average monthly income from 12 months preceding and after the investment month on the size of investments. We compute investments for each asset definition separately. Investment size is the difference in asset before and after investment. In columns 2 and 5, we control for all survey month fixed effects; in columns 4 and 6, we control for survey month and village fixed effects. In Section 3 and for Tables 7 and D.2, to facilitate building investment-loan bridges, we only considered investments larger than 10,000 baht that were made between survey month 15 and month 145. Here, we relax these assumptions and consider investments from across the 160 months and of any size. We compute average monthly income from up to 12 month before and after the date of investment. See discussions in Section 3.4 and Appendix Section C.3.