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ESSAYS ON ECONOMICS OF RURAL HOUSEHOLDS IN DEVELOPING COUNTRIES

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KENNETH C. GRIFFIN DEPARTMENT OF ECONOMICS

BY
PAPHON KIATSAKULDECHA

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To the less fortunate, may the lessons learned and skills acquired, benefit others

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ABSTRACT

This dissertation consists of two essays on behaviors of rural households in developing countries in response to their unique economic circumstances. These rural households in developing countries are specifically different from their developed counterparts in how they earn their livings. Rather than being a simple wage earner with a single income source, a typical rural household generally engages in both formal wage labor market and other income generating activities, such as farming, raising livestock, or running a small business, at home. Chapter 1 focuses on labor supply responses as consumption smoothing mechanisms against wage and productivity shocks. Chapter 2 analyzes the responses of household durable consumption and business investment in respond to a credit shock.

Chapter 1 investigates the link between consumption change and changes in wages and productivities among households in developing countries. These households generally participate in both a wage labor market and home production activities. For my investigation, I use a reduced-form framework that features households making consumption, savings, and labor supply decisions, at both the intensive and extensive margins. They make these decisions in both the wage labor market and production sectors, in the presence of co-moving wage and productivity shocks. A reduced-form model, including a home production function, is estimated using panel data from Thai villages. The data comprises consumption, assets, labor hours, and earnings in both labor market and home production. Unobserved productivities for non-participants in production are jointly estimated with model parameters through a Markov Chain Monte Carlo technique. I focus on labor supply responses on both labor market and production sectors as consumption insurance mechanisms. Overall, I find evidence of strong consumption smoothing to both wage and productivity shocks. Labor supply

decisions, on both extensive and intensive margin, respond to both shocks, and indeed account for significant portions of consumption insurance.

Chapter 2 investigates the underlying life-cycle patterns of Thai households' durable expenditures and business investment. I found that durable expenditures were highest among younger households while business investments were highest among middle-age households. I then built a three-asset heterogenous agent life-cycle model that performs reasonably well in matching these life-cycle patterns in the data. Next, I investigated the impact of Thailand's "Million Baht Village Fund" program, Thailand's large-scale credit injections in 2002, on durable expenditures and business investments. The main empirical findings were that households responded significantly to credit injection by purchasing household durables rather and investing in household business. The latter was the intended purpose of the credit injection program. Further, a simulation exercise on relaxation of credit constraint based on proposed structural model was able to capture the qualitative difference in life cycle patterns among participants and non-participants of the credit injection program.

CHAPTER 1

DUAL SECTORS AND CONSUMPTION INSURANCE IN DEVELOPING ECONOMIES

1.1 Introduction

In this paper, I investigate the link between consumption change and changes in wages and productivities among households in developing countries. These households generally participate in both a wage labor market and home production activities. For my investigation, I use a reduced-form framework that features households making consumption, savings, and labor supply decisions, at both the intensive and extensive margins. They make these decisions in both the wage labor market and production sectors, in the presence of co-moving wage and productivity shocks. A reduced-form model, including a home production function, is estimated using panel data from Thai villages. The data comprises consumption, assets, labor hours, and earnings in both labor market and home production.

A large number of studies has established the link between movements in household consumption and movements in idiosyncratic income. The majority of these studies relates changes in consumption to changes in persistent and non-persistent income components. For example, Blundell, Pistaferrir, Preston (2008) use a reduced-form approach based on a Euler equation approximation of a standard Bewley model to provide an empirical benchmark to test the degree of consumption insurance. They find that around 36% of permanent income shocks and 95% of transitory income shocks are insurable (i.e., not translating into movements in consumption). Overall, the striking finding in their work is that household consumption appears significantly smoothed despite highly persistent income shocks. But, questions emerge:

what economic quantities are driving the income shocks? Andd what are the household's mechanisms behind such smoothing? In this paper, I attempt to answer these questions in the context of the developing economy of Thailand.

Among earlier studies, such as Blundell, Pistaferri, Prestion (2008) and Kaplan and Violante (2014), the household's income process is typically assumed to be exogenous and is estimated with total income data. This standard approach is appropriate for developed countries, in which most households derive their income from a single source, namely wage earnings. For these households, their income fluctuation could be decomposed into fluctuations of wages and working hours. Wage fluctuation is the main driving force behind total income fluctuation in this setting. Some studies, such as Heathcote, Storesletten, Violante (2014), shift the focus to the consumption responses to wage shocks. However, a typical household today might not have only a single earner and a single earner might not hold a single job. In general, the household's total income is exposed to income fluctuations across all household members and all income generating activities the members participate in. In a more recent literature, Blundell, Pistaferri, Saporta (2016) examine household consumption responses to wage shocks from both primary and secondary earners in a family. Koustas (2018) studies consumption responses to wage shocks among individuals participating in ride-share driving as secondary jobs.

In the context of developing countries, most households have multiple income sources. A large fraction of these households are either small farmers or small business owners concurrently with being wage earners. They derive their income from both the labor market and various home production activities, such as cultivating crops, raising livestock, or running small food stands. They have to decide on how much to consume, how many hours to work in the labor market, and how many hours to contribute to home production activities. Home production also utilizes their assets as working capital. These decisions depend on the households' asset levels, wages, and productivities. Hence, unlike their developed counterparts whose main income risks are associated with wage fluctuations, households in rural Thailand face risks from both wage and productivity fluctuations.

How do households react to income shocks, from multiple sources, without fully cutting consumption? The most standard way is to adjust their assets through savings and borrowings. Within this channel, the literature has explored several limitations to optimal asset adjustments, including credit market imperfection (Zeldes, 1989), illiquid assets (Kaplan and Violante, 2014), and consumption commitments (Chetty and Szeidl, 2007). In developing countries, these limitations, especially access to formal credit markets, tend to be more severe. However, households are still able to insure their consumption to a large degree. One way they can do so is through gifts and transfers within their risk-sharing networks of families and friends. Those risk-sharing networks can be generally sustained among village households in developing countries due to their repeated interactions and limited informational asymmetries. In these village economies, household consumption does not respond strongly to own idiosyncratic income shocks once village income is controlled for (Townsend, 1994; Chiappori et al, 2014).

Aside from adjusting their assets, households could also respond to income fluctuations, particularly wage fluctuations, by adjusting their working hours. Using U.S. data, Heathcote, Storesletter, Violante (2014) find that about 20 percent of wage shocks are smoothed through labor supply adjustment. Within labor supply channel, adjusting total working hours of the household is not the only possible response. For example, a household with multiple earners can also respond to the primary earner's wage shocks by adjusting the secondary earner's working hours as well. Blundell, Pistaferri, Saporta (2016) show that family labor supply accounts for about 60 percent of the consumption insurance among U.S. households. Another possible form consumption insurance within labor supply channel is through diversification of income generating activities. In the U.S., Koustas (2018) finds substantial increases in consumption smoothing among households that take on part-time ride-share jobs, due to more flexibility in adjusting their working hours. In developing countries, the diversification of income generating activities is even more prevalent. As mentioned, typical rural Thai households generally hold wage earning jobs along with some home production activities. When facing with wage or productivity shocks, the household can respond by adjusting working hours in the affected sector as well as reallocating overall working hours between sectors to smooth out their consumption.

Within developing countries, the key questions are: How much consumption insurance against wage and productivity shocks do these households have? How do participation and working hours in labor market and home production sectors respond to wage and productivity fluctuations? And how much consumption insurance does labor reallocation between the two sectors provide?

In order to answer those questions, I set up a flexible consumption-saving framework with two endogenous choices of labor supply, in market work sector and in the home production sector. This framework would, as in traditional literature, allow for consumption smoothing via asset adjustment as well as via labor supply changes within the two sectors, on both intensive and extensive margins.

Focusing on labor supply response mechanism, I abstract from specifying inter-household risk-sharing arrangements. The overall effect of these arrangements along with the household's own ability to self-insure through borrowings and savings is reflected in the assets adjustment channel.

The paper proceeds as follows: I discuss the partial equilibrium framework with households facing wage and productivity fluctuations and making decisions on consumption and working hours within the labor market and home production sector in Section 1.2. Section 1.3 presents the reduced-form specification of the framework. Section 1.4 provides detailed discussions of the data and empirical strategy, along with wage computations and production function estimations. In Section 1.5, I describe in detail the steps for the joint estimation of unobserved productivity and reduced-form model parameters via a Markov Chain Monte Carlo approach. Section 1.6 presents the main estimates of the reduced-form model. Overall, the model estimates show that consumption react very little to wage and productivity shocks, with elasticity of 0.008 and 0.032, respectively. Section 1.7 discusses the degree of consumption insurance. I show that 74.6% of consumption insurance to wage shocks and 37.2% of consumption insurance to productivity shocks came through labor supply reallocation channel, combined over extensive and intensive margins. Finally, Section 8 concludes with a summary and directions for future work.

1.2 General Framework

1.2.1 Model Setup

The general framework in this paper is a variation of the standard consumption-saving model with two options for the household to supply labor: either in a labor market for a fixed hourly wage or in home production activities, where home production also uses productive capital. This setting will be a partial equilibrium model where wages, interest rates on assets, and productivities are exogenously given to the households. This assumption is consistent with the view of Thai villages as small open economies (Paweenawat and Townsend (2014)).

The life-time utility for household i is given by

$$\sum_{t=0}^{\infty} \mathbb{E}_0[\beta^t U(C_{i,t}, L_{i,t}^1, L_{i,t}^2; X_{i,t})]$$

where $C_{i,t}$ denotes consumption, $L_{i,t}^1$ denotes working hours in the labor market, $L_{i,t}^2$ denotes working hours in the home production activities, and $X_{i,t}$ is a vector of taste-shifters, including household characteristics, location effects, and time effects, at each time t.

Household income consists of two parts, wage income and home production income.

Household i's wage income is given by $W_{i,t} \cdot L_{i,t}^1$ where $W_{i,t}$ is the hourly wage rate in the labor market.

Household i's home production is given by the production function $F(A_{i,t}, L_{i,t}^2; Z_{i,t})$ where $Z_{i,t}$ is household productivity and $A_{i,t}$ is the level of household assets in period t, that is utilized as working capital.

In each period, given total assets $A_{i,t}$, and upon realizing wage $W_{i,t}$, and productivity $Z_{i,t}$, the household chooses consumption $C_{i,t}$, working hours in the labor market $L_{i,t}^1$, working hours in production $L_{i,t}^2$, and assets $A_{i,t+1}$ to carry forward.

The household budget constraint can be written as

$$A_{i,t+1} = R \cdot A_{i,t} + W_{i,t} \cdot L_{i,t}^1 + F(A_{i,t}, L_{i,t}^2; Z_{i,t}) - C_{i,t}.$$

The joint process for wages and productivity $(W_{i,t}, Z_{i,t})$ is assumed to be a stationary Markov process $G(\cdot)$.

The household cannot hold negative assets. That is $A_{i,t} \geq 0$.

Hence, the household's maximization problem is

$$\max_{\{C_{i,t},A_{i,t+1},L^1_{i,t},L^2_{i,t}\}} \sum_{t=0}^{\infty} \mathbb{E}_0[\beta^t U(C_{i,t}, L^1_{i,t}, L^2_{i,t}; X_{i,t})]$$

$$s.t. \quad A_{i,t+1} = R \cdot A_{i,t} + W_{i,t} \cdot L^1_{i,t} + F(A_{i,t}, L^2_{i,t}; Z_{i,t}) - C_{i,t}$$

$$A_{i,t+1} \geq 0$$

$$A_{i,0}, W_{i,0}, Z_{i,0} \ given$$

where the expectation uses $G(\cdot)$.

This problem can be re-written recursively as

$$V(A, W, Z; X) = \max_{\{C,A',L^1,L^2\}} \{U(C, L^1, L^2; X) + \beta \mathbb{E}[V(A', W', Z'; X) \mid W, Z]\}$$

$$s.t. \quad A' = R \cdot A + W \cdot L^1 + F(A, L^2; Z) - C$$

$$A' \geq 0$$

We can see here that the consumption, labor supply choices, and future asset choice are functions of current assets, current wages, and current productivities. That is, we can write the general model solution as:

$$C_{i,t} = C(A_{i,t}, W_{i,t}, Z_{i,t}; X_{i,t}) \quad (1)$$

$$L^1_{i,t} = L^1(A_{i,t}, W_{i,t}, Z_{i,t}; X_{i,t}) \quad (2)$$

$$L^2_{i,t} = L^2(A_{i,t}, W_{i,t}, Z_{i,t}; X_{i,t}) \quad (3)$$

$$A_{i,t+1} = A(A_{i,t}, W_{i,t}, Z_{i,t}; X_{i,t}) \quad (4)$$

The derivatives of the functional forms $(1)-(3)$ with respect to assets, wages, and productivities, are the main objects of interest in this paper.

First, $\frac{d\,log(C)}{d\,log(A)}$, $\frac{d\,log(C)}{d\,log(W)}$, and $\frac{d\,log(C)}{d\,log(Z)}$ are measures of the marginal propensity to consume out of total assets, wages, and productivities, respectively.

Next, $\frac{d\,log(L^1)}{d\,log(A)}$, $\frac{d\,log(L^1)}{d\,log(W)}$, and $\frac{d\,log(L^1)}{d\,log(Z)}$ are the elasticities of the labor market hours for total assets, wages, and productivities, respectively.

Finally, $\frac{d\,log(L^2)}{d\,log(A)}$, $\frac{d\,log(L^2)}{d\,log(W)}$, and $\frac{d\,log(L^2)}{d\,log(Z)}$ are the elasticities of the home production hours for total assets, wages, and productivities, respectively.

1.2.2 Transmission of Shocks onto Working Hours

Here, I explain in intuitive terms how working hours in the two sectors respond to wage and productivity shocks. It is useful to first address the directions of income and substitution effects from increases in assets, wages, and productivities.

Suppose that the standard assumption of leisure as a normal good holds, increases in assets, wages, and productivities should all have negative income effects on labor supplies in both sectors. This is because households do not wish to work longer hours once their budget sets expand.

An increase in assets has no substitution effect on the labor supply in the market but has a positive substitution effect on the labor supply in home production. Because assets are a complement to labor in the production function, households with higher assets have higher marginal productivity of labor in production. Therefore, the substitution effect says they should supply more hours there.

An increase in wage has a positive substitution effect on the labor supply in the market and negative substitution effect on labor supply in production. This is because marginal productivity of labor becomes higher in labor market in comparison to production.

Oppositely, an increase in productivity has a negative substitution effect on the labor supply in the market and has a positive substitution effect on the labor supply in production. Again, this is because the marginal productivity of labor becomes higher in production compared to the labor market.

The overall effects of changes in assets, wages, and productivities on labor supplies in both sectors are the sum of the respective income and substitution effects as described above.

1.3 Reduced-Form Model

The main goal here is to identify the effects from the general model as described in the previous section. The reduced-form approach provides the advantage of capturing the dynamic effects of asset, wage, and productivity changes on consumption and the labor supply in both sectors without imposing further structure for household preferences as required in a full structural model.

From this section onward, lower-case variables represent the log of the corresponding variables in the general framework.

In log terms, consumption is assumed to be a linear functions of assets, wages, and productivities. That is consumption rule (1) becomes

$$c_{i,t} = \Theta'_{c,X} X_{i,t} + \eta_{c,a} a_{i,t} + \eta_{c,w} w_{i,t} + \eta_{c,z} z_{i,t} + \epsilon^{c}_{i,t} \tag{5}$$

where $\epsilon^{c}_{i,t} \sim \mathcal{N}(0, \sigma_c^2)$.

Similarly, in log terms, future assets are assumed to be linear functions of current assets, wages, and productivities. The future asset rule (2) becomes

$$a_{i,t+1} = \Theta'_{a,X} X_{i,t} + \eta_{c,a} a_{i,t} + \eta_{c,w} w_{i,t} + \eta_{c,z} z_{i,t} + \epsilon^{a}_{i,t} \tag{6}$$

where $\epsilon^{a}_{i,t} \sim \mathcal{N}(0, \sigma^2_a)$.

Next, conditioned on participation, labor market hours, in log terms, are assumed to be linear functions of assets, wages, and productivities. Participation is assumed to follow a probit function of assets, wages, productivities, and indicators for past participations in both wage labor market sector and home production sector. Overall, the labor market hours rule (3) is now given by

$$\begin{aligned} D^1_{i,t} =& 1\{\Phi'_{l1,X} X_{i,t} + \phi_{l1,a} a_{i,t} + \phi_{l1,w} w_{i,t} + \\ & \phi_{l1,z} z_{i,t} + \delta_{1,1} D^1_{i,t-1} + \delta_{1,2} D^2_{i,t-1} + \zeta^{l1}_{i,t} > 0\} \qquad (7) \\ l^1_{i,t+1} =& D^1_{i,t} \cdot [\Theta'_{l1,X} X_{i,t} + \eta_{l1,a} a_{i,t} + \eta_{l1,w} w_{i,t} + \eta_{l1,z} z_{i,t} + \epsilon^{l1}_{i,t}] \qquad (8) \end{aligned}$$

where $\epsilon^{l1}_{i,t} \sim \mathcal{N}(0, \sigma^2_{l1})$, $\zeta^{l1}_{i,t} \sim \mathcal{N}(0, 1)$ and $D^1_{i,t}$, $D^2_{i,t}$ are indicators of whether the household participates in the wage labor marker or in home production, respectively.

Finally, conditioned on participation, home production hours, in log terms, are also assumed to be linear functions of assets, wage, and productivity. Participation is also assumed to follow a probit function of assets, wages, productivities, and indicators for past past participation in both sectors. That is, the home production hours rule (4) is now given by:

$$
\begin{aligned}
D^2_{i,t} =& 1\{\Phi'_{l2,X} X_{i,t} + \phi_{l2,a} a_{i,t} + \phi_{l2,w} w_{i,t} + \\
& \phi_{l2,z} z_{i,t} + \delta_{2,1} D^1_{i,t-1} + \delta_{2,2} D^2_{i,t-1} + \zeta^{l2}_{i,t} > 0\} \qquad (9) \\
l^2_{i,t+1} =& D^2_{i,t} \cdot [\Theta'_{l2,X} X_{i,t} + \eta_{l2,a} a_{i,t} + \eta_{l2,w} w_{i,t} + \eta_{l2,z} z_{i,t} + \epsilon^{l2}_{i,t}] \qquad (10)
\end{aligned}
$$

where $\epsilon^{l2}_{i,t} \sim \mathcal{N}(0, \sigma^2_{l2})$ and $\zeta^{l2}_{i,t} \sim \mathcal{N}(0, 1)$.

From $(5) - (10)$, each coefficient $\eta_{p,q}$ captures the targeted derivative $\frac{d\,log(P)}{d\,log(Q)}$ for $P \in \{C_{i,t}, A_{i,t+1}, L^1_{i,t}, L^2_{i,t}\}$ and $Q \in \{A_{i,t}, W_{i,t}, Z_{i,t}\}$. They can be interpreted as the marginal propensity to consume, save, or supply labor with respect to asset, wage shocks, and productivity shocks. It is worth to mention that, under the linear reduced-form model, these marginal propensities are implicitly assumed to be constant across individuals and time periods. In order to relax these assumptions, one could use more general reduced-form specifications that allow for nonlinearities in decision rules.

In addition to the reduced-form model described by $(5) - (10)$, the wages and productivities are assumed to jointly evolve as a VAR(1) process :

$$
\begin{bmatrix} w_{i,t+1} \\ z_{i,t+1} \end{bmatrix} = \begin{bmatrix} \mu'_{w,X} X_{i,t} \\ \mu'_{z,X} X_{i,t} \end{bmatrix} + \begin{bmatrix} \rho_{1,1} & \rho_{1,2} \\ \rho_{2,1} & \rho_{2,2} \end{bmatrix} \begin{bmatrix} w_{i,t} \\ z_{i,t} \end{bmatrix} + \begin{bmatrix} \epsilon^w_{i,t} \\ \epsilon^z_{i,t} \end{bmatrix} \qquad (11)
$$

where $\epsilon^w_{i,t} \sim \mathcal{N}(0, \sigma^2_w)$ and $\epsilon^z_{i,t} \sim \mathcal{N}(0, \sigma^2_z)$.

Furthermore, initial wages and productivities are assumed to be jointly distributed as:

$$\begin{bmatrix} w_{i,1} \\ z_{i,1} \end{bmatrix} \sim \mathcal{N}(\begin{bmatrix} \mu_{1,w} \\ \mu_{1,z} \end{bmatrix}, \begin{bmatrix} \sigma_{1,w}^2 & \rho_{w1,z1}\sigma_{1,w}\sigma_{1,z} \\ \rho_{w1,z1}\sigma_{1,w}\sigma_{1,z} & \sigma_{1,z}^2 \end{bmatrix}) \quad (12)$$

The reason to believe that wage and productivity are correlated is that there are some individual skills, such as accounting, that are useful in both the labor market and home production Hence, the household that learns that skill could benefit in both wage and productivity.

Next, the household wage income is given by

$$Y_{i,t}^1 = W_{i,t} L_{i.t}^1 \ , \quad (13)$$

and, the home production function is assumed to be in a Cobb-Douglas form :

$$Y_{i,t}^2 = e^{z_{i,t}} A_{i,t}^{\alpha} (L_{i,t}^2)^{\psi} \ . \quad (14)$$

Further, among the error terms, the pairwise correlation is only allowed for the pair $(\epsilon_{i,t}^{l1}, \zeta_{i,t}^{l1})$ and $(\epsilon_{i,t}^{l2}, \zeta_{i,t}^{l2})$. All the error terms are otherwise assumed to be independent. These assumptions are very strong in the sense that they allow no cross correlation among consumption, future assets, labor supplies, future wages, and future productivities, except through variations in current assets, wages, productivities, and characteristics. In other words, if there is any common factor that could affect any pair of key variables in the model, then that factor must be included in the characteristics. Overall, this condition requires characteristics $X_{i,t}$ to sufficiently account for any common variation in each pair of model variables. As the best attempt to achieve this goal, I must allow for $X_{i,t}$ to include controls for unobserved heterogeneity. The approach I chose, given the structure of the model, is grouped fixed effects which I will discuss in a later section

Because of those independence assumptions and given that assets, wages, productivities, and characteristics are known, equations (5), (6), and (11) can be separately estimated via standard ordinary least square while the pairs (7) − (8) and (9) − (10) can each be estimated via the Heckman selection method. The difficulty in estimation arises from the fact that wage and productivity are not fully observed. This fact requires a development of estimation strategy which I will develop after presenting the data in the next section.

1.4 Data and Empirical Strategy

1.4.1 The Townsend Thai Project Monthly Survey

The data in this project come from the Townsend Thai Project Monthly Survey. The survey comprises a panel of 720 households from 16 villages across 4 Thai provinces : Buriram and Srisaket in the more agricultural-oriented northeast region and Lopburi and Chachoengsao in the more urbanized central region. The survey started in 1998 and continued with an unusual long length of over 190 months. The survey questionaire has a remarkable level of detail on consumption, assets, working hours, and incomes from paid works and from production activities. Details on contruction of model variables from the survey data are in Table 1.1.

In this paper, I chose a subsample of 571 households to form a balanced panel. The data are aggregated at household level and annualized into the economic-year level where each year is defined as the time from April from one calendar year to

Table 1.1: Variable Descriptions

Variable	Data Source
$C_{i,t}$	Household Consumption
$A_{i,t}$	Financial Assets (Cash, Bank Deposits) and Physical Assets (Land, Structure, Appliances, Agricultural Tools, Business Equipment)
$L^1_{i,t}$	Sum of Individual Working Hours from Paid Jobs
$L^2_{i,t}$	Sum of Individual Working Hours from Production Activities (Agriculture, Livestock, Business, Fish&Shrimp)
$Y^1_{i,t}$	Sum of Individual Income from Paid Jobs
$Y^2_{i,t}$	Sum of Household Income from Production Activities (Agriculture, Livestock, Business, Fish&Shrimp)
$X_{i,t}$	Demographics (Household Family Size, Individual Age, Gender, Education Level) and Controls for Unobserved Heterogeneity (See Section 7)

March in the next calendar year. The beginning of each economic year corresponds to the timing of new crop season for agricultural households that constitute a large part of the sample. Consumption, income, and working hours (from each source), are aggregated within each economic year while assets are taken from April observations, which mark the beginning of each year. For the scope of the project, I use 12 economic years in total : the first economic year is from month 9-20 in the survey (April 1999-March 2000) and the last economic year is from month 141-152 (April 2010-March 2011)[1].

Before estimating the reduced-form model, I first identify the key descriptive patterns in the key model variables for the four provinces.

Overall, consumption is normally distributed with a slightly higher mean in the central, more urbanized regions of Chachoegsao and Lopburi. Total assets as well as income and working hours in both sectors are overall left-skewed. That is, there

1. As of now, there is more information from later years. However, I decided to keep the time frame to before the big flood in late 2011 - early 2012 that could cause some outlier problems.

are more households with lower incomes and lower assets than average. The average income and working hours in both sectors tend to be somewhat lower in the north-eastern more rural regions of Buriram and Srisaket. For more detail, the probability density plots of these variables are provided in appendix A.

From Figure 1.1, consumption tends be relatively flat compared to both labor income and production income across all four provinces. This flatness indicates the existence of consumption mechanisms. Further, the labor income increases over time and shows more variation with observable large jumps around year 7-10 (corresponding to 2006-2009), particularly in Srisaket. Home production income, on the other hand, is relatively flat in all four provinces.

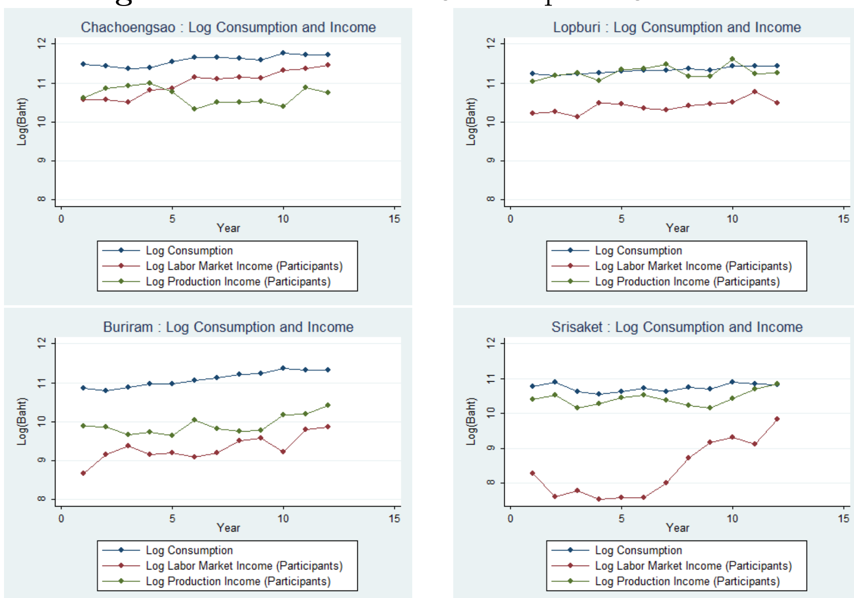
Figure 1.2 shows that assets accumulate over time for Chachoengsao, Lopburi, and Srisaket but remain relatively flat overall with a sharp drop around year 8 (corresponding to 2007) in Buriram.

Figure 1.3 shows that the participations in labor market are relatively flat in Chachoengsao and Lopburi but decrease in Buriram and Srisaket. The patterns of participations in home production are similarly flat and decrease slightly across all four provinces.

Figure 1.4 shows that working hours in the labor market increase over time in Chachoengsao and Srisaket and are somewhat flat in Buriram and Lopburi. Home production hours, on the other hand, tend to decrease over time in all four provinces, especially in Lopburi and Srisaket.

To summarize, more urbanized regions tend to have higher consumption, larger asset holdings, higher income, and higher working hours in both sectors. The common patterns over time are smooth consumption, asset accumulation, decreasing participations in the labor market, increasing labor market hours, and relatively flat participation and hours in home production sector. However, there are significant

Figure 1.1. Income and Consumption Over Time



differences in both the distributions and evolutions over time in these key variables across all for provinces. Overall, these underlying region-time heterogeneities need to be accounted for in the analysis.

1.4.2 Empirical Strategy

The empirical strategy of this paper is divided into three steps. In the first step (Section 1.4.4), wages are computed and unobserved wages are approximated through mincer-type regressions. Next, in the second step (Section 5), production function (14) is estimated via a control function approach, by using the intermediate input as a proxy variable. In the last step (Section 1.5), unobserved productivities and model parameters from $(5)-(12)$ are jointly estimated as a state-space model, taken estimated wages and production function coefficients as ingredients.

Figure 1.2. Assets Over Time

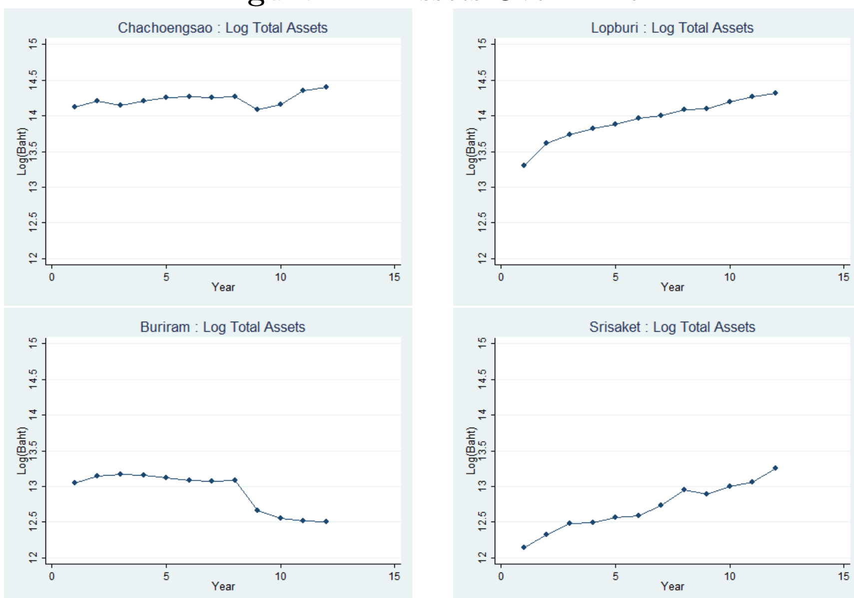


Figure 1.3. Labor Participations Over Time

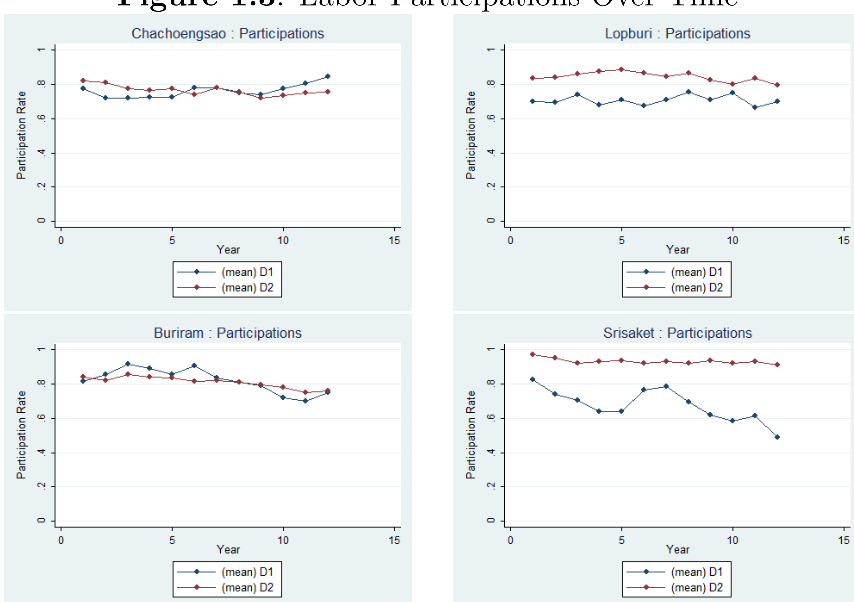
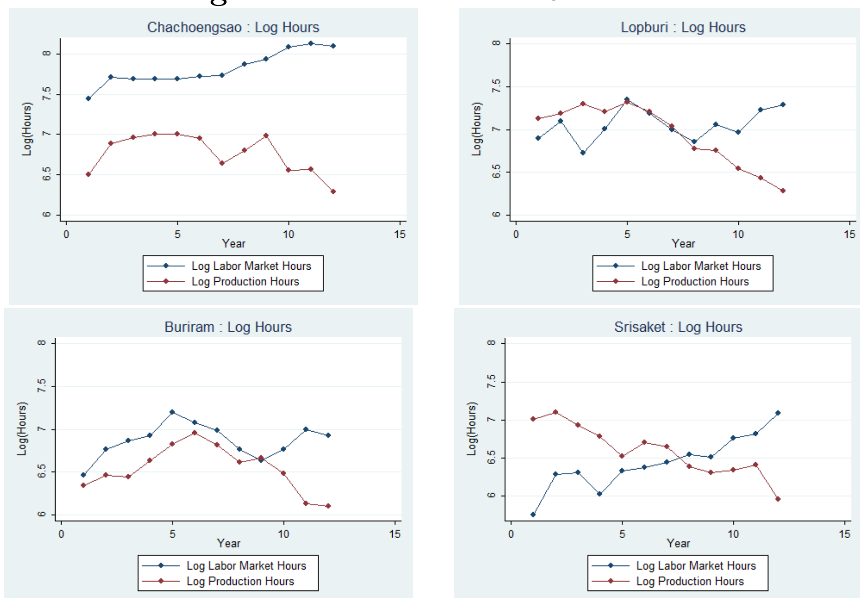


Figure 1.4. Labor Hours Over Time



1.4.3 Group Heterogeneity

As mentioned in Section 3, for estimated elasticity coefficients to be valid, I need to control for unobserved household heterogeneity. The most straightforward approach is to include household fixed effects among the group of control variables $X_{i,t}$. The major issue with this approach is the well-known incidental parameter bias, because the model is nonlinear. This paper follows the approach in Bonhomme, Lamadon, Manresa (2017) of using grouped fixed effects. The sample of 571 households is divided into 4 groups with a k-mean clustering method. The choice of clustering moments are based on average assets, average consumption, and participation probabilities in the labor market and home production, along with household characteristics. The group identifiers are then added to the group of regressors in $X_{i,t}$.

1.4.4 Wage Computation

With information on household labor income and total working hours in paid-labor sector, the hourly wage for each household in a given year is obtained via dividing the total (net) household labor income by the total labor hours, combined across all members, that the household supplied to labor market in the particular year[2]. The problem with this approach is that one can only compute wages for households that do participate in a labor market, that is supplying strictly positive labor hours. As I am interested in the effect of wages on labor supplies in both intensive and extensive margins, I need to also infer the wages for non-participants. Based on the basis that the wages' fluctuations are mainly at the time-village level. I estimate individual wages with village-level mincer-type regressions :

$$w_{i,t} = \beta'_{village(i)} X_{i,t} + \sum_{\tau=1}^{12} \gamma_{village(i),\tau} \cdot 1_{\{t=\tau\}} + \epsilon_{i,t} \quad (15)$$

Here, $w_{i,t}$ denotes the logarithm of labor wages for household i ain year t. The variable for household characteristics variable $X_{i,t}$ contains household size, age and age-squared for the household hold head, dummies for education of the household head, and a dummy for gender of the household head for household i at year t. Further, the regression coefficients $\beta_{village(i)}$ and $\gamma_{village(i),\tau}$ are restricted to be the same within each village (where the notation $village(i)$ represents the village that household i belongs to) but can differ across different villages. Essentially, this regression model implies households with the same characteristics within the same village should have the same expected log labor wage.

2. This method could result in so-called "division bias" if measurement error exists for hours. I will attempt to address this issue in later version.

After estimating (15) at each village level, I can compute the estimated household log labor wage as: $\hat{w}_{i,t} := \hat{\beta}'_{village(i)} X_{i,t} + \sum_{\tau=1}^{12} \hat{\gamma}_{village(i),\tau} \cdot Year_{\tau}$. This is the main wage measure in this paper and is written as $w_{i,t}$ from here onward.

Overall, the wage distributions are somewhat normal across all four provinces, with somewhat higher mean and concentration around the mean in Chachoengsao and Lopburi. This indicates that households in urbanized regions have higher average wages and less variation in wages. The probability density plots of wage distributions in all four provinces are provided in Appendix A.

From Figure 1.5, average wage increases over time with a large increase between year 6 to year 9 for Buriram and Srisaket, but remain relatively flat for Chachoengsao and Lopburi. This finding corresponds with the same time period as the large increase in labor income shown earlier. The finding is possibly due to a series of changes in regional government policies during the period and would be an interesting area for further research.

1.4.5 Production Function Estimation

For the production function estimation, I assume that log productivity follows the following process :

$$z_{i,t} = \Lambda_{i.t} + \rho w_{i,t-1} + \Upsilon' X_{i,t} + \sum_{\tau=1}^{12} \Gamma_{\tau} \cdot 1_{\{t=\tau\}} + \nu_{i,t} \quad (16)$$

where $\Lambda_{i.t}$ is the persistent productivity component, and $\nu_{i,t} \overset{iid}{\sim} \mathcal{N}(0, \sigma^2)$ is the transitory productivity component. One can see that reduced-form specification $(11) - (12)$

for joint process of wage and productivity is consistent with this setup as the it preserves the Markov dependence structure.

Taking the logarithm of the production function (14) now yields

$$y_{i,t}^2 = \underbrace{\Lambda_{i.t} + \rho w_{i,t-1} + \Upsilon' X_{i,t} + \sum_{\tau=1}^{12} \Gamma_\tau \cdot 1_{\{t=\tau\}} + \nu_{i,t}}_{z_{i,t}} + \alpha a_{i,t} + \psi l_{i,t}^2 \qquad (17)$$

Our goal in this section is to estimate (17) from the data. Based on the coefficient estimates, I can then compute the estimate of log productivity : $\hat{z}_{i,t} = y_{i.t} - \hat{\alpha} a_{i.t} - \hat{\psi} l_{i,t}^2$.

Estimation of (16) requires making an assumption on unobserved productivity component $\Lambda_{i.t}$.

The main assumption in this paper is that $\Lambda_{i,t}$ follows the Markov process

$$\Lambda_{i,t} = \mathbb{E}[\Lambda_{i,t} \mid \Lambda_{i,t-1}] + \zeta_{i,t} \qquad (18)$$

with

$$\mathbb{E}[\zeta_{i,t} \mid a_{i,t}] = 0 \quad (19)$$

and

$$\mathbb{E}[\zeta_{i,t} \mid l_{i,t-1}] = 0 \quad (20)$$

Under (19) and (20), capital is pre-determined while labor is a free input. That is the households cannot adjust their capital stock (total assets) after realizing productivity in each period but they can adjust the labor supply.

The estimation method in this paper closely follows the control function approach in Ackerberg et al. (2015) and requires the use of an intermediate input $m_{i,t}$ as a proxy variable. The key identification assumption is that $m_{i,t} = f_t(\Lambda_{i,t}, a_{i,t}, l^2_{i,t})$ where $f_t(\cdot)$ is invertible and hence implies $\Lambda_{i,t} = f_t^{-1}(a_{i,t}, l^2_{i,t}, m_{i,t})$. This allows me to re-write (17) as

$$y^2_{i,t} - \alpha a_{i,t} - \psi l^2_{i,t} = f_t^{-1}(a_{i,t}, l_{i,t}, m_{i,t}) + \Upsilon' X_{i,t} + \sum_{\tau=1}^{12} \Gamma_\tau \cdot 1_{\{t=\tau\}} \tag{21}$$

As the first step, starting with each pair of guess (α, ψ), (21) is estimated via semi-parametric regressions with polynomials that approximate $f_t^{-1}(a_{i,t}, l_{i,t}, m_{i,t})$. The estimate $\hat{\Lambda}_{i,t}(\alpha, \psi)$ is obtained for the corresponding guess pair.

In the second step, (18) is estimated with a nonparametric regression of $\hat{\Lambda}_{i,t}(\alpha, \psi)$ on the polynomial functions of $\hat{\Lambda}_{i,t-1}(\alpha, \psi)$. This steps yields the residual sample analogue $\hat{\zeta_{i,t}}(\alpha, \psi)$.

In the final step, moment conditions (19) and (20) are used to obtain the estimates $(\hat{\alpha}, \hat{\psi})$.

All procedures above are implemented with the Stata module PRODEST in Rovigatti and Mollisi (2016). The information of intermediate inputs include reported expenses on fertilizers, gas, merchandise, and feed in production activities.

The main production function estimates are reported in Table 1.2. The labor elasticity is estimated to be 0.541 while the capital elasticity is estimated to be 0.361. Furthermore, the productivity increases with education up until the lower secondary level and declines afterward. This finding suggests that although education improves productivity, higher educated households specialize in skills unrelated to production activities.

As an alternative approach, I could assume $\Lambda_{i,t} = \Lambda$, that is the mean log productivity, net of the household characteristics and the common time effect, is a constant. Under this assumption, (16) can be estimated using ordinary least square regression of $y_{i,t}$ on $X_{i,t}$, $k_{i,t}$, and $l_{i,t}$. This assumption, however, restricts productivity to being uncorrelated with the contemporaneous input choices. Such a condition could be violated due to simultaneity bias from the fact that the choice of inputs could have been made from the household's prior knowledge of the productivity level (Marschak and Andrews (1944)).

Another possible assumption is $\Lambda_{i,t} = \Lambda_i$, that is the mean log productivity, net of the household characteristics and the common time effect, is time-invariant and household-specific. Under this assumption, (16) can be estimated with a fixed effect regression of $y_{i,t}$ on $X_{i,t}$, $k_{i,t}$, and $l_{i,t}$ plus household dummies. This approach resolves the issue of simultaneity bias. However, having a time-invariant household-specific productivity component is a rather strong assumption that tends to not hold in the long panel with possible structural changes.

Alternate production function estimates using both ordinary least square and fixed effect regressions are reported in appendix A1.2.

Further, one key assumption in my estimation is that all assets can be utilized as production capital. But this assumption could be oversimplifying. Particularly, in the case where households are holding a significant amount of cash, one could argue that those parts of asset portfolios should not be a part of production capital. For a robustness check, similar production function estimates with only physical assets as a measure for capital are also reported in appendix A1.2.

Table 1.2: Main Production Function Estimates

	Log(Income from Household Production)
Log(Hours)	0.541***
	(0.0928)
Log(Total Assets)	0.361***
	(0.0199)
Lagged Log Wage	0.142
	(0.0960)
Age of Head	0.0196
	(0.131)
Age-square of Head	-0.000205
	(0.189)
Household Size	0.0296
	(0.0484)
Male Head	0.159
	(0.0818)
Prim. Ed.	0.161*
	(0.0667)
Lower Sec. Ed.	0.484***
	(0.0512)
Upper Sec. Ed.	0.101
	(0.0694)
Above Sec. Ed.	-0.404***
	(0.0523)
Observations	5040

Standard errors in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Similar to computing wages, my approach, so far, cannot provide productivity estimates for the period when the household does not produce.

One possible approach, again, is to use a village-level regression

$$z_{i,t} = \tilde{\beta}'_{village(i)} X_{i,t} + \sum_{\tau=1}^{12} \tilde{\gamma}_{village(i),\tau} \cdot 1_{\{t=\tau\}} + \epsilon_{i,t} \quad (22)$$

to obtain an estimate $\hat{z}_{i,t}$ as a measure for log productivity for all households in the sample. This preliminary approach, despite its simplicity, is less preferred due to the fact that productivity tends to vary much more than wages for Thai households in the sample.

In section 1.5, I present the more robust main approach for joint estimation of reduced-form model and unobserved productivity. Estimates of production function coefficients from this section are part of the main ingredients for the next estimations steps.

1.4.6 Preliminary Patterns

Before moving on to estimating the full reduced-form model, I first show how consumption and working hours in both sectors, qualitatively, co-move with wages and productivities. I use wage estimates from (15) and preliminary productivity estimates from (22) to identify patterns of consumption, working hours in labor market, and working hours in home production, across deciles of assets, wages, and productivities, that are net of household characteristics. Figures 1.6-1.8 show the results.

Figure 1.6 shows that consumption overall increases with assets, wages, and productivities. This finding indicates that the movements in these three variables indeed transmit onto movement in consumption. The next question to be explored with more robust estimates is to what degree does consumption respond to these fluctuations.

Figure 1.7 shows that the labor market hours of participants, overall decrease with assets, somewhat increase with wages, and decrease with productivities. Households with larger asset holdings work fewer hours in the labor market; wage increases encourage households to work longer hours; and an increase in productivity encourages households to work fewer hours in the labor market.

Figure 1.8 illustrates that home production hours of participants overall increase with assets, decrease with wages, and are somewhat flat with productivities except with a very large decrease at a high level. Households with larger asset holdings work longer hours on home production; households with higher wage work fewer hours in home production; households with higher productivities have constant working hours in home production except those at a very high productivity level who tend to work much fewer hours.

Overall, these preliminary patterns show that assets, wages, and productivities all have positive impacts on consumption. Households with larger assets tend to switch to home production, that utilizes assets as a production factor. An increase in either wage or productivity generally encourages households to supply more working hours in the respective sector and less hours in the other sector, with some exceptions.

For robustness check, more regression findings with these preliminary productivity estimates are also reported in appendix A1.3.

1.5 Joint Estimation : State-Space Model

The reduced-form model given by $(5) - (12)$ and production function (14) are considered the state-space model with log productivity, $\{z_{i,t}\}$ along with the probit indices for participations in both sectors, $\{v^1_{i,t}, v^2_{i,t}\}$, as hidden states. Estimation targets are coefficients in $(5)-(12)$. Further, I denote these coefficients jointly as Ω.

Log productivities in periods when production labor hours are observed are fixed and obtained from computing $\hat{z}_{i,t} = y_{i.t} - \hat{\alpha}k_{i.t} - \hat{\psi}l_{i,t}$, with estimates $\hat{\alpha}$ and $\hat{\psi}$ taken from section 1.4.5.

The estimation procedure, as a variation of the Markov Chain Monte Carlo method, alternates between parameter update steps and hidden state update steps. First, the coefficients in $(5)-(12)$ are estimated based on data and previous guesses on the unobserved productivity. This step involves running ordinary least square regressions for consumption, future assets, and joint-wage productivity equations and running Heckman selection regressions for labor hours and participations in the labor market and home production. Next, unobserved log productivities along with the underlying probit indices are drawn via Gibbs Sampling method, that is based on the posterior distribution given the current guess on model parameters. The use of Gibbs Sampling method in this step allows the hidden productivities and the underlying probit indices to be alternately drawn from their own posteriors, after conditioning on other variables, parameters, and data. The method significantly reduces the computational burden compared to the alternative of drawing all hidden states at once based on their joint posteriors.

Specifically, starting with a guess vector for hidden states $\{z^{(1)}_{i,t}, v^{1,(1)}_{i,t}, v^{2,(1)}_{i,t}\}$, we iterate the following steps on $s = 0, ..., 1000$:

1. *Parameter Update Step* :

   Estimate model parameters $\Omega^{(s)}$ using observed data and current guess of hidden states $\{z^{(s)}_{i,t}, v^{1,(s)}_{i,t}, v^{2,(s)}_{i,t}\}$:

(a) Parameters for the consumption rule (5) and asset rule (6) are estimated via ordinary least square regressions.

(b) Parameters for the labor market participation rule (7) and hours rule (8) are estimated via Heckman selection method.

(c) Parameters for the home production participation rule (9) and hours rule (10) are estimated via Heckman selection method.

(d) Parameters for the joint wage-productivity process (11) – (12) are computed for initial distribution and estimated via ordinary least square regressions for evolutions.

2. *Hidden State Update Step* :

Draw hidden states $\{z_{i,t}^{(s)}, v_{i,t}^{1,(s)}, v_{i,t}^{2,(s)}\}$ given $\{z_{i,t}^{(s-1)}, v_{i,t}^{1,(s-1)}, v_{i,t}^{2,(s-1)}\}$ and $\Omega^{(s)}$ by using posterior distributions. This step is done in blocks via the Gibbs Samplings (100 sub-iterations for each sub-step below) :

(a) Draw each $z_{i,t}^{(s)}$ from the posterior distribution of $z_{i,t}$ given $v_{i,t}^1, v_{i,t}^2$, data $x_{i,t}$, and $\Omega^{(s)}$

(b) Draw each $v_{i,t}^{1,(s)}$ from the posterior distribution of $v_{i,t}^1$ given $z_{i,t}$, data $x_{i,t}$, and $\Omega^{(s)}$

(c) Draw each $v_{i,t}^{2,(s)}$ from the posterior distribution of $v_{i,t}^2$ given $z_{i,t}$, data $x_{i,t}$, and $\Omega^{(s)}$

Estimates $\Omega^{(s)}$ from iterations $s = 201$ to $s = 1000$ are used to compute the distributions of coefficient estimates.

More detail on estimation steps and how to compute the posterior distributions of log productivity are given the data are provided in appendix A1.4.

1.6 Main Results and Discussion

The estimates of the key coefficients in (5)-(12) are provided in Tables 1.3-1.9.

1.6.1 Productivity Estimates

Figure 1.9 shows that, similar to wages, productivities are relatively flat across all provinces over time. The average productivities are slightly lower in Lopburi and Buriram. More detail on the distribution of estimated productivities are provided in appendix A.

1.6.2 Joint Wage-Productivity Evolution

Table 1.3: Parameter Estimates : Joint Wage-Productivity Process

Parameter	Estimates (s.e.)
$\rho_{1,1}$ (Future Wage Elasticity on Current Wage)	0.849*** (0.000)
$\rho_{1,2}$ (Future Wage Elasticity on Current Productivity)	0.008*** (0.002)
$\rho_{2,1}$ (Future Productivity Elasticity on Current Wage)	0.032** (0.012)
$\rho_{2,2}$ (Future Productivity Elasticity on Current Productivity)	0.435*** (0.016)

The estimates of the joint process parameters in Table 1.3 confirms the idea that wages and productivities do indeed co-evolve over time. The table shows that the wages are more persistent over time than the productivities, after controlling for time effects and household characteristics. Since individual skills should carry over time, this finding potentially suggests that wage earning jobs are relying more on skills than production that relies on both skills and certain conditions such as farm weather or soil quality.

1.6.3 Consumption

Table 1.4: Parameter Estimates : Consumption Rule

Parameters	Estimates (s.e.)
$\eta_{c,a}$ (Consumption Elasticity in Assets)	0.849*** (0.000)
$\eta_{c,w}$ (Consumption Elasticity in Wage)	0.008*** (0.001)
$\eta_{c,z}$ (Consumption Elasticity in Productivity)	0.032*** (0.003)

The estimates of the consumption equation in Table 1.4 show that a 1% decrease in total assets leads to a 0.849% decrease in consumption, a 1% decrease in wage would lead to a 0.008% decrease in consumption, and a 1% decrease in productivity would lead to a 0.032% decrease in consumption. These results indiciate that households with less assets almost proportionally consume less. However, the consumption elasticities in the wage and productivity changes are very small. Using the notion in Blundell, Pistaferri, Preston (2008), the partial insurance coefficients for wage and productivity shocks to be $1 - 0.008 = 0.992$ and $1 - 0.032 = 0.968$, respectively. These cofficients mean that 99.2% of the wage shocks and 96.8% of the productivity shocks are insured by the households. These results show that households are very well insured against both wage and productivity shocks.

1.6.4 Future Assets

Table 1.5 shows that a 1% decrease in total assets today leads to a 0.904% decrease in future assets, a 1% decrease in wage leads to a 0.036% decrease in future assets, and a 1% decrease in productivity leads to a 0.043% decrease in future assets. These

Figure 1.5. Estimated Wage Over Time

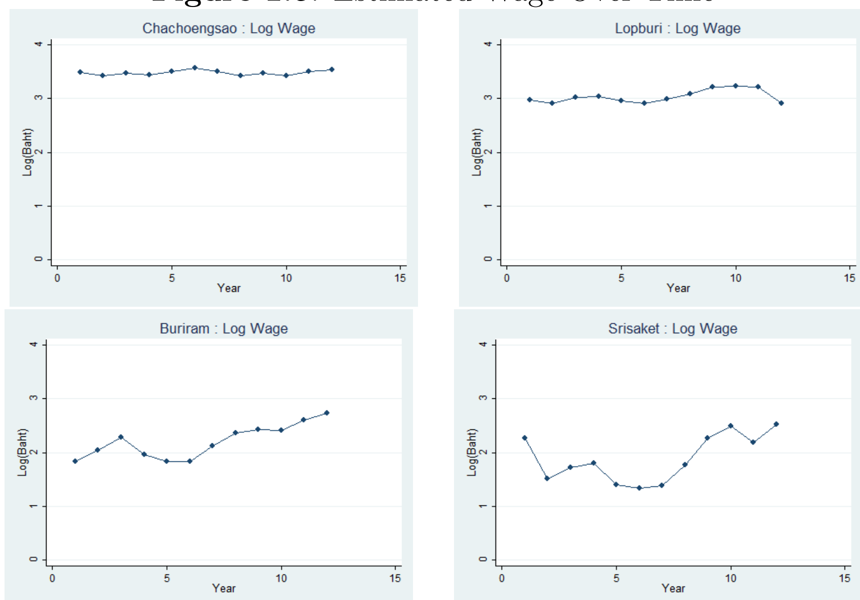


Table 1.5: Parameter Estimates : Future Assets Rule

Parameter	Estimates (s.e.)
$\eta_{a,a}$ (Future Assets Elasticity in Current Assets)	0.904*** (0.000)
$\eta_{a,w}$(Future Assets Elasticity in Current Wage)	0.036*** (0.000)
$\eta_{a,z}$(Future Assest Elasticity in Current Productivity)	0.043*** (0.007)

Figure 1.6. Consumption by Deciles of Assets, Wage, Productivity

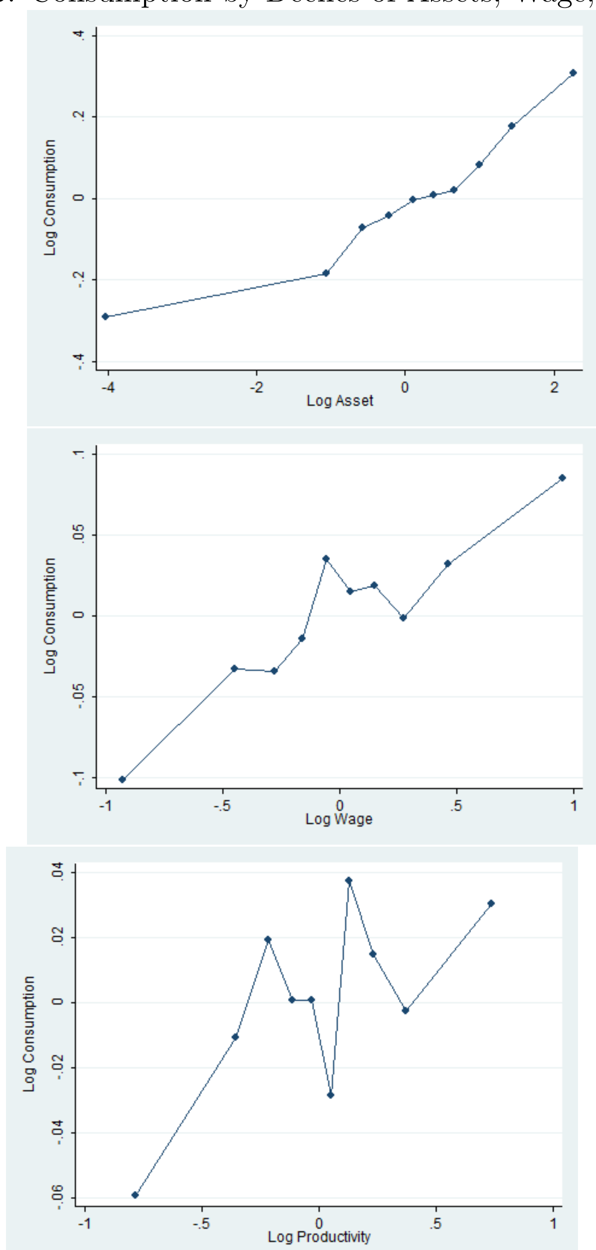


Figure 1.7. Market Hours by Deciles of Assets, Wage, Productivity

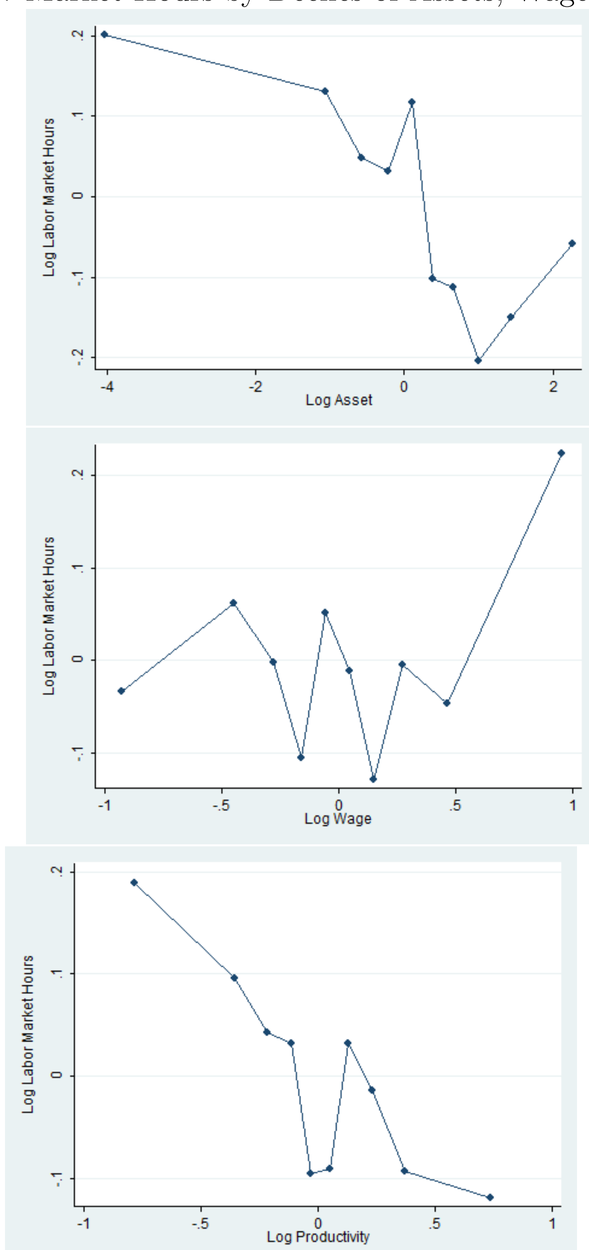


Figure 1.8. Production Hours by Deciles of Assets, Wage, Productivity

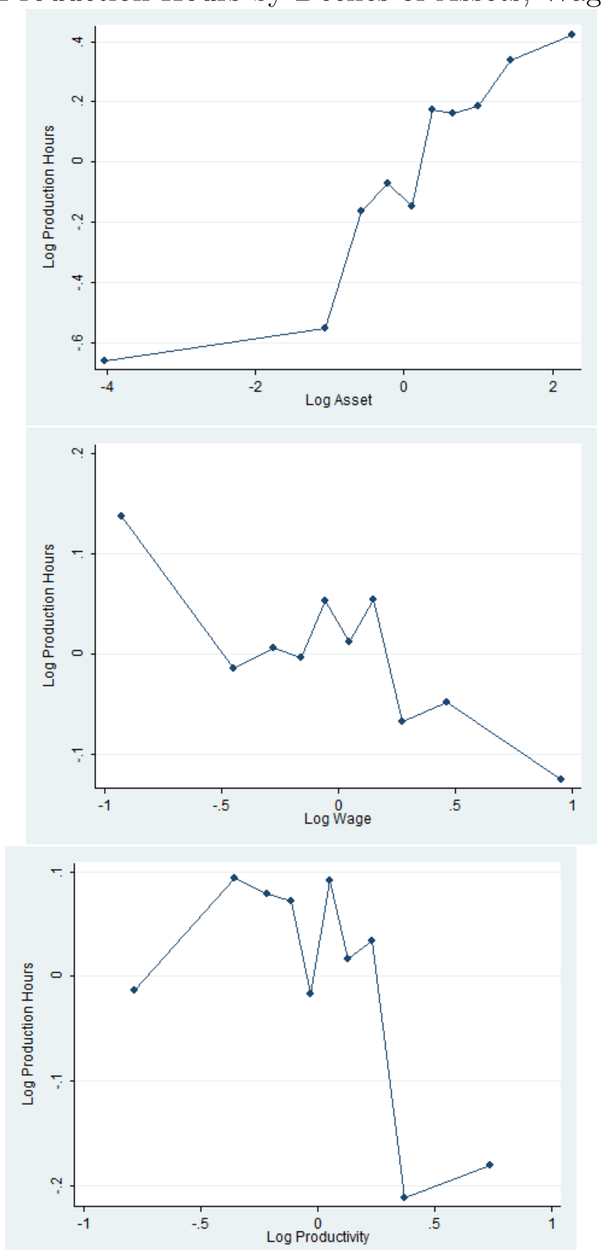
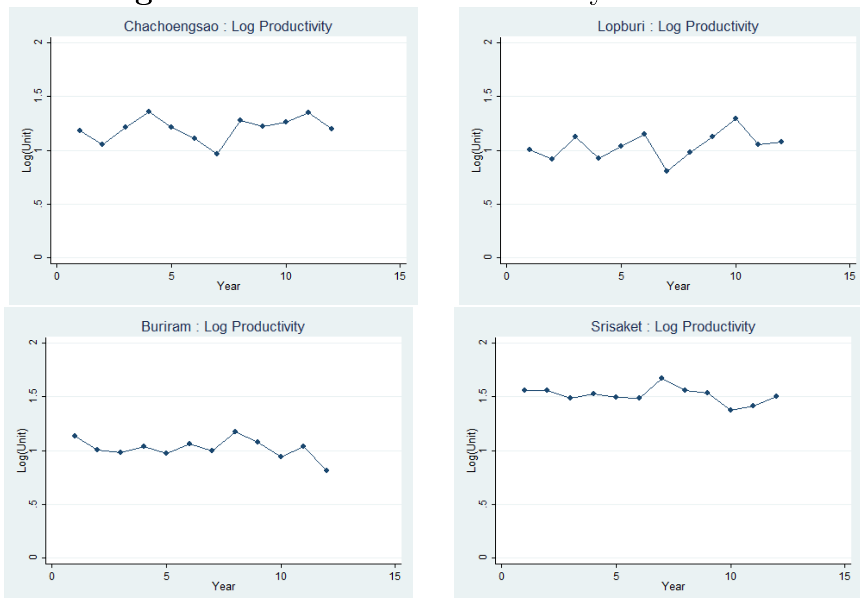


Figure 1.9. Estimated Productivity Over Time



findings indicate that households use their savings to insure themselves against both wage and productivity shocks.

1.6.5 Hours and Participation

Table 1.6: Parameter Estimates : Labor Market Hours Rule

Parameter	Estimates (s.e.)
$\eta_{l1,a}$ (Labor Market Hours Elasticity in Assets)	0.001*** (0.000)
$\eta_{l1,w}$ (Labor Market Hours Elasticity in Wage)	0.083*** (0.002)
$\eta_{l1,z}$ (Labor Market Hours Elasticity in Productivity)	-0.081*** (0.007)

On the intensive margin, Table 1.6 shows that a 1% decrease in total assets leads to a 0.001% decrease in labor market hours, a 1% decrease in wage leads to a 0.083% decrease in labor market hours, and a 1% decrease in wage leads to a 0.081% increase in production hours. Table 1.8 shows that a 1% decrease in total assets leads to

Table 1.7: Parameter Estimates : Labor Market Participation (Probit)

Parameter	Estimates (s.e.)
$\phi_{l1,a}$ (Assets Effect)	-0.021*** (0.000)
$\phi_{l1,w}$ (Wage Effect)	-0.081*** (0.000)
$\phi_{l1,z}$ (Productivity Effect)	0.014 (0.010)
$\delta_{1,1}$ (Past Parcitipation in Labor Market Effect)	1.593*** (0.000)
$\delta_{1,2}$ (Past Parcitipation in Production Effect)	-0.042*** (0.006)

Table 1.8: Parameter Estimates : Production Hours Rule

Parameter	Estimates (s.e.)
$\eta_{l2,a}$ (Production Hours Elasticity in Assets)	0.037*** (0.000)
$\eta_{l2,w}$ (Production Hours Elasticity in Wage)	-0.112*** (0.002)
$\eta_{l2,z}$ (Production Hours Elasticity in Productivity)	-0.146*** (0.010)

Table 1.9: Parameter Estimates : Production Participation (Probit)

Parameter	Estimates (s.e.)
$\phi_{l2,a}$ (Asset Effect)	0.028*** (0.002)
$\phi_{l2,w}$ (Wage Effect)	-0.081*** (0.012)
$\phi_{l2,z}$ (Productivity Effect)	0.296*** (0.030)
$\delta_{2,1}$ (Past Parcitipation in Labor Market Effect)	0.074*** (0.015)
$\delta_{2,2}$ (Past Parcitipation in Production Effect)	2.328*** (0.017)

a 0.037% decrease in production hours, a 1% decrease in wages leads to a 0.112% increase in labor market hours, and a 1% decrease in wage leads to a 0.146% increase in production hours.

On the extensive margin, Table 1.7 shows that a decrease in total assets, a decrease in wages, and an increase in productivities make households more likely to participate in the labor market. Table 1.9 shows that an increase in total assets, a decrease in wages, and an increase in productivities make households more likely to participate in production. Past participations, however, turn out to be the key factor in determining current participations. Households likely remain participants in both the labor market and production once they have participated. However, households that participated in production are less likely to participate in the labor market. On the other hand, households that participate in the labor market also are more likely to participate in production.

The first key observation from the results is that households with higher total assets, on the extensive margin, are more likely to participate in production but less likely to participate in the labor market. On the intensive margin, households with higher assets also work longer hours in production. Overall, the substitution effect from an increase in assets is stronger than the income effect on production hours in this case. Further, although the elasticity is very small, the hours in the labor market unexpectedly increase with assets on the intensive margin.

The second observation is that, on the intensive margin, households with higher wages work longer hours in the labor market and shorter hours in production. That is, the substitution effects dominate the income effects for labor market hours and reinforce the income effects for production hours. On the extensive margin, households are rather less likely to participate in either sector when wages increase. I argue that income effects tend to dominate here, perhaps among previous non-participants.

However, the participation probabilities are much more affected by past participations than current wages in the estimates.

Further, on the intensive margin, households with higher productivities work fewer hours in both the labor market and production. Here, the income effects from an increase in productivity dominate the substitution effects on production hours and reinforces the substitution effects on labor market hours. On the other hand, households with higher productivities are more likely to participate in production but are indifferent to participating in labor market. The substitution effect dominates the income effect in this case among previous non-participants. But, past participations still hold much higher impacts on the extensive margin than changes in productivities in the estimates.

1.7 Consumption Insurance Decomposition

So far, the results have shown that household consumption is rather well insured against both wage and productivity shocks. The next question to answer in this section is how much insurance comes from labor supply reallocation across the two sectors and how much insurance comes from change in savings.

Using a similar approach to Blundell, Pistaferri, Saporta (2016), I can approximately decompose the effects of a wage shock on consumption as:

$$\frac{\partial c}{\partial w} = \frac{\partial y}{\partial w} - \frac{\partial (S/Y)}{\partial w} \quad (23)$$

where $\frac{\partial y}{\partial w}$ is the effect of the log wage change on the log total household income and $\frac{\partial (S/Y)}{\partial w}$ is the effect of the log wage change on savings.

Furthermore, the effect of the log wage change on the log total household income can be approximately decomposed into

$$\frac{\partial y}{\partial w} = \theta \frac{\partial y_1}{\partial w} + (1-\theta)\frac{\partial y_2}{\partial w} \quad (24)$$

where θ is the fraction of household income from the labor market and $(1-\theta)$ is the fraction of household income from production.

Now, based on (13) and (14), I can write the effect of the log wage change on the log labor income as:

$$\frac{\partial y_1}{\partial w} = \frac{\partial (w + l_1)}{\partial w} = 1 + \eta_{l1,w}$$

and the effect of log wage change on log production income as

$$\frac{\partial y_2}{\partial w} = \frac{\partial (z + \alpha a + \psi l^2)}{\partial w} = \psi \eta_{l2,w}$$

Overall, (23) can be re-written as:

$$\eta_{c,w} = \theta(1 + \eta_{l1,w}) + (1-\theta)(\psi \eta_{l2,w}) - \frac{\partial (S/Y)}{\partial w} \quad (25)$$

Based on (25), the overall change in consumption comes from four effects : 1. the income distribution between two sectors (θ), 2. the labor hour response in labor market sector $(1 + \eta_{l1,w})$, 3. the labor hour response in production sector $(\psi \eta_{l2,w})$, and 4. the change in savings $(\frac{\partial (S/Y)}{\partial w})$.

The estimate of θ, from overall sample, is the average labor income share $\hat{\theta} = 0.28$. From section 6 and 8, other relevant estimates are $\hat{\eta}_{c,w} = 0.008$, $\hat{\eta}_{l1,w} = 0.083$, $\hat{\eta}_{l2,w} = -0.112$, and $\hat{\psi} = 0.541$.

Based on these estimates,the response of consumption to a 1% decrease in wages can be decomposed in four steps :

1. Assuming no income distribution across sector $\theta = 1$, fixed labor hours $\eta_{l1,w} = \eta_{l2,w} = 0$, and no change in savings $\frac{\partial(S/Y)}{\partial w} = 0$. In this case, the household, who is a pure wage earner without self-insurance through savings, would reduce consumption by 1%, the same magnitude of wage decrease.

2. Assuming income distribution $\theta = 0.28$, but still fixed labor hours and no change in savings. In this case, consumption elasticity would be $\theta = 0.28$. By allowing households to allocate income sources between two sectors, the magnitude of consumption response reduces to only 0.28%.

3. Assuming income distribution, labor hour responses in both sectors $\eta_{l1,w} = 0.083$ and $\eta_{l2,w} = -0.112$, and no change in savings. In this case, consumption elasticity would be $\theta(1 + \eta_{l1,w}) + (1 - \theta)(\psi\eta_{l2,w}) = 0.26$. By allowing income distribution between two sectors plus behavioral responses in labor hours, the magnitude of consumption response reduces further to 0.26%

4. Assuming income distribution, labor hour responses, as well as change in savings. In this case, consumption elasticity would be the estimate $\eta_{c,w} = 0.008$. That is savings adjustment further reduces consumption response from 0.26% to 0.008%.

Considering an average household who chooses to participate in both labor market and production with share of income $\theta = 0.28$ from labor market. Step 2 above shows that, on the extensive margin, participations in both sectors allow consumption to decrease only by 0.28% to a 1% decrease in wage, which is 0.72 percentage point of insurance. Steps 3 shows that, on the intensive margin, labor supply responses further reduce the response to 0.26%, that is 0.02 percentage point of insurance. Finally, step 4 shows that change in savings further reduce the response to 0.008%, that is further 0.252 percentage point of insurance. Overall, out of 0.992 percentage point of consumption insurance from 1 percentage point of wage decrease, 72.6% of insurance comes from decisions to participate in both sectors, 2.0% of insurance comes from labor hours responses and 25.40 of the remaining insurance comes from adjustment of savings.

Using a similar analysis, I decompose the effect of productivity shock on consumption as:

$$\frac{\partial c}{\partial z} = \frac{\partial y}{\partial z} - \frac{\partial (S/Y)}{\partial z} \quad (26)$$

with

$$\frac{\partial y}{\partial z} = \theta \frac{\partial y_1}{\partial z} + (1-\theta) \frac{\partial y_2}{\partial z} \quad (27)$$

where

$$\frac{\partial y_1}{\partial z} = \frac{\partial (w + l_1)}{\partial z} = \eta_{l1,z}$$

and

$$\frac{\partial y_2}{\partial z} = \frac{\partial(z + \alpha a + \psi l^2)}{\partial z} = 1 + \psi\eta_{l2,z}$$

Hence, (26) can be re-written as

$$\eta_{c,z} = \theta(\eta_{l1,z}) + (1-\theta)(1+\psi\eta_{l2,z}) - \frac{\partial(S/Y)}{\partial z} \quad (28)$$

From section 8, the relevant estimates are $\hat{\eta}_{c,z} = 0.032$, $\hat{\eta}_{l1,z} = -0.081$, and $\hat{\eta}_{l2,w} = -0.146$. Again, based on these estimates, one can decompose response of consumption to a 1% productivity shock in four steps :

1. Assuming no income distribution across sector $\theta = 0$, fixed labor hours $\eta_{l1,z} = \eta_{l2,z} = 0$, and no change in savings $\frac{\partial(S/Y)}{\partial z} = 0$. In this case, the household, who is a pure producer without self-insurance through savings, would reduce consumption by 1%, the same magnitude of wage decrease.

2. Assume income distribution $\theta = 0.28$, but still fixed labor hours and no change in savings. In this case, consumption elasticity would be $1 - \theta = 0.72$. By allowing households to distribute income between two sectors, the magnitude of consumption response reduces to only 0.72%.

3. Assume income distribution, labor hour responses in both sectors $\eta_{l1,z} = -0.081$ and $\eta_{l2,z} = -0.146$, and no change in savings. In this case, consumption elasticity would be $\theta(\eta_{l1,z}) + (1-\theta)(1+\psi\eta_{l2,z}) = 0.64$. By allowing income allocation between two sectors plus behavioral responses in labor supplies, the magnitude of consumption response reduces to 0.64%

4. Assume income distribution, labor hour responses, as well as change in savings. In this case, consumption elasticity would be the estimate $\eta_{c,z} = 0.032$. That is insurance through savings further reduces consumption response from 0.64% to 0.032%.

This process shows that out of a $1 - 0.032 = 0.968$ percentage point of consumption insurance from a productivity shock, 0.28 percentage point comes from extensive margin participations $0.72 - 0.64 = 0.08$ percentage point comes from labor hours responses in the intensive margin and $0.64 - 0.032 = 0.608$ percentage point comese from savings. Overall, 28.9% of insurance comes from decisions to participate in both sectors, 8.3% of insurance comes from adjusting labor hours and 62.8 of remaining insurance comes from the adjustment of savings.

1.8 Conclusion and Direction for Future Works

This paper, within the developing country context of Thai villages, studies a framework with households making consumption and labor supply decisions across the wage labor market and home production under the presence of wage and productivity shocks. I use a reduced-form method that assumes mixed linear-probit decision rules for consumption and labor supplies on both the intensive and extensive margins and allows for joint evolution of wages and productivities. First, I estimate the unobserved wages for non-participants in labor market, that has less variation at individual level, through mincer-type village-level regressions. Next, the production function is estimated through a control function approach using the intermediate input as proxy variable. Finally, I jointly estimate the unobserved productivities along with reduced-form model coefficients through a Markov Chain Monte Carlo approach, that uses the production function estimate as an input. Overall, the model estimates show very small consumption responses to wage and productivity shocks, that indicates very strong insurance mechanisms. The model estimates also show that working hours have a significant response to wage and productivity shocks. On the intensive margin, hours in labor market increase and hours in production tend decrease, in response to a wage increase. This response means that substitution effects dominate the wage change. Also, on the intensive margin, the hours in both labor market and production decrease, in response to a productivity increase. This response indicates that income effects dominate the change in productivity. Using the model estimates, I compute that labor supply responses in the two sectors to wage and productivity shocks do play large roles in explaining part of the consumption insurance. In particular, 74.6% of total consumption insurance from the wage shock comes from the labor supply responses and 37.2% of total consumption insurance from the productivity shock comes from the labor supply responses, on both intensive and extensive margins. It is worth to mention that extensive margin responses provide larger degrees of consumption insurance than than intensive margin responses to both wage and productivity shocks.

My current work can be extended in a number of directions.

First, studies could use a more realistic flexible reduced-form specification of decision rules that allow for nonlinear responses of consumption and labor supply to wage and productivity shocks This direction could follow a variation of the nonlinear panel data approach in the study of earnings and consumption dynamics in Arellano, Blundell, Bonhomme (2017).

Next, although the labor supply responses in the two sectors do indeed explain signficant portions of the consumption insurance to wage and productivity shocks, there are still large portions of the remaining consumption insurance interpreted as coming from savings adjustment in the current limited framework. The assets adjustment channel could incorporate other important consumption insurance mechanisms. In a developing economiy, risk-sharing arrangements among village members through gifts and transfers are a strong consumption smoothing force in the literature. Therefore, the study of a more flexible framework that allows for labor supply responses in two sectors within the risk-sharing setting might be interesting for future work.

Lastly, although it is true one general major drawback of a reduced-form approach is the limited potential for counterfactual policy studies, the reduced-form estimates still serve as a valuable starting point for a more structural approach. For example, the reduced-form parameter estimates can be used as model calibration targets for a full structural model. Moreover, the reduced-form estimates can also be used to purge data out of the effects of taste-shifters and other parameters of less interest and reduce the dimension for a structural model. At this point, the goals for my future project are to use a structural model in this similar framework to perform a welfare analysis : computing the consumption equivalence value of the labor market and production sectors, and performing counter policy analysis on real events, for example, the 2012 minimum wage law in Thailand (wage shifts), the government agricultural price support policy (productivity shifts), and the village fund program (relaxation of borrowing constraints).

Appendix A1.1 : Descriptive Statistics

Probability density plots for consumption, total assets, working hours, and income across labor market and home production are provided in Figures 1.10-1.15. Plots for estimated wages and estimated productivities are given in Figures 1.16-1.17.

Figure 1.10. Consumption : Probability Density Plots

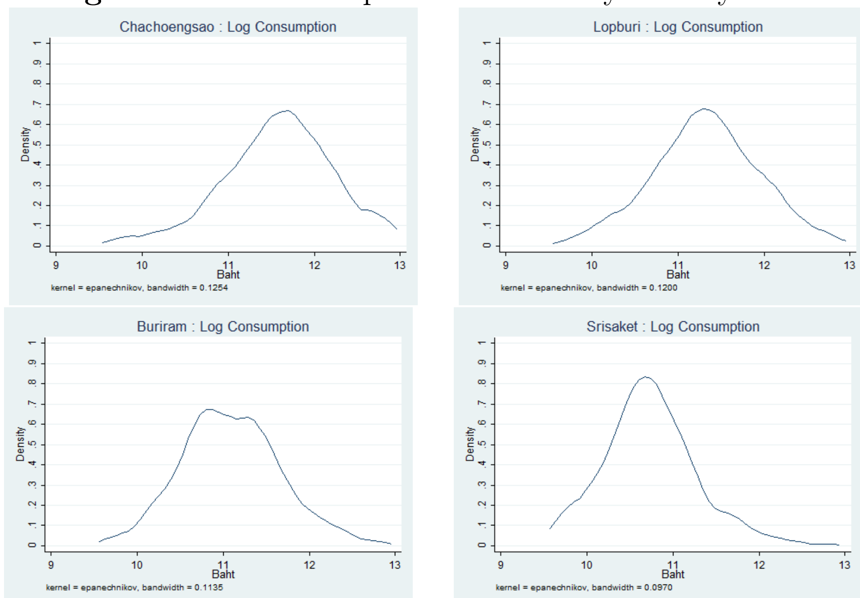


Figure 1.11. Assets : Probability Density Plots

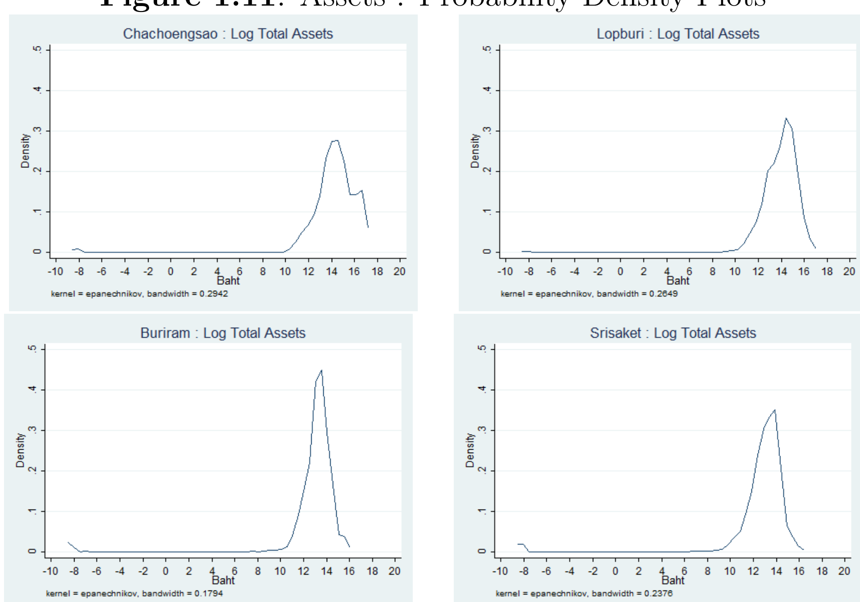


Figure 1.12. Labor Market Hours : Probability Density Plots

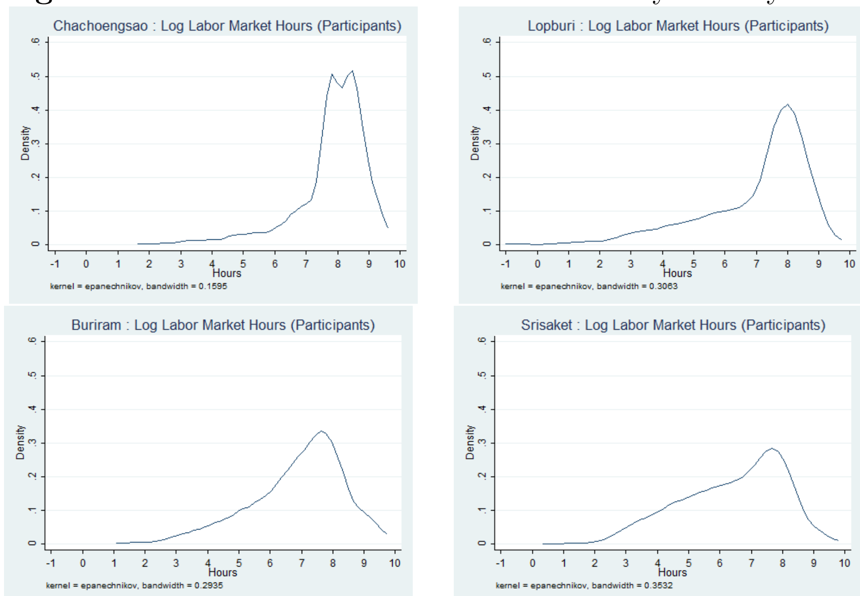


Figure 1.13. Labor Market Income : Probability Density Plots

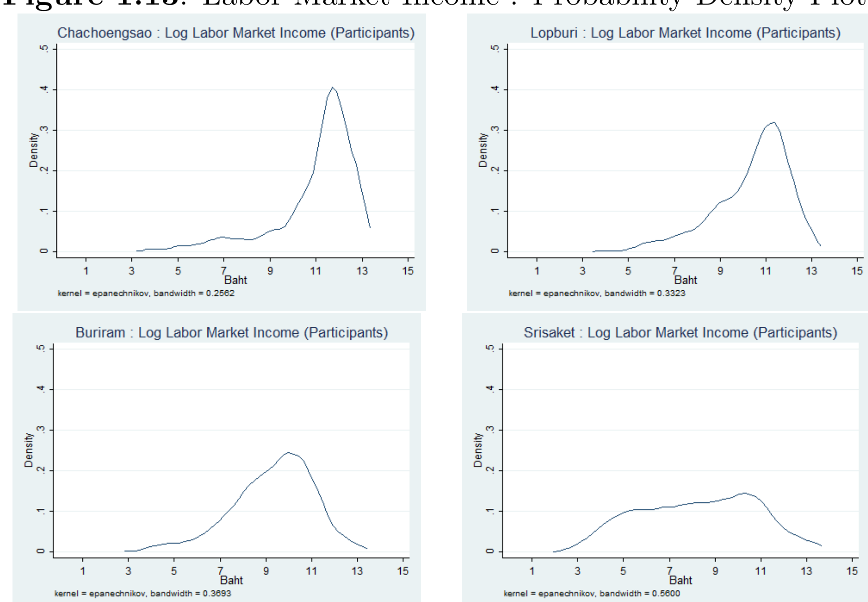


Figure 1.14. Home Production Hours : Probability Density Plots

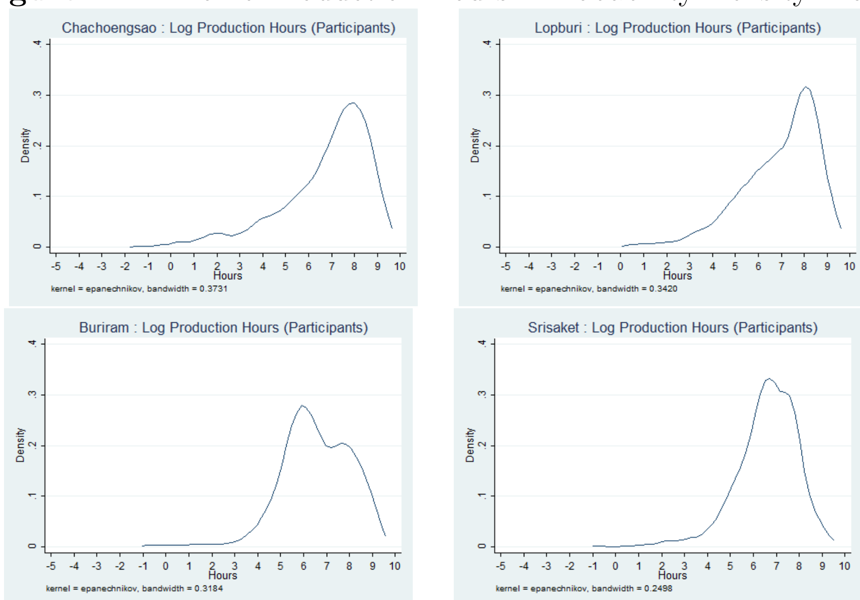


Figure 1.15. Home Production Income : Probability Density Plots

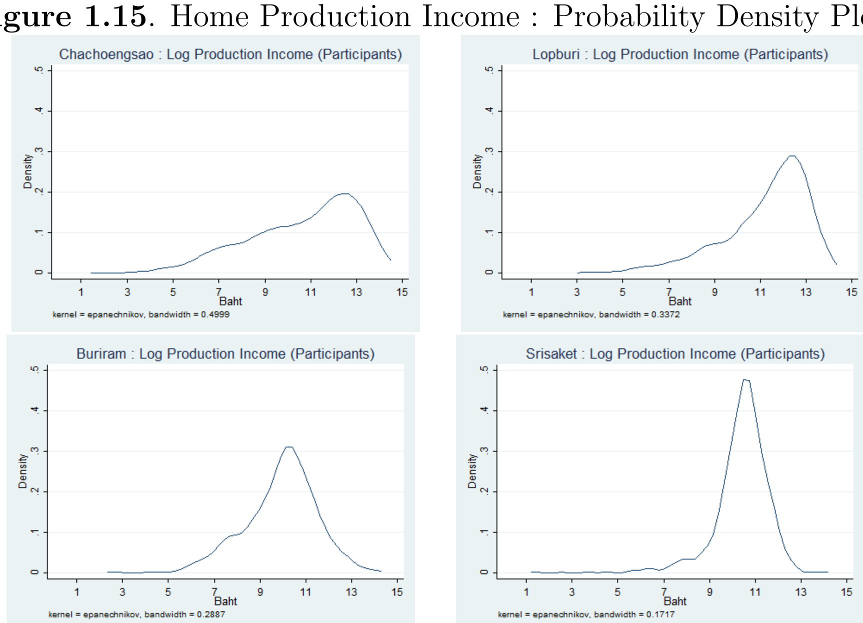


Figure 1.16. Estimated Wage : Probability Density Plots

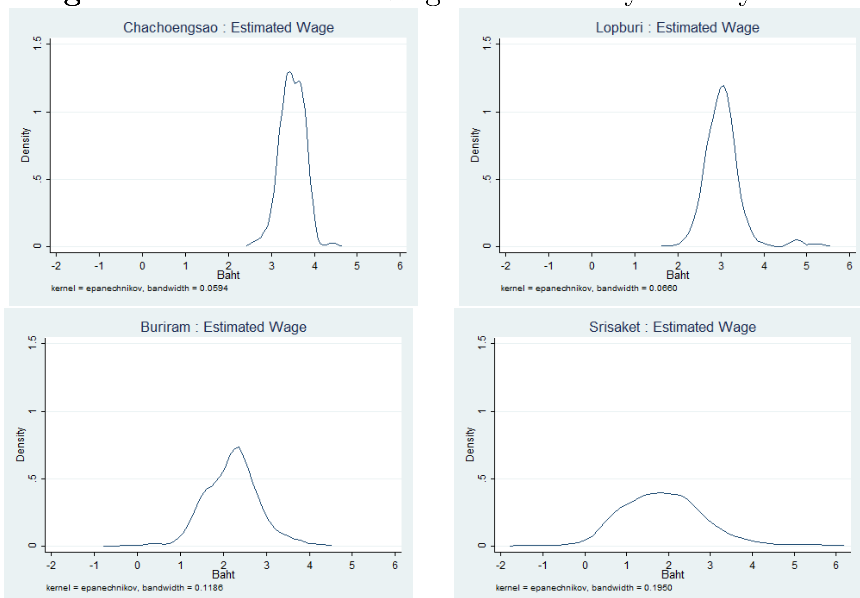
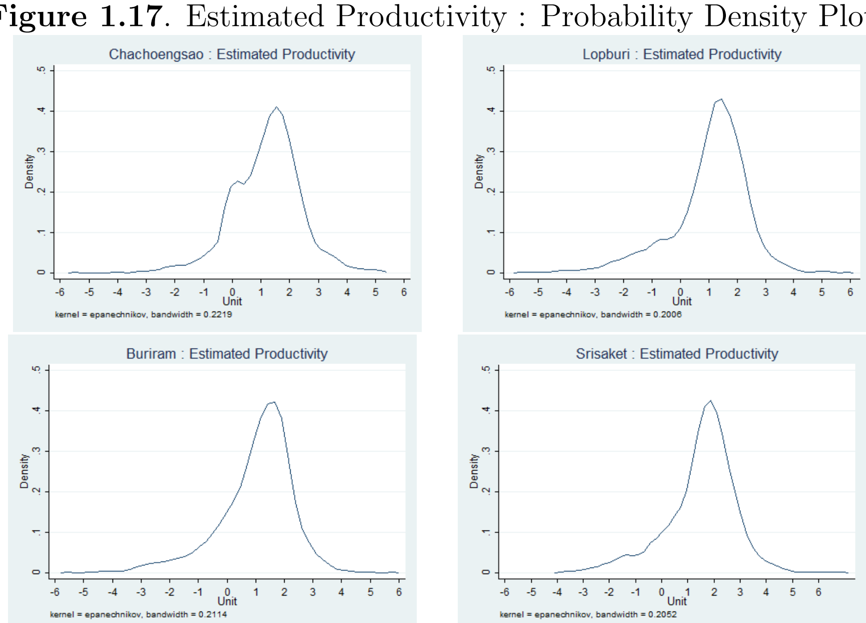


Figure 1.17. Estimated Productivity : Probability Density Plots



Appendix A1.2 : Alternate Production Function Estimations

Estimates using total assets as working capital are reported in table 1.10.

Estimates using physical assets as working capital are reported in table 1.11.

Appendix A1.3 : Alternate Findings with Regression-Predicted Productivity

This appendix provides linear regression and probit estimates for reduced-form model (5) − (12) treating regression-predicted productivities as observed.

For robustness, I include 4 following specifications that differ in the set of control variables:

- Specification 1 : no additional control
- Specification 2 : gender, household size, education level, age, age-square
- Specification 3 : Specification 2 plus province dummies
- Specification 4 : Specification 2 plus village dummies

Regression estimates are reported in Table 1.12-1.17.

Table 1.10: Production Function Estimates: Total Assets as Capital

	OLS	FE	ACF
Log(Hours)	0.582***	0.409***	0.541***
	(0.0111)	(0.0153)	(0.0928)
Log(Total Assets)	0.354***	0.0304	0.361***
	(0.0153)	(0.0433)	(0.0199)
Lagged Log Wage	0.0701***	0.0606	0.142
	(0.0188)	(0.0370)	(0.0960)
Age of Head	0.0120	0.0524*	0.0196
	(0.00997)	(0.0242)	(0.131)
Age-square of Head	-0.000200*	-0.000374*	-0.000205
	(0.0000877)	(0.000151)	(0.189)
Household Size	0.0309***	0.0608***	0.0296
	(0.00894)	(0.0149)	(0.0484)
Male Head	0.106**	-0.307	0.159
	(0.0370)	(0.371)	(0.0818)
Prim. Ed.	0.179**	-0.485	0.161*
	(0.0565)	(0.575)	(0.0667)
Lower Sec. Ed.	0.477***	0.583	0.484***
	(0.143)	(0.551)	(0.0512)
Upper Sec. Ed.	0.168	0.0690	0.101
	(0.0956)	(0.542)	(0.0694)
Above Sec. Ed.	-0.354**	0.282	-0.404***
	(0.129)	(0.414)	(0.0523)
Time Dummies	Yes	Yes	No
Household Dummies	No	Yes	No
Observations	5121	5121	5040

Standard errors in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 1.11: Production Function Estimates: Physical Assets as Capital

	OLS	FE	ACF
Log(Hours)	0.602***	0.404***	0.377***
	(0.0115)	(0.0154)	(0.0602)
Log(Physical Assets)	0.212***	0.0645***	0.0260
	(0.0134)	(0.0186)	(0.0728)
Lagged Log Wage	0.161***	0.0622	0.169***
	(0.0184)	(0.0369)	(0.0454)
Age of Head	0.0234*	0.0528*	-0.218*
	(0.0102)	(0.0235)	(0.0961)
Age-square of Head	-0.000233**	-0.000366*	0.421**
	(0.0000900)	(0.000150)	(0.163)
Household Size	0.0421***	0.0534***	-0.00948
	(0.00915)	(0.0150)	(0.0324)
Male Head	0.0898*	-0.393	0.231***
	(0.0380)	(0.369)	(0.0665)
Prim. Ed.	0.264***	-0.308	0.144***
	(0.0578)	(0.574)	(0.0344)
Lower Sec. Ed.	0.587***	0.770	0.705***
	(0.147)	(0.553)	(0.0487)
Upper Sec. Ed.	0.351***	0.301	0.369***
	(0.0976)	(0.545)	(0.0493)
Above Sec. Ed.	-0.423**	0.417	-0.451***
	(0.133)	(0.416)	(0.0446)
Time Dummies	Yes	Yes	No
Household Dummies	No	Yes	No
Observations	5121	5121	5040

Standard errors in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 1.12: Robustness: Log Consumption Equation Estimates

	Spec 1	Spec 2	Spec 3	Spec 4
Log(Total Assets)	0.0566***	0.0483***	0.0385***	0.0372***
	(21.07)	(19.64)	(16.21)	(15.68)
Log(Wage)	0.297***	0.281***	0.106***	0.0931***
	(38.21)	(37.80)	(10.25)	(8.37)
Log(TFP)	0.100***	-0.0315*	0.0304*	0.0300*
	(8.52)	(-2.57)	(2.31)	(2.18)
Male Head		0.0198	0.00983	0.0198
		(1.32)	(0.68)	(1.37)
Household Size		0.142***	0.147***	0.146***
		(39.08)	(41.88)	(41.61)
Prim. Ed.		-0.00764	0.0767***	0.0687**
		(-0.33)	(3.36)	(2.98)
Lower Sec. Ed.		0.232***	0.408***	0.392***
		(3.78)	(6.96)	(6.71)
Upper Sec. Ed.		0.164***	0.269***	0.268***
		(4.10)	(6.97)	(6.89)
Above Sec. Ed.		0.0444	0.498***	0.537***
		(0.90)	(9.93)	(10.60)
Age of Head		0.0226***	0.0240***	0.0232***
		(5.79)	(6.44)	(6.20)
Age-square of Head		-0.000263***	-0.000261***	-0.000255***
		(-7.60)	(-7.92)	(-7.73)
Time Dummies	No	Yes	Yes	Yes
Province Dummies	No	No	Yes	No
Village Dummies	No	No	No	Yes
Observations	6852	6852	6852	6852

t statistics in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 1.13: Robustness: Log Future Assest Equation Estimates

	Spec 1	Spec 2	Spec 3	Spec 4
Log(Total Assets)	0.880***	0.876***	0.875***	0.874***
	(159.92)	(154.30)	(152.06)	(150.35)
Log(Wage)	0.0926***	0.0874***	0.0637*	0.0397
	(5.96)	(5.21)	(2.54)	(1.44)
Log(TFP)	0.0816**	0.0954***	0.0499	0.0552
	(3.28)	(3.35)	(1.53)	(1.62)
Male Head		0.0743*	0.0754*	0.0827*
		(2.16)	(2.17)	(2.35)
Household Size		0.00913	0.0127	0.0124
		(1.09)	(1.50)	(1.44)
Prim. Ed.		0.0802	0.0642	0.0737
		(1.51)	(1.17)	(1.31)
Lower Sec. Ed.		0.203	0.212	0.224
		(1.45)	(1.50)	(1.57)
Upper Sec. Ed.		0.177	0.160	0.183
		(1.92)	(1.71)	(1.93)
Above Sec. Ed.		0.328**	0.332**	0.371**
		(2.89)	(2.75)	(3.00)
Age of Head		0.0271**	0.0273**	0.0268**
		(2.99)	(3.01)	(2.91)
Age-square of Head		-0.000195*	-0.000204*	-0.000198*
		(-2.41)	(-2.52)	(-2.41)
Time Dummies	No	Yes	Yes	Yes
Province Dummies	No	No	Yes	No
Village Dummies	No	No	No	Yes
Observations	6281	6281	6281	6281

t statistics in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 1.14: Robustness: Labor Market Participation Estimates

	Spec 1	Spec 2	Spec 3	Spec 4
select				
Log(Total Assets)	-0.0433***	-0.0457***	-0.0549***	-0.0436***
	(-5.99)	(-5.54)	(-6.39)	(-5.10)
Log(Wage)	0.0745***	0.0674**	-0.0288	-0.0381
	(4.03)	(3.25)	(-0.94)	(-1.13)
Log(TFP)	-0.0821**	-0.289***	-0.178***	-0.0718
	(-2.93)	(-8.39)	(-4.53)	(-1.71)
Male Head		-0.0107	-0.0204	-0.0302
		(-0.26)	(-0.48)	(-0.70)
Household Size		0.216***	0.219***	0.225***
		(19.99)	(19.78)	(19.89)
Prim. Ed.		-0.358***	-0.259***	-0.320***
		(-5.18)	(-3.62)	(-4.33)
Lower Sec. Ed.		-1.021***	-0.916***	-0.927***
		(-6.19)	(-5.53)	(-5.44)
Upper Sec. Ed.		-0.724***	-0.626***	-0.813***
		(-6.39)	(-5.49)	(-6.92)
Above Sec. Ed.		1.225**	1.656***	1.657***
		(2.96)	(3.82)	(3.70)
Age of Head		-0.0129	-0.0136	-0.0139
		(-1.14)	(-1.19)	(-1.19)
Age-square of Head		-0.000110	-0.0000861	-0.0000597
		(-1.11)	(-0.86)	(-0.59)
Time Dummies	No	Yes	Yes	Yes
Province Dummies	No	No	Yes	No
Village Dummies	No	No	Yes	Yes
Observations	6852	6852	6852	6852

t statistics in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 1.15: Robustness: Log Labor Market Hours Estimates

	Spec 1	Spec 2	Spec 3	Spec 4
Log(Market Hours)				
Log(Total Assets)	0.0393	0.0130	0.00810	-0.00175
	(0.57)	(1.10)	(0.52)	(-0.16)
Log(Wage)	0.409**	0.442***	0.124*	0.118**
	(2.86)	(13.42)	(2.05)	(2.58)
Log(TFP)	0.0264	-0.0840	-0.0183	-0.156**
	(0.16)	(-1.06)	(-0.21)	(-2.72)
Male Head		-0.119*	-0.0741	-0.0841
		(-1.97)	(-0.94)	(-1.43)
Household Size		0.0234	-0.0231	0.0352
		(0.51)	(-0.42)	(1.01)
Prim. Ed.		0.333**	0.348*	0.303**
		(2.89)	(2.53)	(2.99)
Lower Sec. Ed.		0.854**	1.274**	0.987***
		(2.58)	(3.17)	(3.50)
Upper Sec. Ed.		0.312	0.486	0.416*
		(1.41)	(1.84)	(2.10)
Above Sec. Ed.		-0.202	0.204	0.422*
		(-1.04)	(0.70)	(2.05)
Age of Head		0.0231	0.0161	0.0161
		(1.48)	(0.79)	(1.06)
Age-square of Head		-0.000201	-0.0000967	-0.000189
		(-1.36)	(-0.51)	(-1.38)
Observations	6852	6852	6852	6852

t statistics in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 1.16: Robustness: Production Participation Estimates

	Spec 1	Spec 2	Spec 3	Spec 4
select				
Log(Total Assets)	0.0581***	0.0503***	0.0595***	0.0567***
	(9.50)	(7.87)	(9.20)	(8.51)
Log(Wage)	-0.244***	-0.272***	-0.0669	-0.0312
	(-11.09)	(-10.71)	(-1.73)	(-0.74)
Log(TFP)	0.310***	0.258***	0.143***	-0.00195
	(10.32)	(7.17)	(3.61)	(-0.05)
Male Head		0.189***	0.210***	0.342***
		(4.29)	(4.66)	(7.21)
Household Size		0.115***	0.117***	0.113***
		(9.58)	(9.41)	(8.80)
Prim. Ed.		0.0866	-0.0293	-0.0483
		(1.24)	(-0.40)	(-0.62)
Lower Sec. Ed.		0.0959	-0.175	-0.0259
		(0.48)	(-0.86)	(-0.12)
Upper Sec. Ed.		0.504***	0.298*	0.280
		(3.62)	(2.13)	(1.90)
Above Sec. Ed.		0.314*	-0.303*	-0.414*
		(2.23)	(-1.99)	(-2.57)
Age of Head		0.0777***	0.0802***	0.0964***
		(6.71)	(6.82)	(7.73)
Age-square of Head		-0.000699***	-0.000747***	-0.000902***
		(-6.86)	(-7.21)	(-8.25)
Time Dummies	No	Yes	Yes	Yes
Province Dummies	No	No	Yes	No
Village Dummies	No	No	Yes	Yes
Observations	6852	6852	6852	6852

t statistics in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 1.17: Robustness: Log Production Hours Estimates

	Spec 1	Spec 2	Spec 3	Spec 4
Log(Production Hours)				
Log(Total Assets)	0.0629*	0.0791***	0.0734***	0.0949***
	(2.56)	(5.02)	(4.52)	(7.10)
Log(Wage)	0.123	0.0991	-0.133***	-0.146***
	(1.62)	(1.84)	(-3.46)	(-3.95)
Log(TFP)	-0.217*	-0.133	-0.191**	-0.141**
	(-2.14)	(-1.94)	(-3.00)	(-2.65)
Male Head		0.0483	0.0932	0.151*
		(0.75)	(1.51)	(2.30)
Household Size		0.117***	0.144***	0.168***
		(5.39)	(7.24)	(9.94)
Prim. Ed.		0.0204	0.0861	0.0787
		(0.25)	(1.05)	(0.98)
Lower Sec. Ed.		0.296	0.382	0.332
		(1.44)	(1.89)	(1.71)
Upper Sec. Ed.		0.248	0.313*	0.368**
		(1.65)	(2.29)	(2.81)
Above Sec. Ed.		-0.207	0.270	0.177
		(-1.14)	(1.42)	(0.93)
Age of Head		0.0124	0.0223	0.0433*
		(0.62)	(1.19)	(2.49)
Age-square of Head		-0.000223	-0.000313	-0.000509**
		(-1.23)	(-1.82)	(-3.21)
Observations	6852	6852	6852	6852

t statistics in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Appendix A1.4 : More Details on Joint Estimation Steps

Precise estimation procedures are given as follows:

Step 0 : Initialize the algorithm with guess $\{z_{i,t}^{(1)}, v_{i,t}^{1,(1)}, v_{i,t}^{2,(1)}\}$

Suppose we are now at iteration (s) and is given $\{z_{i,t}^{(s)}, v_{i,t}^{1,(s)}, v_{i,t}^{2,(s)}\}$

Step 1 : Update model parameters $\Omega^{(s)}$ defined as the set of reduced-form coefficients in (5) − (12), along with standard errors of residuals within each regression. Specifically,

- Compute $(\mu_{1,w}, \mu_{1,z}, \sigma^2_{1,w}, \sigma^2_{1,z}, \rho_{w1,z1})$ from the joint distribution of $(w_{i,1}, z_{i,1})$.
- Estimate OLS regressions of $\begin{bmatrix} w_{i,t+1} \\ z_{i,t+1} \end{bmatrix}$ on $\begin{bmatrix} w_{i,t} \\ z_{i,t} \end{bmatrix}$ and $X_{i,t}$

  to obtain $\{\mu_{w,X}, \mu_{z,X}, \rho_{11}, \rho_{12}, \rho_{21}, \rho_{22}, \sigma^2_w, \sigma^2_z\}$
- Estimate OLS regression of $c_{i,t}$ on $(a_{i,t}, w_{i,t}, z_{i,t}, X_{i,t})$

  to obtain $(\Theta_{c,X}, \eta_{c,a}, \eta_{c,w}, \eta_{c,z}, \sigma^2_c)$
- Estimate OLS regression of $a_{i,t}$ on $(a_{i,t}, w_{i,t}, z_{i,t}, X_{i,t})$

  to obtain $(\Theta_{a,X}, \eta_{a,a}, \eta_{a,w}, \eta_{a,z}, \sigma^2_c)$
- Estimate Heckit regression of $l^1_{i,t}$ on $(a_{i,t}, w_{i,t}, z_{i,t}, X_{i,t}, D^1_{i,t-1}, D^2_{i,t-1})$ to obtain $(\Theta_{l1,X}, \eta_{l1,a}, \eta_{l1,w}, \eta_{l1,z}, \sigma^2_{l1})$ and $(\Phi_{l1,X}, \phi_{l1,a}, \phi_{l1,w}, \phi_{l1,z}, \delta_{1,1}, \delta_{1,2}, \sigma^2_{l1})$
- Estimate Heckit Selection regression of $l^2_{i,t}$ on $(a_{i,t}, w_{i,t}, z_{i,t}, X_{i,t}, D^1_{i,t-1}, D^2_{i,t-1})$ to obtain $(\Theta_{l2,X}, \eta_{l2,a}, \eta_{l2,w}, \eta_{l2,z}, \sigma^2_{l2})$ and $(\Phi_{l2,X}, \phi_{l2,a}, \phi_{l2,w}, \phi_{l2,z}, \delta_{1,1}, \delta_{1,2}\sigma^2_{l2})$

Step 2 : Assume we know $\Omega^{(s)}$, we would like to draw $\{z_{i,t}^{(s+1)}, v_{i,t}^{1,(s+1)}, v_{i,t}^{2,(s+1)}\}$ given $\{z_{i,t}^{(s)}, v_{i,t}^{1,(s)}, v_{i,t}^{2,(s)}\}$ and $\Omega^{(s)}$. We will do this by Gibbs sampling.

- Step 2.0 : Initialize Gibbs sampling with sub-iteration 0. with $(z_{i,-t}^{(0)}, v_i^{(0)}, x_{i,t}^{(0)}) = (z_{i,-t}^{(s)}, v_i^{(s)}, x_{i,t}^{(s)})$, from the main-iteration (s).

  Suppose we are now at sub-iteration r

- Step 2.1 : For each i, we draw $z_{i,t}^{(r+1)}$ from posterior distribution of

  $p(z_{i,t} \mid z_{i,-t}^{(r)}, v_i^{1,(r)}, v_i^{2,(r)}, x_{i,t}^{(r)}; \Theta^{(s)})$

- Step 2.2 : For each i, we draw $(v_{i,t}^{1,(r+1)}, v_{i,t}^{2,(r+1)})$ from posterior distribution of $p(v_{i,t}^{1,(r+1)}, v_{i,t}^{2,(r+1)} \mid z_{i,-t}^{(r)}, v_i^{1,(r)}, v_i^{2,(r)}, x_{i,t}^{(r)}; \Theta^{(s)})$

  Repeat Step 2.1-Step 2.2 for $R = 1000$ sub-iterations.

Repeat Step 1 - Step 2 for $S = 1000$ iterations while storing $\Omega^{(s)}$.

Estimates $\Omega^{(s)}$ from $s = 201$ to $s = 1000$ are used to compute the distribution of coefficient estimates.

Within the above steps, the posterior distributions of hidden states given data can be derived as follows :

Here, I will omit subscript i from now on.

First, I compute the posterior Distribution for $\{z_t\}$:

For $2 \leq t \leq 11$,

$$\begin{aligned} p(z_t \mid z_{-t}, v^1, v^2) \propto & p(z_t \mid w_{t-1}, z_{t-1}) \times p(w_{t+1} \mid w_t, z_t) \times p(z_{t+1} \mid w_t, z_t) \\ & \times p(a_{t+1} \mid a_t, w_t, z_t) \times p(c_t \mid a_t, w_t, z_t) \\ & \times p(v_t^1 \mid a_t, w_t, z_t) \times p(l_t^1 \mid a_t, w_t, z_t)^{1_{\{v_t^1 > 0\}}} \\ & \times p(v_t^2 \mid a_t, w_t, z_t) \times p(l_t^2 \mid a_t, w_t, z_t)^{1_{\{v_t^2 > 0\}}} \end{aligned}$$

Also,

$$p(z_1 \mid z_{-1}, v^1, v^2) \propto p(z_1 \mid w_1) \times p(w_2 \mid w_1, z_1) \times p(z_2 \mid w_1, z_1)$$
$$\times\, p(a_2 \mid a_1, w_1, z_1) \times p(c_1 \mid a_1, w_1, z_1)$$
$$\times\, p(v_1^1 \mid a_1, w_1, z_1) \times p(l_1^1 \mid a_1, w_1, z_1)^{1_{\{v_1^1 > 0\}}}$$
$$\times\, p(v_1^2 \mid a_1, w_1, z_1) \times p(l_1^2 \mid a_1, w_1, z_1)^{1_{\{v_1^2 > 0\}}}$$

And,

$$p(z_{12} \mid z_{-12}, v, x) \propto p(z_{12} \mid w_{11}, z_{11}) \times p(c_{12} \mid a_{12}, w_{12}, z_{12})$$
$$\times\, p(v_{12}^1 \mid a_{12}, w_{12}, z_{12}) \times p(l_{12}^1 \mid a_{12}, w_{12}, z_{12})^{1_{\{v_{12}^1 > 0\}}}$$
$$\times\, p(v_{12}^2 \mid a_{12}, w_{12}, z_{12}) \times p(l_{12}^2 \mid a_{12}, w_{12}, z_{12})^{1_{\{v_{12}^2 > 0\}}}$$

Where

$$p(z_t \mid w_{t-1}, z_{t-1}) \propto exp\{-\frac{(z_t - \rho_{21} w_{t-1} - \rho_{22} z_{t-1} - \mu'_{z,X} X_{i,t-1})^2}{2\sigma_z^2}\}$$

$$p(w_{t+1} \mid w_t, z_t) \propto exp\{-\frac{(w_{t+1} - \rho_{11} w_t - \rho_{12} z_t - \mu'_{w,X} X_{i,t}}{2\sigma_w^2}\}$$

$$p(z_{t+1} \mid w_t, z_t) \propto exp\{-\frac{(z_{t+1} - \rho_{21} w_t - \rho_{22} z_t - \mu'_{z,X} X_{i,t})^2}{2\sigma_z^2}\}$$

$$p(a_{t+1} \mid a_t, w_t, z_t) \propto exp\{-\frac{(a_{t+1} - \eta_{A,A}a_t - \eta_{A,w}w_t - \eta_{A,z}z_t - \mu'_{a,X}X_{i,t})^2}{2\sigma_A^2}\}$$

$$p(c_t \mid a_t, w_t, z_t) \propto exp\{-\frac{(c_t - \eta_{c,A}a_t - \eta_{c,w}w_t - \eta_{c,z}z_t - \mu'_{c,X}X_{i,t})^2}{2\sigma_c^2}\}$$

$$p(l_t^1 \mid a_t, w_t, z_t) \propto exp\{-\frac{(l_t^1 - \eta_{l1,A}a_t - \eta_{l1,w}w_t - \eta_{l1,z}z_t - \mu'_{l1,X}X_{i,t})^2}{2\sigma_{l1}^2}\}$$

$$p(l_t^2 \mid a_t, w_t, z_t) \propto exp\{-\frac{(l_t^2 - \eta_{l2,A}a_t - \eta_{l2,w}w_t - \eta_{l2,z}z_t - \mu'_{l2,X}X_{i,t})^2}{2\sigma_{l2}^2}\}$$

$$p(v_t^1 \mid a_t, w_t, z_t) \propto exp\{-(\Theta'_{l1,X}X_{i,t} + \phi_{l1,A}a_t + \phi_{l1,w}w_t + \phi_{l1,z}z_t)^2\}$$

$$p(v_t^2 \mid a_t, w_t, z_t) \propto exp\{-(\Theta'_{l2,X}X_{i,t} + \phi_{l2,A}a_t + \phi_{l2,w}w_t + \phi_{l2,z}z_t)^2\}$$

$$p(z_1 \mid w_1) \propto exp\{-\frac{(z_1 - (\mu_{1,z} + \frac{\rho_{w1,z1}\sigma_{1,z}}{\sigma_{1,w}}(w_1 - \mu_{1,w}))^2}{2(1 - \rho_{w1,z1}^2)\sigma_{1,z}^2}\}$$

To summary,

$$p(z_t \mid z_{-t}, v, x) \propto \mathcal{N}(\frac{\zeta_t}{\Lambda_t}, \frac{1}{\Lambda_t})$$

where

$$\begin{aligned}
\zeta_t =& \frac{\mu_{1,z} + \frac{\rho_{w1,z1}\sigma_{1,z}}{\sigma_{1,w}}(w_1 - \mu_{1,w})}{2(1-\rho_{w1,z1}^2)\sigma_{1,z}^2} 1_{\{t=1\}} + \\
& \frac{\rho_{21} w_{t-1} + \rho_{22} z_{t-1} + \mu'_{z,X} X_{i,t-1}}{2\sigma_z^2} 1_{\{t \geq 2\}} + \\
& \rho_{12} \frac{w_{t+1} - \rho_{11} w_t - \mu'_{w,X} X_{i,t}}{2\sigma_w^2} 1_{\{t \leq 11\}} + \\
& \rho_{22} \frac{z_{t+1} - \rho_{21} w_t - \mu'_{z,X} X_{i,t}}{2\sigma_z^2} 1_{\{t \leq 11\}} + \\
& \eta_{A,z} \frac{a_{t+1} - \eta_{A,A} a_t - \eta_{A,w} w_t - \mu'_{a,X} X_{i,t}}{2\sigma_A^2} + \\
& \eta_{c,z} \frac{c_t - \eta_{c,A} a_t - \eta_{c,w} w_t - \mu'_{c,X} X_{i,t}}{2\sigma_c^2} + \\
& \phi_{l1,z}(v_t^1 - \mu'_{l1,X} X_{i,t} - \phi_{l1,A} a_t - \phi_{l1,w} w_t) + \\
& \eta_{l1,z}(\frac{l_t^1 - \eta_{l1,A} a_t - \eta_{l1,w} w_t - \Theta'_{l1,X} X_{i,t}}{2\sigma_{l1}^2}) 1_{\{v_t^1 \geq 0\}} + \\
& \phi_{l2,z}(v_t^2 - \mu'_{l1,X} X_{i,t} - \phi_{l2,A} a_t - \phi_{l2,w} w_t) + \\
& \eta_{l2,z}(\frac{l_t^2 - \eta_{l2,A} a_t - \eta_{l2,w} w_t - \Theta'_{l2,X} X_{i,t}}{2\sigma_{l2}^2}) 1_{\{v_t^2 \geq 0\}}
\end{aligned}$$

and

$$\Lambda_t = \frac{1}{2(1-\rho_{w1,z1}^2)\sigma_{1,z}^2} 1_{\{t=1\}} + \frac{1}{2\sigma_z^2} 1_{\{t\geq 2\}} + \frac{\rho_{12}^2}{2\sigma_w^2} 1_{\{t\leq 11\}} + \frac{\rho_{22}^2}{2\sigma_z^2} 1_{\{t\leq 11\}}$$
$$+ \frac{\eta_{A,z}^2}{2\sigma_A^2} + \frac{\eta_{c,z}^2}{2\sigma_c^2} + \phi_{l1,z}^2 + \phi_{l2,z}^2 + \frac{\eta_{l1,z}^2}{2\sigma_{l1}^2} 1_{\{v_t^1\geq 0\}} + \frac{\eta_{l2,z}^2}{2\sigma_{l2}^2} 1_{\{v_t^2\geq 0\}}$$

Next, I compute posterior Distribution for $\{v_t^j\}$ where $j = 1, 2$:

Note that

$$p(v_t^j \mid v_{-t}^j, z, x) \propto p(v_t^j \mid a_t, w_t, z_t, D_t^j)$$

When $D_t^j = 1$, we have

$$p(v_t^j \mid v_{-t}^j, z, x) \propto \frac{\frac{1}{\sqrt{2\pi}} exp(-(v_t^j - \Theta'_{lj,X} X_{i,t} - \phi_{lj,A} a_t - \phi_{lj,w} w_t - \phi_{lj,z} z_t)^2}{1 - \Phi(-\Theta'_{lj,X} X_{i,t} - \phi_{lj,A} a_t - \phi_{lj,w} w_t - \phi_{lj,z} z_t)}$$

When $D_t^j = 0$, we have

$$p(v_t^j \mid v_{-t}^j, z, x) \propto \frac{\frac{1}{\sqrt{2\pi}} exp(-(v_t^j - \Theta'_{lj,X} X_{i,t} \phi_{lj,A} a_t - \phi_{lj,w} w_t - \phi_{lj,z} z_t)^2}{\Phi(-\Theta'_{lj,X} X_{i,t} - \phi_{lj,A} a_t - \phi_{lj,w} w_t - \phi_{lj,z} z_t)}$$

That is

$$p(v_t^j \mid v_{-t}^j, z, x) \propto \begin{cases} \mathcal{UTN}(\mu_v, 1, -\mu_v) & if \quad D_j^t = 1 \\ \mathcal{LTN}(\mu_v, 1, -\mu_v) & if \quad D_j^t = 0 \end{cases}$$

where $\mu_{vt}^j := \Theta'_{lj,X} X_{i,t} + \phi_{lj,A} a_t + \phi_{lj,w} w_t + \phi_{lj,z} z_t$

CHAPTER 2

DURABLES, INVESTMENT, AND CREDIT IN DEVELOPING ECONOMIES

2.1 Introduction

What are the patterns of durable purchases and household business investments in developing countries where many households are either self-employed farmers or small business owners? What are the effects of a relaxation in credit limit under the presence of durable goods and investment opportunities? Is credit extension an effective method in stimulating capital investment among small entrepreneurial households, with the aim of inducing internal growth, given purchasing durable goods as a competing mean for savings?

Recent empirical evidence, mainly from the U.S. and Europe, shows that durables play an important role in households' life cycle decision. For example, Krueger and Fernandez-Villaverde (2011), using CEX data, found that young households choose to hold most of their wealth in durables and keep very little liquid assets. Using a controlled experiment on varying credit card limits at a European retail bank, Aydin (2015) found that about two-third of household borrowing on average is associated with purchases of durables. All these evidence suggest the importance of explicit modeling of durables in household's life cycle. So far, a heterogenous agent model with liquid assets and illiquid durables performs relatively well in matching empirical findings from developed countries. In this type of model, the main mechanism driving large durable purchases is the, so far assumed exogenous, persistence income process. In particular, when households are hit by positive income shocks, they would have an incentive to borrow and invest in durables with the expectation of paying off the debts in the next few periods when their income likely remain high. It is interesting to see whether such a life cycle pattern holds and whether a similar framework with durables can be used to study developing countries.

Before taking the existing life cycle models with durables to study households in developing countries, one must take into account the underlying differences between those households and their developed counterparts. One of the most distinctive feature of households in developing countries is their source of income. Those households do not simply provide inputs, in forms of labor and capital, and consume the outputs. Rather, they do directly engage and make decisions in production activities. Those households derive income not only from their wage earnings and returns on savings but also from profits of their small businesses or farms. Based on evidence from Thailand, Samphantharak and Townsend (2008) draws an analogy between a household and a firm. Specifically, each household in developing countries concurrently makes consumption decisions as a household and makes investment decisions as a firm, based on individual productivity. This fact makes endogenizing investment decision especially crucial for studying these households, whom should also be treated as small entrepreneurs.

Taking households' investment decision into account, we can now see the impact of credit. Many households, despite high marginal return from investing in entrepreneurial activities, are forced to invest much less than they would choose to without the credit limits. It is reasonable for us to believe that a relaxation in the credit limits would induce these constrained households to invest significantly more. This idea tends to serve as a justification for founding various, both formal and informal, intermediary institutions targeting small entrepreneurial households in the rural areas among developing countries. Nevertheless, those institutions found various levels of success. It generally remains unclear whether the provision of extra liquidity is an effective method in stimulating capital accumulation. One possible explanation suggesting why such a policy might not be as effective as intended is the existence of durable stock as a more appealing investment option.

As discussed above, both sets of literature suggest the importance of durables and investment in households' life cycle decisions. The existing framework with durables generally assumed exogenous income process, ignoring investment decision entirely. The framework with investment, on the other hand, typically provides the households with only options of consuming non-durable goods, investing into liquid savings, or investing into capital stock. The first goal of this paper is investigate, both empirically and theoretically, how these two saving mechanisms should interact when put together in a single framework. The second goal is then to analyze the effects of credit on durable purchases and household business investments. Toward the second goal, a microcredit intervention program in Thailand, namely the Thai Million Baht Village Fund Program, provides a sizable quasi-experimental framework for evaluations of credit's impacts.

The plan for this paper is as follows. I first summarize the relevant background of the Thai Village Fund program in section 2.2 and describe the data employed in the empirical analysis in section 2.3. Notable patterns of durable purchases and household business investments across age and income groups, based on pre-intervention data, are documented in section 2.4. Determinants of Village Fund borrowers are documented in section 2.5. In section 2.6, I first present qualitative differences among Village Fund borrowers and non-borrowers. I then present two empirical approaches in evaluating the program's effects on durable purchases and household business investments. Overall, I found significantly positive impact of the program on all outcome variables. In section 2.7, I present a theoretical model which qualitatively captures the patterns described in section 2.4 and section 2.5. The chapter concludes with potential directions for future work in section 2. 8.

2.2 Thai Village Fund Program : Background

Thailand's "Million Baht Village Fund" program came as a part of Thai Rak Thai (TRT) party's political platform in the 2000 general election. The government-elect proposed to provide 1 million baht (about $24,000 given the exchange rate at that time) to each of approximately 77,000 villages across the country. The purported goal of the fund was for each village to establish its own independent village bank, run by local committees, to provide intra village lendings. At launch, the government officials claimed that the fund was aimed for stimulating the rural economy, particularly targeting new production activities such as processing and packaging which add values to existing agricultural products The size of the fund was approximately 12% of average annual village income, which is a sizable amount. The program was implemented rather rapidly. After the initiation in 2001, 92% of all Thai villages received the fund by the end of 2002 and this fraction rose to 99% by 2005 (Boonperm et al, 2009).

Before receiving the 1 million Baht transfer from the government, the village must first set up a local committee consisting of 9 to 15 members. For most villages, these committees were elected from Village Fund members. In order to become a member, each adult living in the village must either make small deposit or purchase a small share in the village fund account. Once formed, the village fund committee can then open an account at one of the facilitators, including Bank for Agriculture and Agricultural Co-operatives (BAAC), the Government Savings Bank (GSB), or the Krungthep Bank. Most of these facilitators are government-sponsored commercial banks with branches near the local villages. Once the account is setup, the government makes a 1 million baht direct deposit into the account. Each village fund member can then submit loan applications to the local committees who have discretion in setting the loan terms. These loan terms are generally governed by the National Village Fund Office's guidelines requiring the loans to charge positive interest rates and limit loan size to 20,000 Baht in general circumstance while the limit could extend to 50,000 Baht in special circumtances that require committee meeting for approval. Once the village fund committees review and approve loan application, the borrower can then visit one of the facilitator's branches to gain access to the fund. When the payment is due, the borrower is expected to repay the loan with interest by making a deposit back into the village fund account at the facilitator where all transactions are recorded. The village fund committees are responsible for enforcing these repayments.

Due to the program's decentralized nature, there is generally limited information on each individual fund. In particular, the government could not effectively track each village fund's financial status and whether the local committees closely followed the central guidelines. The main available source of information of village funds' performance is the Thai National Statistics Office's 2010 Village Fund Survey on 3,091 sampled existing funds. According to Boonperm et al (2012), 83% of surveyed village funds set a maximum loan size of at most 20,000 Baht. 85.3% of village fund loans were charged with interest rate between 3% and 8%. Most surveyed village funds were able to report their balance sheets and 92.3% of surveyed funds reported some small profits (about 77,000 baht annually) which were paid to share holders, committees, and financing some village welfare programs. Overall, these evidence tend to suggest that village fund committees tend to follow the general guidelines quite closely and it is fair to treat the village fund program as the government's intervention in extending the credit limit.

The most interesting quasi-experimental feature of the village fund program was that each village received the same amount of fund regardless of the village's demographics, financial conditions, or geographical locations. Due to this feature, we should expect villages with smaller population size to be able to distribute more loans with larger average loan sizes. In rural Thailand, villages are geopolitical units formed for administrative purposes. Because there where usually multiple government agencies with conflicting goals involved, the village forming decisions were rather arbitrary. Moreover, the program came as a result of a quick election in 2000 and was almost fully implemented in 2002. Households could not anticipate this program in earlier years. On top of that, the number of villages in Thailand only rose for about 3% between 2000 and 2010. It is very unlikely that many existing villages were split purposely to obtain more funds. Based on these facts, It is reasonable to consider that village size should be exogenous to our outcome variables of interest, namely durable expenditures and household business investment.

2.3 Data

The dataset used in this Chapter comes from the Thai Household Socioeconomic Survey (SES), a government-funded repeated cross-sectional survey conducted by Thailand's National Statistics Office. On average, each survey interviewed approximately 35,000 households within 1,500 villages across Thailand's 76 provinces. From 1999-2004[1], the survey questionaire allows me to extract information for each individual household's flow of non-durable consumption, durable expenditures, and household business investment. The questionaire also allows me to extract each household's income in forms of wages, income from farming activities, and income from non-farming

1. Except 2003, as there was no survey for that year

entrepreneurial activities. The major drawback of this dataset is that the survey did not ask for each household's total wealth and total value of durable stocks. Regarding relevant information on the Village Fund program, the 2002 and 2004 surveys asked whether each surveyed household had borrowed from the village fund. On top of that, the 2004 survey also includes a special questionnaire module on the Village Fund program which contains more detailed information on amount borrowed, stated purpose of borrowing, and repayment status which would allow further analysis.

Extracted from 1999-2004 survey, descriptive statistics of key survey variables, including non-durable consumption, discrete durable purchases, business investments, as well as relevant household characteristics, are reported in Table 2.1.

As a starting point, it is useful to first look at patterns in non-durable consumption, durable purchases, and household business investments across calendar years. As shown in Table 2.1 as well as Figure 2.1, there is significant increase of about 15% in median non-durable consumption from 2002 to 2004. The probabilities of purchasing new vehicles and new household appliances increased overtime and increased significantly from 2002 to 2004. Meanwhile, the probability of household business investment remains relatively flat across time but tends to also be somewhat increasing from 2002 to 2004. Noting that the Thai Village Fund program was mostly implemented by the end of 2002, these observed patterns provide motivation to investigate whether the increases in both non-durable consumption and probabilities of durable purchases from 2002 or 2004 were at least partially associated with credit expansion.

Table 2.1: Descriptive Statistics of Key Variables

Variable / Year	1999	2000	2001	2002	2004
Non-durable Consumption (Median)	80700	82500	84432	87264	97296
Total Household Income (Median)	98016	102660	108000	110196	123612
New Vehicle Purchase (Fraction)	0.036	0.040	0.045	0.055	0.089
New Appliance Purchase (Fraction)	0.062	0.070	0.073	0.086	0.099
Business Investment (Fraction)	0.032	0.030	0.030	0.030	0.030
Age of Household Head (Median)	48	47	47	48	48
High School Graduate (Fraction)	0.610	0.600	0.595	0.589	0.556
College Graduate (Fraction)	0.075	0.071	0.144	0.140	0.154
Female Household Head (Fraction)	0.277	0.284	0.293	0.300	0.320
Household Borrowed from the Village Fund (Fraction)	-	-	-	0.208	0.295
Obs.	7789	24747	12266	34785	34843

Figure 2.1. Patterns across Calendar Years

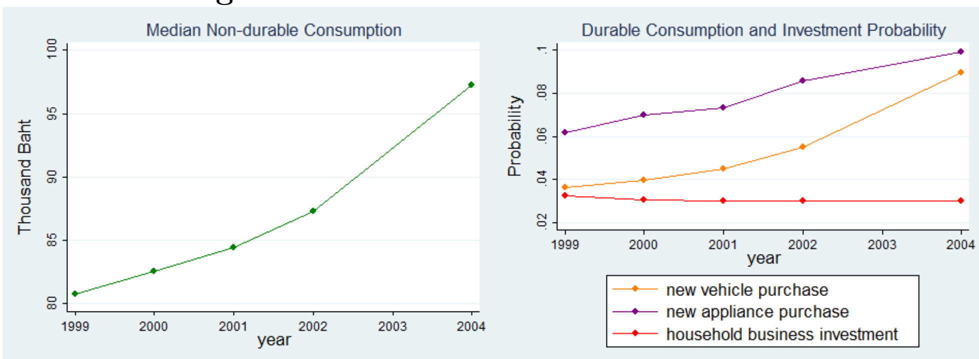
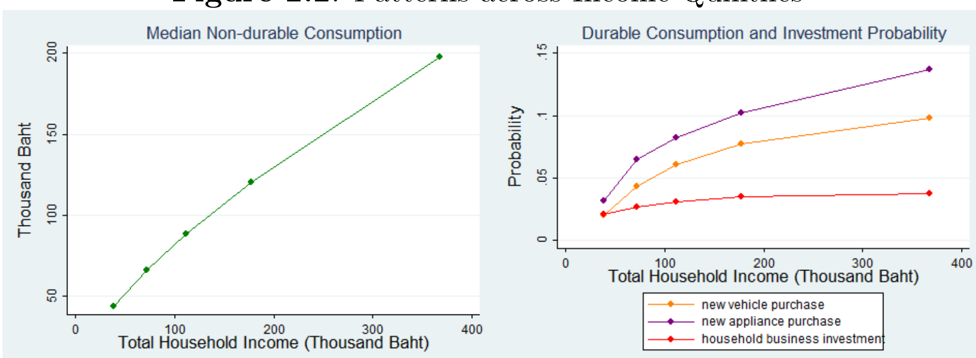


Figure 2.2. Patterns across Income Quintiles

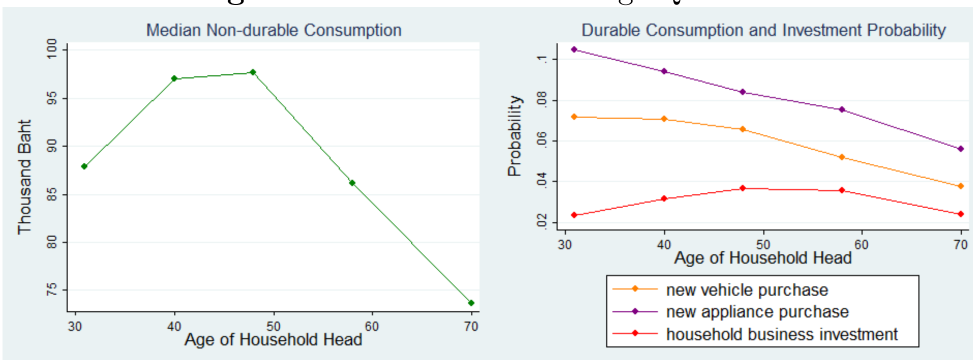


2.4 Pre-intervention Patterns of Non-durable Consumption, Durable Purchases, and Business Investments

The first key goal of this chapter is to understand how non-durable consumption, durable purchases, and business investment decisions vary across income ranges and age profiles. Before proceeding on to investigate the impact of credit from the Thai Village Fund, it is helpful to look at these underlying patterns prior to the program. Using data from 1999-2001 survey, patterns of key variables across quintiles of total household income and age of household head are presented in Figure 2.2 and Figure 2.3, respectively.

From Figure 2.2, non-durable consumption as well as the probabilities of purchasing new vehicles and new household appliances are significantly increasing across

Figure 2.3. Patterns across Age Quintiles



income quintiles. The probability of household business investment also increases substantially from around 2.4% at the lowest income quintile to 4.5% at the highest income quintile. Overall, households with higher total income tend to consume more, are more likely to either purchase durables or make new investments in household businesses.

Based on Figure 2.3, non-durable consumption increases and peaks at the second age quintile and is decreasing afterward. The probabilities of both new vehicle purchases and new appliances are decreasing across age quintiles. Meanwhile, the probability of household business investment increases and peaks at the third age quintile and is decreasing afterward. Overall, younger households consume more and are more likely to purchase durables. Middle-age households are most likely to invest in household business.

2.5 Determinants of Village Fund Borrowing

As mentioned in section 2.2, a household's ability to borrow from the Village Fund program is decided upon the discretion of local village committees. Also, the household's decision to apply for a Village Fund loan is voluntary. Hence, overall participation to the program is likely non-random. Therefore, it is worthwhile to understand how

Figure 2.4. Fractions of VF Borrowers across Income Quintiles

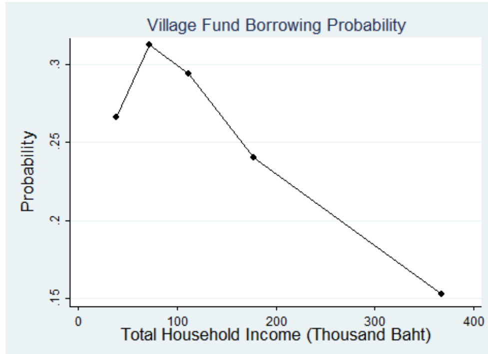
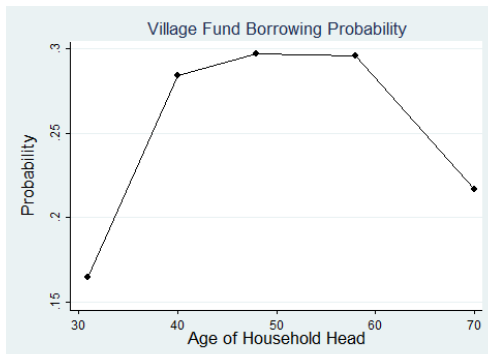


Figure 2.5. Fractions of VF Borrowers across Age Quintiles



program participations differ across key household characteristics. Specifically, Figure 2.4 and Figure 2.5 display the fractions of Village Fund borrowers across income and age groups.

From Figure 2.4, fraction of borrowers peaks at the second quintile and decreases substantially afterward. It seems to be the case here that lower-income households are much more likely to borrow from the fund in general. However, noting that smaller fraction households in the lowest income quintiles borrowed from the fund than the second quintiles, it is plausible that some households in the poorest group were denied loans due to predicted inability to repay.

From Figure 2.5, fraction of borrowers tends to be highest among second, third, and fourth quintiles. That is, middle-aged households are most likely to borrow from the fund.

Recalling from Section 2.2, the fact that Thai Village Fund program distributed the fund equally across all villages implies different intensities of credit injection across villages of different population sizes. Because the program was implemented rather rapidly and village forming processes were more or less arbitrary, it is reasonable to believe that, after controlling for household characteristics, village size is exogenous to households' decisions over non-durable consumption, durable purchases, and business investment[2]. This particular feature of the program allows the use of inverse village size as an exogenous determinant of Village Fund program participation.

In order to verify that the Thai Village Fund program yielded larger credit access to smaller villages, the fractions of household who borrowed from the village fund across quintiles of provincial average village size[3] as well as the average borrowing amount among borrowers are given in Figure 2.6

From the left panel of Figure 2.6, larger fractions of households in smaller villages borrowed from the fund compared to larger villages. This pattern supports the use of inverse village size as an instrument for identifying village fund borrowers. However, from the right panel of Figure 2.5.3, the average borrowing amount does not seem to vary much across village sizes (only about 1,000 baht or $30 difference among the quintiles). Overall, households in smaller villages tend to receive larger access to credit mainly on the extensive margin.

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2. With the caveat that economic conditions could, in principle, have been changing more or less favorably toward smaller villages at the time of the program due to other government policies.

3. Because village size was not reported in 2002 survey onward, the best available approach here is use the provincial average village size from 1999-2001 as approximates for village size in 2002

Figure 2.6. Fractions of VF Borrowers across Village Size Quintiles

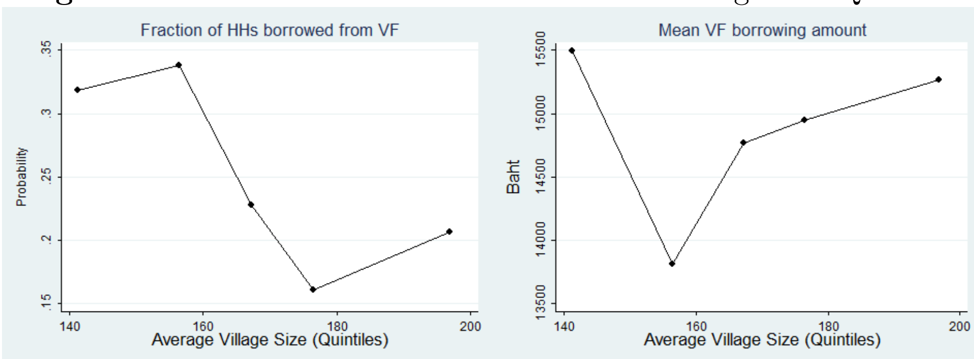
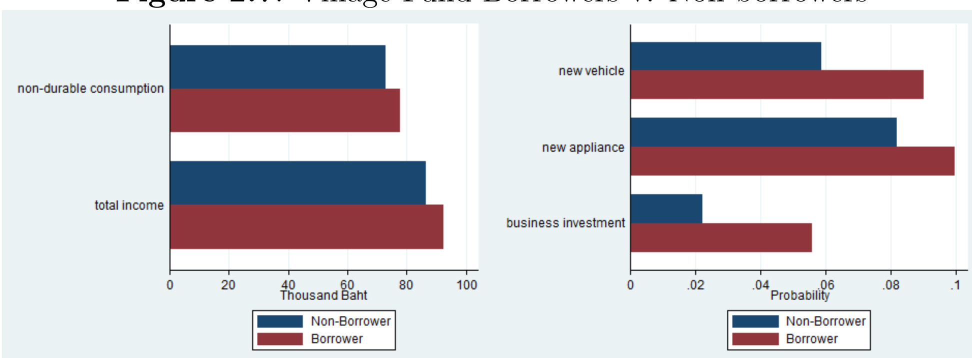


Figure 2.7. Village Fund Borrowers v. Non-borrowers

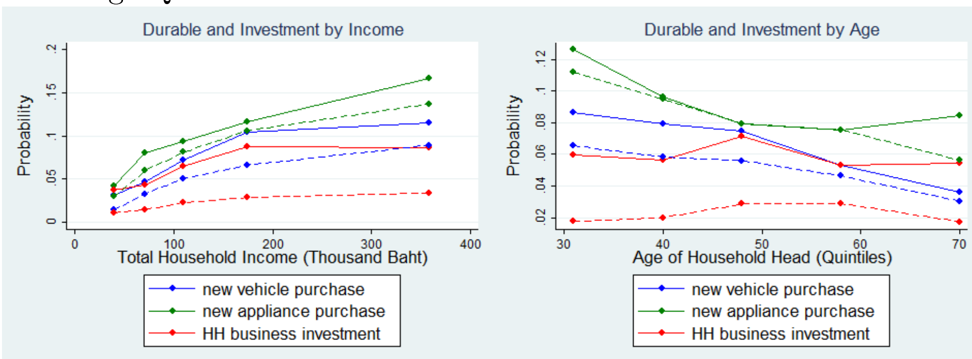


2.6 Evaluations of Village Fund Program's Impacts on Durable Consumption and Business Investment

Qualitative Findings

Now that the underlying patterns in consumption, durable purchases, and household business investment among Thai households as well as the key determinants of Village Fund program participation are explored, the next step is to evaluate the effects of the program intervention on durable purchases and household business investment probabilities. Before introducing a formal test, it is helpful to first document some notable descriptive differences between Village Fund borrowers and non-borrowers.

Figure 2.8. Village Fund Borrowers (solid) v. Non-borrowers (dashed) : Across Income and Age Quintiles



Based on 2002 survey, as shown in Figure 2.7, borrowers and non-borrowers seem to be quite close in term of annual income and annual non-durable consumption level where the borrowers earn and consume slightly more. However, Village Fund borrowers are more likely to purchase durables, both vehicles and appliances, and much more likely to make investments in household business.

Shown in Figure 2.8, Thai Village Fund borrowers are more likely to purchase durables, either vehicles or appliances, as well as make household business investment across all age and income groups.

Average Treatment Effects

With all motivating evidence discussed in preceding sections, the next step of this chapter is to propose a formal empirical study of the Village Fund's impact, with the main focus on durables and business investment. The key goal here is to understand how households who borrowed from the Thai Village Fund, all else equal, become more likely to purchase new durables (vehicles or major appliances) or to invest in household business. In other words, the goal of this section is to measure the treatment effects of the Village Fund program on durable consumption and business investment decisions.

To start, I assume the following specification:

$$Y_i = (1 - VF_i) \cdot Y_i^0 + VF_i \cdot Y_i^1$$

where the outcome variables Y_i for household i are indicators whether the household purchase new vehicles, new appliances, or invest in household business and VF_i is the indicator of household's Village Fund borrowing status. Here, $Y_i = Y_i^0$ when $VF = 0$ and $Y_i = Y_i^1$ when $VF = 1$. Hence, Y_i^0 and Y_i^1 are the household's potential outcomes based on Village Fund participation status. The key goal of this empirical exercise is the estimate the average treatment effect $\mathbb{E}[Y_i^1 - Y_i^0]$. The key estimation challenges here are that potential outcomes are never observed at the same time and assignments to treatment groups, that is Village Fund borrowing status, are not random. In order to overcome those challenges, I utilize a combination of regression-adjusted method and inverse-probability weighting method. The regression-adjusted method allows for separate specifications for Village Fund borrowers and non-borrowers, that is different functional forms for Y_i^1 and Y_i^0 given covariates. The inverse-probability weighting method first estimates the probability of household participating in the Village Fund program and use the inverse of estimated probability as a weight for correction of selection bias.

More specifically, I assume the probabilities of households spending on new vehicle, new appliance, or making new business investment, follow separate probit functions of household characteristics, based on Village Fund borrowing status. The probability of borrowing from Village Fund is assumed to follow another probit function of characteristics. That is

$$Y_0 = 1\{X'\beta_0 + \epsilon_0 > 0\}$$
$$Y_1 = 1\{X'\beta_1 + \epsilon_1 > 0\}$$

and

$$VF = 1\{X'\gamma + \eta > 0\}$$

where $\epsilon_0, \epsilon_1, \eta \sim \mathcal{N}(0,1)$ and η is assume to be uncorrelated with ϵ_0, ϵ_1.

Here, the set of covariates, X, includes household-level characteristics as age of household head (along with squared age), total annual income, education level, household size, gender, as well as village-level characteristics as whether the village is located in a urban area. The conditional independence assumption given above assumes that any other factors that affect Village Fund participation, once household characteristics are controlled for, are independent of the potential outcomes.

Estimation of the system above is implemented the STATA command *teffects* with *ipwra* option. Estimation results are shown in Table 2.2

Based on the first row of Table 2.2, the average treatment effects estimates suggest that households who borrowed from the Thai Village Fund, all else equal, are 3.2% more likely to purchase new vehicle, 1.9% more likely to purchase new appliance, and 3.3% more likely to invest in household business. All of these estimates are

Table 2.2: Average Treatment Effects Estimates from the Village Fund Program

	New Vehicle	New Appliance	New Investment
ATE	0.032*** (0.003)	0.019*** (0.004)	0.033*** (0.002)
Probit Model for VF Non-borrowers			
Age	-0.008 (0.007)	-0.005 (0.006)	0.041*** (0.000)
Age-Squared	0.000 (0.001)	-0.001 (0.001)	-0.001*** (0.000)
Income (Mil. Baht)	1.010*** (0.108)	1.030*** (0.106)	0.536*** (0.091)
High-School Grad.	0.033 (0.050)	0.003 (0.046)	0.227*** (0.070)
College Grad.	0.118* (0.057)	0.057 (0.052)	0.111 (0.093)
Probit Model for VF Borrowers			
Age	–0.009 (0.010)	0.005 (0.010)	0.000 (0.012)
Age-Squared	0.000 (0.010)	0.000 (0.000)	0.000 (0.000)
Income (Mil. Baht)	0.678*** (0.262)	0.414** (0.171)	0.720*** (0.097)
High-School Grad.	0.114** (0.061)	-0.087 (0.056)	0.047 (0.069)
College Grad.	0.234*** (0.070)	0.146** (0.066)	0.035 (0.083)
Probit Model for VF Participation			
Age	0.075*** (0.004)		
Age-Squared	-0.001*** (0.000)		
Income (Mil. Baht)	-0.034*** (0.006)		
High-School Grad.	0.138*** (0.026)		
College Grad.	0.134*** (0.031)		

statistically significant at 99% confidence level, suggesting significant impact of Thai Village Fund on both durable purchases and household business investment.

Among the covariates, we can observe negative impacts of age for both new vehicle purchase (although not statistically significant) and new appliance purchase while we observe positive impact of age on household business investment along with negative impact of age squared. These findings are in line with the life cycle patterns described in Figure 2.3 that younger households are more likely to purchase durables while household business investment tends to be most active among middle-age households. For income, we observe significantly positive impact of total annual income on all three outcome variables. This is also in line with the qualitative patterns in Figure 2.2 that households with higher annual income are more likely to both purchase durables and invest in business.

Regarding determinants of Village Fund borrowing, the model suggests that borrowing probability peaks among middle-age households and decreases in income. These findings are in line with the report in Section 2.5.

Instrumental Variable Approach

An alternative solution to estimate the impact of Village Fund program, despite non-randomness of participants, is to use an instrumental variable. As motivated in Section 2.5, I propose the use of inverse village size, $\frac{1}{h}$, as an instrument for Village Fund borrowing status. Specifically, I now assume the following two-stage probit specification :

Table 2.3: First-Stage Probit for Village Fund Particpation (Marginal Effects)

	VF Participation
Inverse Village Size	47.66** (4.74)
Age	0.013*** (0.001)
Age-Squared	-0.001*** (0.000)
Income (Mil. Baht)	-0.126*** (0.017)
High-School Grad.	0.150*** (0.022)
College Grad.	0.141*** (0.027)
Female Head	-0.032*** (0.005)

$$Y = 1\{X'\beta + VF \cdot \eta + \epsilon > 0\}$$
$$VF = 1\{X'\gamma + \frac{1}{h} \cdot \zeta + \nu > 0\}$$

where $\epsilon, \nu \sim \mathcal{N}(0,1)$ and are uncorrelated with X and $\frac{1}{h}$.

where $\frac{1}{h}$ is the inverse (provincial average) village size and all other variables are as defined in the baseline model. The othogonality conditions for this model are that both X amd $\frac{1}{h}$ are uncorrelated with ϵ, v.

The above model is estimated as a binary probit specification. The estimates are presented in Table 2.3 and Table 2.4.

From first-stage regression in Table 2.3, we can observe the significantly positive impact of inverse village size, $\frac{1}{h}$, on the probability of household borrowing from the Village Fund program. For interpretation, the coefficient of 47.66 suggests that the probability for a household living in a village of size n to borrow from Village Fund will decrease by $\frac{47.66}{n^2}$ as n increases by one. For example, the model predicts that adding one househould to a village of size 100 will decrease borrowing probability for each individual household by about 0.48%. This finding is in line with the pattern described in the left panel of Figure 5.5. Furthermore, we see positive coefficient for age and negative coefficient for squared age, suggesting that Village Fund borrowers are mostly middle-age households, which is in line with qualitative findings in Figure 5.4. We also see negative coefficient for total annual income which is, as well, in line with findings in Figure 5.3 that households with lower income are more likely to borrow from the Village Fund program. These findings are again in line with Section 2.5.

From Table 2.4, the second-stage regression now predicts that households who borrowed from the Village Fund program are 3.84% less likely to purchase new vehicle (which is surprising although not statistically significant at 95% confidence level), 11% significantly more likely to purchase new appliance, and 5% more likely to invest in household business (although not significant at 95% level). The findings, using instrumental variable approach, for impacts of Village Fund borrowings on new appliance purchase and household business investment in the instrumented model are in line with the previous findings, while it is not the same case for new vehicle purchase.

2.7 Theoretical Exercise

Recall that, from both before and after the Thai Village Fund intervention, younger households are more likely to purchase durables while business investments become more frequent among middle-age households. After the intervention, both probabilities of durable purchases and business investments increase across all age groups.

Table 2.4: Second Stage Probit (Marginal Effects)

	New Vehicle	New Appliance	New Investment
VF	-0.038 (0.003)	0.110** (0.004)	0.051 (0.002)
Age	0.001 (0.000)	-0.003*** (0.001)	0.001* (0.000)
Age-Squared	0.000 (0.001)	0.000*** (0.000)	-0.001* (0.000)
Income (Mil. Baht)	0.056*** (0.013)	0.086*** (0.017)	0.023*** (0.007)
High-School Grad.	0.007 (0.004)	-0.001 (0.006)	0.017 (0.020)
College Grad.	0.006 (0.005)	0.027*** (0.006)	-0.009 (0.003)
Female Head	-0.005* (0.003)	0.008** (0.003)	-0.000*** (0.002)

These key qualitative findings are the main targets to be captured by a version of heterogeneous agent life-cycle model in this section.

2.7.1 General Setup

Timing and Population

Suppose the economy consists of heterogenous households, indexed by i, and that each household in the economy lives for T periods. Let us assume here, for simplicity, that each household who dies leaves no bequest and gets replaced by a newborn household who start off with no asset holdings.

Preferences

Households are maximizing expected utility from time-separable preferences over non-durable consumption, $C_{i,t}$ and stock of durables, $D_{i,t}$, with discount factor β. The expected utility for a household of age τ can be written as

$$\mathbb{E}_{\tau}[\sum_{t=\tau}^{T}\beta^{t}u(C_{i,t},D_{i,t})]$$

I will assume here that the period utility is taking the Cobb-Douglas form

$$u(C_{i,t},D_{i,t})=\frac{(C_{i,t}^{\alpha}D_{i,t}^{1-\alpha})^{1-\gamma}}{1-\gamma}$$

Asset Portfolio

Each household has access to three different categories of assets.

The first category is liquid assets, $A_{i,t}$. I will assume here that $A_{i,t}$ takes on continuous values and can be saved or borrowed at real interest rate $1+r$. This liquid asset is subjected to a borrowing limit $A_{i,t}\geq-\underline{\text{a}}$.

The second category is durable assets, $D_{i,t}$, which is an argument of household's utility function $u(\cdot)$. I will assume here that $D_{i,t}$ has unity cost per unit and takes on discrete values in the set $\mathcal{D} = \{d^1, ..., d^N\}$ with $0 = d^1 < d^2 < ... < d^N$. In each period, there is no resale market for durables and each household can only adjust their durable stocks upward. For example, a household with current durable level d^j could choose to spend $d^k - d^j$ in order to adjust its durable stock to d^k for some $k > j$. I will also assumes here that durable stock $D_{i,t}$ follows stochastic depreciation where, with probability δ, if a household chooses to hold durable stock d^j with $j > 1$ at the end of period t, it will start period $t+1$ with durable stock d^{j-1} and, with probability $1-\delta$, it will start period $t+1$ with durable stock d^j. Note that if $j = 1$, then durable stock does not depreciate any further.

The third category is household business assets, $H_{i,t}$, which I assumes to take on discrete values in the set $\mathcal{H} = \{h^1, ..., h^M\}$ with $0 = h^1 < h^2 < ... < h^M$ and has unity cost per unit. Investment in household business assets yields gross return at rate R in the sense that household with business assets of size $H_{i,t}$ in period t receives business income flow of $RH_{i,t}$. Investment in household business assets requires a random opportunity. Specifically, at the beginning of period t, each household, currently holding $H_{i,t}$, receives take-it-or-leave-it offer of new potential business asset level $\tilde{H}_{i,t} > H_{i,t}$ that is drawn from $\mathcal{H}$ with conditional probability $\mathcal{G}(\cdot \mid H_{i,t})$. If the household chooses to invesst in the new potential business asset level, it has to pay the difference $\tilde{H}_{i,t} - H_{i,t}$, and start period $t+1$ with new business level $H_{i,t+1} = \tilde{H}_{i,t}$. Instead, if the household chooses not to invest, it stays at the initial business level $H_{i,t+1} = H_{i,t}$.

Labor Income

On top of business income $RH_{i,t}$ described above, each household also receives labor income $Y_{i,t} = z(\tau) \cdot e_t$ where $z(\tau)$ is the deterministic life-cycle component for household with age τ and $e_{i,t}$ is the stochastic component. Let us assumes here that $e_{i,t}$ follows an AR(1) markov process

$$e_{i,t} = \rho e_{i,t-1} + \xi_{i,t}$$

for all t and $\xi_{i,t} \sim \mathcal{N}(0, \sigma^2)$.

Default

It is possible, under some parameter values of the model, that a household with low enough labor income shock may result in $-\underline{\text{a}} > Y_{i,t} + RH_{i,t} + A_{i,t}(1+r)$. That is, even with zero non-durable consumption and no adjustment in either durable assets or business assets, the household's budget constraint cannot bind. In this case, the household needs to default. I will assume here that defaulted households lose all their current durable assets and business assets, maintain minimum consumption level $\underline{\text{c}}$ in the current period, and reset their liquid asset holdings to 0 at the beginning of the next period.

2.7.2 *Recursive Formulation*

Let us denote by $V(A, D, H; \tilde{H}, e, \tau)$ the value function for each household of age τ with current portfolio (A, D, H) who receives potential new business level $\tilde{H} > H$ along with current stochastic income shock e. Also, let $\tilde{D}$ be the end-of-period durable stocks and let I be the indicator of household's investment decision. We can write the household's maximization problem in recursive form as

$$V(A,D,H;\tilde{H},e,\tau) = \underset{C,A',\tilde{D},I}{max} \{[\frac{(C^{\alpha}D^{1-\alpha})^{1-\gamma}}{1-\gamma}] + \beta\hat{V}(A',\tilde{D},H',e,\tau+1)]\}$$

$$\begin{aligned} subject\ to\quad & C + A' + I(\tilde{H}-H) + (\tilde{D}-D) \leq z(\tau)\cdot e + RH + A(1+r) & [1] \\ & A' \geq -\underline{a} & [2] \\ & \tilde{D} \geq D & [3] \\ & H' = I\cdot\tilde{H} + (1-I)\cdot H & [4] \end{aligned}$$

where [1] is the household's budget constraint, [2] is the household's borrowing limit, [3] is the no-resale market constraint for durable stocks, and [4] refers to evolution of business asset according to household's investment decision. That is, if $I = 1$, then $H' = \tilde{H}$ and, if $I = 0$, then $H' = H$.

Here, the function $\hat{V}(A',\tilde{D},H';e,\tau+1)$ denotes the expected continuation value of a household of age τ who chooses to carry over liquid asset A', end-of-period durable asset $\tilde{D}$, new business asset level H', and current draw of labor income shock e.

Based on stochastic durable depreciation, suppose $\tilde{D} = d^l$ then we have

$$\hat{V}(A',\tilde{D},H';e,\tau+1) = \begin{cases} (1-\delta)\cdot\mathbb{E}_{\tau}[V(A',d^l,H';\tilde{H}',e',\tau+1)] & if \quad l>1 \\ +\delta\cdot\mathbb{E}_{\tau}[V(A',d^{l-1},H';\tilde{H}',e',\tau+1)] & \\ \mathbb{E}_{\tau}[V(A',d^l,H';\tilde{H}',e',\tau+1)] & if \quad l=1 \end{cases}$$

Both value function and optimal policy functions presented above can be solved numerically using standard backward induction method.

Table 2.5: Parameter Choices

Parameter	Definition	Value
α	Income Share for Non-durable Consumption	0.7
γ	Coefficient of Relative Risk Aversion	1.2
δ	Durable Depreciation Probability	0.01
r	Real Interest Rate	0.05
$\underline{\text{a}}$	Borrowing Limit	0
β	Discount Factor	0.93
T	Age Limit[4]	60
ρ	$AR(1)$ Coefficient of Deterministic Component	0.6
σ	Variance of Deterministic Component	0.4
$\underline{\text{c}}$	Minimum Consumption Level for Default	0.001

2.7.3 Numerical Example

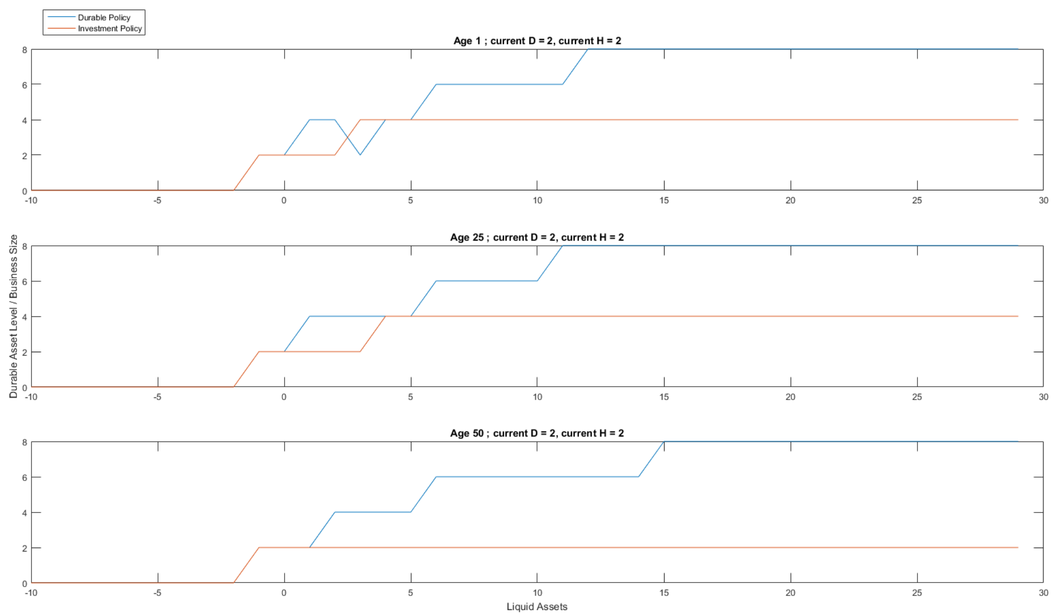
In order to illustrate the important qualitative features of the model, I will now focus on a fairly simple case with 5 possible discrete levels for durable stocks, $\mathcal{D} = \{0, 2, 4, 6, 8\}$ and 5 possible discrete levels for household business asset holdings, $\mathcal{H} = \{0, 2, 4, 6, 8\}$. Regarding portfolio adjustment, in each period, households can freely adjust their durable stocks to any higher level but can only adjust their business asset holdings upward by one step above[5] with probability $\pi = 0.4$. All other model parametrizations are shown in Table 2.5.

Figure 2.9 presents three examples of computed policy functions for households' decisions to adjust their durable stock upward and to make investment in household business. All households in these examples hold current durable stock $D = 2$ and current household business asset level $H = 2$ and receives a business investment opportunity $\tilde{H} = 4$. The top panel corresponds to a young household who have just

4. I assumes here that economic age $t = 0$ in the model corresponds to a young household of age 20.

5. For example, from current $H = 2$ to new level $H' = 4$

Figure 2.9. Value Functions

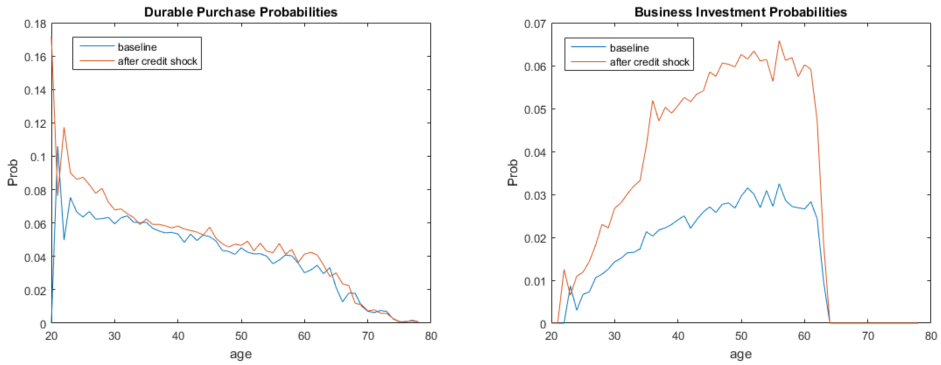


entered the economy. The middle panel corresponds to a middle-age household who is about halfway through economic life. The bottom panel corresponds to an old-age household with few periods left in the economy. By first looking at household business investment decisions across the three panels, we can see that the liquid asset thresholds for investment are increasing in age. Similarly for durables, we do see that the thresholds for upward adjustments are overall higher for older households. The key reason here is that durables provide longer service and business investment yields income flow for longer periods for younger households, resulting in higher continuation values and lower cutoffs.

2.7.4 Simulation

Using the computed value functions, I now look to investigate the effects of relaxing a borrowing constraint via simulation. In particular, I assume the economy consists

Figure 2.10. Patterns Across Life Cycle: Simulation



of $S = 10,000$ households at each age. As each household enters the economy, it starts with zero initial liquid asset, initial durable stock $D = 2$, and initial business asset $H = 2$. In the baseline model, I keep all the parameter values as described in Section 2.7.3 and compute the probabilities that households in each age group would either make upward adjustment to their durable stocks or make investment to household business. Next, I introduce a positive credit shock which shifts the borrowing limit from $\underline{a} = 0$ to $\underline{a} = 1$. Looking one period ahead, I then, once again, compute the probabilities of durable purchases and household business investments across age groups in the model after the change in credit limit. These findings are summarized in Figure 2.10.

In the baseline model, we can observe that the probabilities for durable purchases are decreasing in age from the left panel of Figure 2.10 and that probabilities for household business investments tend to be highest among middle-age households in the right panel of Figure 2.10. In the model after credit shock, we also see that similar patterns for both durable purchases and business investment hold across the life cycle. In comparison, we can notice that by relaxing the borrowing limit, households are more likely to purchase durables and invest in household business across all age groups. All of these findings from model simulations are, more or less, in line with qualitative features from the Thai SES data on life cycle patterns of vehicle purchases, appliance purchases, and investment.

In the model, the key mechanic driving life-cycle patterns we found above is the limited investment opportunity. Recalling from Figure 2.10, the liquid asset thresholds for durable purchases and investment are always lower for younger households, suggesting that they should be most active group in both spending categories, given the same asset portfolio and the same investment opportunity. The main reason many households choose to delay their business investment until middle-age is simply because they could not find the right opportunity to do so when they were younger. In particular, a young household with ample liquid asset holdings might not receive an appropriate draw of new business size. If the continuation value for adjusting durable stock upward is higher than waiting for new investment opportunity in the next period, the young household would then choose to first purchase durables and retain smaller liquid asset holdings. It would then require some time for the household to re-accumulate liquit asset up to the point where it is, once again, optimal to invest in household business. The positive impacts of credit constraint relaxation in the model on the extensive margins of durable purchases and household business investments come from households with liquid asset holdings close to durable purchase or investment thresholds in the baseline model, who could not invest or purchase durables before. Relaxed credit constriant implies lower thresholds across all households and essentially allows these households at the margin to take up investment opportunities not available before.

2.8 Conclusion and Directions for Future Work

In this chapter, I first investigated the patterns of durable purchases and household business investment across income and age profiles among Thai households from 1999-2001, right before the credit injection from Thai Village Fund program. The main findings are that both durable purchases and business investments are both more active among households with higher income, durable purchases are more likely among younger households, and business investments are most active among middle-age households. These patterns remain qualitatively the same after the Village Fund intervention in 2002 with higher probabilities to purchase durables and to invest in household business overall. On the empirical side, the results, although not very robust with instrumental variable method, tend to confirm these findings. On the theoretical side, the proposed heterogenous agent life-cycle model performs reasonably well in matching the qualitative life cycle patterns in the data.

For future work, in the empirical direction, I would like to repeat this study on different datasets, both from Thailand and potentially from other developing countries, to confirm robustness of overall findings. In particular, a more precise measure of village size, which is required for first-stage regression, would more extremely helpful in obtaining more precise estimates in the second-stage regressions of the empirical model. In the theoretical direction, a potential study is to calibrate parameters in the current life-cycle model to match realistic income and asset distributions from the data. A calibrated model could then be used to evaluate and compare the welfare gains among alternative policies such as credit injections, lump-sum transfers or direct subsidies of business investments. Unfortunately, the Thai SES data, which I used in this chapter, does not provide sufficient moment conditions for this calibration exercise.

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