

Does Climate Change Affect the Formation of Human Capital in Thailand?

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ABSTRACT

Human capital is one of the main determinants of economic development. However, much of the literature on household human capital investment examines the relationship between exogenous variables such as fundamental household characteristics, and the government policies and the formation of human capital. Little attention has focused on the impact of climate change on human capital investment. This paper combines the Thai Household Socio-Economic Panel Survey during 2005-2007 with the regional rainfall data reported by 83 weather stations from 1988 to 2007 to gauge the impact of climate change on human capital investment in Thailand. Transitory income shock and income uncertainty due to rainfall variation are generated to examine its impact on two categories of human capital formation: educational spending and health spending. Controlling for household-head characteristics, child and other members characteristics, and regional characteristics; the empirical results reveal that climate change affects human capital formation in some Thai agricultural households and in some regions. Transitory income shock is negatively associated with educational expenditure when households throughout the country and northeastern region are used as a sample, while health expenditure negatively responds to transitory income shocks for sample households in the whole country and a group of central, eastern, and western regions.

Keywords: Climate change; transitory income shock; income uncertainty; human capital investment

JEL Classification: Q54, Q56, D15, I00

Mathematics Subject Classification: 91B02, 62P20, 97K80

1. INTRODUCTION

As with other resources, the quality of human resources is one of the main determinants of economic development. Human capital formation is the transformative process of human resources with effective input such as education, training, health and nutrition into human capital, which means the stock of knowledge, skills, and talent that individuals possess. However, achieving this process does not only depend on the government, but also on the households in those countries.

According to Becker's economic theory of households (Becker, 1965), demand for household human capital investment is obtained by maximizing a household's utility to the full extent of its income budget. Consequently, derived demand equations indicate that, apart from the head of the household's preferences, demand for household human capital investment also depends on the benefits and costs of investments (Handa et al., 2004). However, Becker's household economic theory is an extended version of the traditional consumer theory.¹ As such, the impact of risks and uncertainty can be annexed to Becker's household economic theory as an additional determinant of a household's human capital investment.

Under the strict version of the Permanent Income Hypothesis (PIH), risk and uncertainty should not affect household consumption. Nevertheless, several studies reveal that risk and uncertainty still highly influence a household's consumption and production, especially in developing countries where the credit and insurance market is incomplete due to transaction costs, asymmetric information problems and difficulties in enforcing contracts (Morduch, 1995). Under an incomplete credit and insurance market, therefore, households need to find mechanisms to smooth their consumptions when facing shocks. Even though there are many alternative mechanisms such as using savings, selling assets and shifting labor from farm to off-farm, increasing child labor, removing children from school, cutting educational expenditure, and even cutting health expenditures may be alternative consumption smoothing mechanisms. These latter groups of mechanisms nevertheless affect a household's human capital investment in the long term.

Thailand is a developing country located in the tropical region of Southeast Asia. Most regions in Thailand typically experience a long period of warm weather with moderate to low rainfall. Only the eastern and southern region has temperatures that are generally mild, with heavy rainfall throughout the year due to the maritime characteristic of these regions. Additionally, a large number of households still practice farming despite the Thai economy developing over the past three decades. For these reasons, water is an important resource that is highly influential on the well-being of Thai households, especially agricultural households. However, it is generally acknowledged in the present that climate change is responsible for extreme weather events. It can bring about heavy rainfall or severe drought (The Royal Society and National Academy of Sciences, 2014). Consequently, investigating the impact of climate change on human capital formation is a challenge.

To achieve this investigation, this paper combines the Thai Household Socio-Economic Panel Survey during 2005-2007 with the regional rainfall data reported by 83 weather stations from 1988 to 2007. Using these two data sets together with an adapted methodology of Paxson (1992) and Kazianga and Udry (2006), transitory income shock and income uncertainty due to rainfall variation are generated to examine its impact on two categories of human capital formation: educational spending and health spending.² The empirical results reveal that climate change affects human capital formation in some Thai agricultural households and in some regions. Transitory income shock is negatively associated with educational expenditure when households throughout the country and northeastern region are used as a sample, while health expenditures negatively responds to transitory income shocks for sample households in the whole country and a group of central, eastern, and western regions.

2. THEORETICAL BACKGROUND AND LITERATURE REVIEW

Human capital is the stock of knowledge, skills, and capacities that individuals possess to produce economic value.³ To generate human capital, one needs to transform human resources with effective inputs; such as, training, education, nutrition, and healthcare. This transformation process is known as the human capital formation, and both the government and households can account for this formation. Climate change can directly and indirectly effect on human capital. Several studies (e.g. Kazianga and Udry, 2006; Kazianga, 2012; Franchini and Mannucci, 2025; Irshad and Danko, 2018; Dincsoy, 2016) indicate that climate change cause troubles for numerous households, especially agricultural households in developing countries.

There are at least three economic theories that explain why climate change should affect a household's human capital formation. The first and most direct model is Becker's economic theory of households (Becker, 1965). Unlike the traditional consumer theory, Becker considers the households as both consumers and producers. To obtain the demand functions for market goods and non-market goods; such as, children's education and health, households maximize their utilities subject to the full income budget constraints that include time. A solution from this optimization problem presents that the demand for children's education and health are functions of the price of market goods, wages, time and non-labor income. This indicates that household income has a direct influence on children's education and health. Consequently, if climate change leads to income fluctuation, this should also affect the formation of household human capital.

Secondly, climate change does not only directly affect the human capital formation as stated in Becker's model, but may also have an indirect effect through consumption smoothing mechanisms as shown in the prediction of the standard version of Freidman's Permanent Income Hypothesis (PIH) (Freidman, 1957). According to this hypothesis, if households maximize their lifetime quadratic utility function subject to the intertemporal budget constraint, the solution of the dynamic optimization would show that only the change in permanent income would affect consumption. Transitory income shocks should not affect consumption. These are always true if the credit market is unaffected and households can also avail of some consumption smoothing mechanisms; for instance, borrowing, savings, selling assets, using child labor, and excluding some types of expenditure; such as, education and health. Therefore, if climate change results in transitory income shocks, some households may select discarding educational and health expenditures to smooth their consumption. This channel could be another way which climate change could affect the formation of human capital.

Finally, eliminating educational and health expenditures is not only used to smooth household consumption when faced with income shocks, but may also be used as precautionary savings to shield future income uncertainty. Several studies (Carroll, 1994; Skinner, 1988; Zeldes, 1989) have indicated that some households may prepare for the uncertainty of their future income. These households thus require savings to insure against a time of need in the future. Removing educational and health expenditures may be an optional choice to increase savings, especially for agricultural households who are mostly poor and often face uncertainty due to climate change. Therefore, if some

households save for a time of need by eliminating educational and health expenditures, this would be difficult to reject its effect on their human capital formation.

In conclusion, even though there exists economic theories that explain the possible relationship between climate change and the formation of human capital, there is little empirical research that has directly investigated this topic. Most related literature has specifically examined the association between household income with human capital formation either in terms of the education-based approach; such as, school enrolment, years of schooling and educational attainment, or the cost-based approach; such as, educational spending. With regards to these related studies, most research has found household income to be the main determinant of human capital formation. Furthermore, several studies (Brown, 2006; Duryea, 1998; Jacoby and Mansuri, 2014; Jacoby and Skoufias, 1997; Kazianga, 2012; Sawada, 1997; Shafiq, 2007) have also found that transitory income shocks have a significant effect on the formation of human capital. Apart from investigating the relationship between income and human capital formation in the two above terms, some studies (Beegle, et al., 2006; Dehejia and Gatti, 2002; Fitzimmons, 2003; Guarcello et al., 2003; Ranjan, 2001; Ridao-Cano, 2001) have also examined the impact of income on child labour, which should affect the formation of human capital.

As indicated earlier, not only excluding educational expenditure, but also eliminating health expenditure can affect human capital formation. Several studies (Kristensen and Andersen, 2016; Olasehinde and Olaniyan, 2017; Parker and Wong, 1997; Rous and Hotchkiss, 2003; Rout, 2008) have discovered household income to be the main determinant of health expenditure similar to educational expenditure. Therefore, if climate change affects household income, it should also affect health expenditure, and then deteriorate the formation of household human capital.

3. PRELIMINARY DATA AND STATISTICAL SUMMARY

As indicated earlier, a large number of Thai households are still agriculturists even if Thailand is now a newly industrialized country. Rainfall is thus still one of the main factors, which has an influence on Thai agricultural households' well-being. Natural disasters; such as, flood and drought highly and inevitably effect household income. Figure 1 indicates that flood and drought damage numerous agricultural lands throughout Thailand every year. This implies that those farmers whose land is affected by such natural disaster should face hardship if the credit market is also experiencing difficulty and there is no government assistance or any consumption smoothing mechanisms. Figure 2 represents the possibility in which flood and drought should affect a household's well-being. This is because even if the average household income is higher than the average household expenditure, there is very little difference. Therefore, Thai household savings should not be too high, especially for poor households. Furthermore, Thai household debt is still high every year. Consequently, if the credit market is incomplete and there are not any alternatives for assistance, some households, especially poor households, may decide to eliminate some expenditure which should not affect household consumption; such as, entertainment, clothing, education as well as health when they face heavy

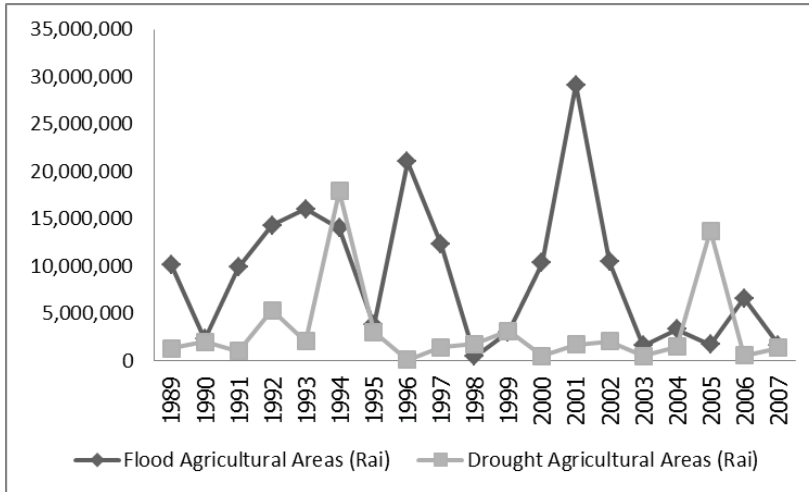


Figure 1. Flood and drought agricultural areas

Source: Department of Disaster Prevention and Mitigation

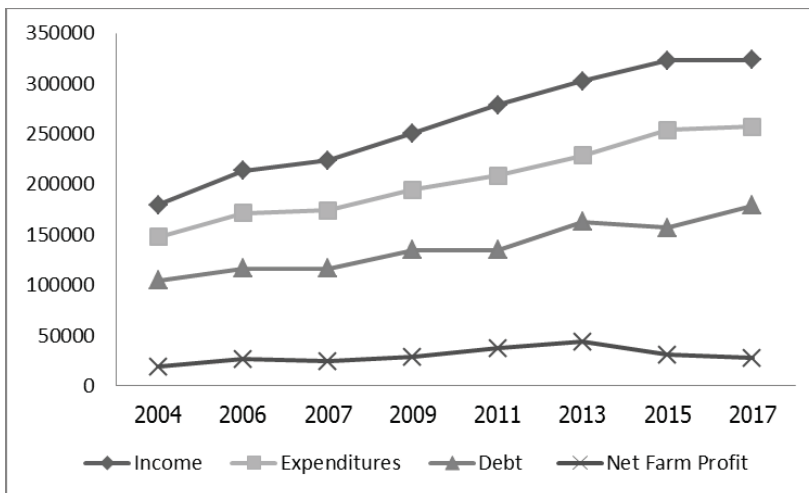


Figure 2. Income, expenditures, debt and net farm profit of Thai households

Source: The National Statistical Office Thailand

flooding and drought. Thus, it would be difficult to reject the impact on the formation of household human capital when deleting educational and health expenditures is an option. However, the above situations may affect Thai households differently. This is because there are climatic and economic differences in each region of Thailand. The climate of Thailand is under the influence of seasonal monsoon winds; i.e., the Southwest monsoon and Northeast monsoon. The Southwest monsoon,

which starts in May, brings a stream of warm moist air from the Indian Ocean towards Thailand causing abundant rain over the country. In contrast, the Northeast monsoon, which starts in October, brings cold, dry air from the anticyclone in Mainland China over major parts of Thailand, especially the Northern and Northeastern regions that have areas of higher altitudes. In the South, the monsoon causes mild weather and abundant rain along the East coast (Thai Meteorological Department, 2016). Figure 3 presents the differences in the annual average rainfall for the five regions in Thailand. Moreover, it indicates the main reason why the effect of climate change on a household's human capital formation for each region should be separately examined. Figure 3 shows that the Southern region has greater rainfall than other regions while the amounts of rainfall slightly differ in other regions. However, it should be noted that even though there are slight differences of rainfall between the Northeast and other regions except the South, the Northeast often faces drought compared to other regions. This is because there is very little forest and rivers in this region. Moreover, Northeast soil is mostly sandy, which has low water storage and poor properties for supporting plant growth. Therefore, this region, which is mostly cultivated land, often anticipates that it will be affected by drought and flood.

This paper uses two data sets to empirically examine the paper's objectives. The first data set is the Thai Household Socio-Economic Panel Survey provided by the National Statistical Office (NSO),⁴ and the second is regional rainfall data collected by the Meteorological Department in the Ministry of Information and Technology. The Thai Household Socio-Economic Panel Survey was the first panel data set conducted by a Thai governmental organization. It reported socio-economic data on repeated households during 2005-2007. In each survey round, sample households from 76 provinces all over the country, both inside and outside municipal areas were selected using two-stage stratified sampling. There were 6,000 households (both non-agricultural and agricultural households) for the first survey round, but the contribution response rate was about 96.2 and 93.1 percent in 2005 and 2007, respectively. The Meteorological department in the Ministry of Information and Technology provide regional rainfall data from 1988 to 2007 from 115 weather stations in Thailand. Only 83 weather stations nevertheless are utilized due to the matching-up process; that is, households were matched to only the nearest weather stations. Nevertheless, this paper only uses agricultural households as the sample group since the main objective of this paper is to investigate the impact of climate change through household income on household's human capital formation sample household. Therefore, under this sample selection criteria, total sample of agricultural households from three years panel data is about 5,650 after a cleaning data process.

The main variables used this paper are summarized for the case of entire sample of households in Table 1. Total income is the sum of farm profit and non-farm income. Educational expenditures are the sum of educational goods and service expenditures; for example, money spent on school fees, textbooks, uniforms, school supplies and private tutoring. Health expenditures are the sum of medical treatment expense, medicine expense, and medical supplies expense. All of these nominal variables are adjusted by using the Provincial Consumer Price Index (PCPI) provided by the Internal Commercial Department in the Ministry of Commerce to obtain their real values. As

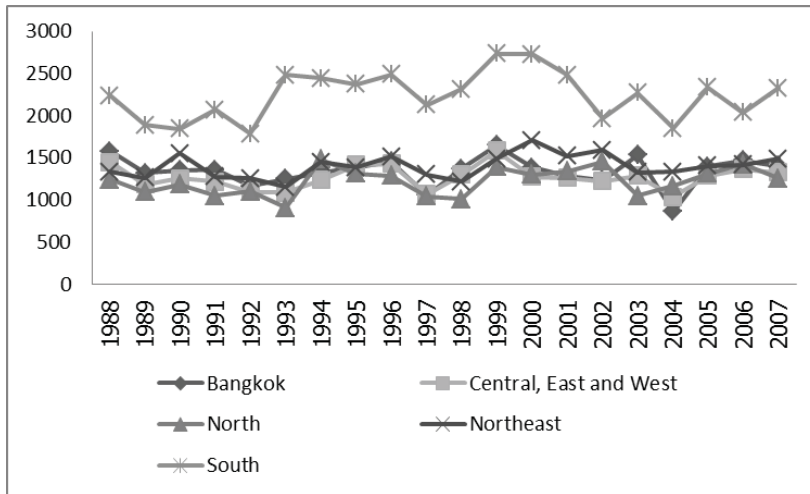


Figure 3. Annual average rainfall

Source: the Meteorological Department

mentioned earlier, not only there are differences in rainfall which can affect Thai farmers, but differences in soil quality are another reason for investigation by separate region. Khanchanakul et al., (2000) indicate that the southern and northeastern regions have low-quality soil, while the other regions have high-quality soil. If the main objective of this paper is investigating the impact of climate change through household income on human capital formation of agricultural households, the quality of soil should also be controlled.

4. ESTIMATION STRATEGIES

By adapting Becker's household economic model and consumption smoothing mechanism model based on the PIH, the two baseline empirical models used in this paper can be expressed in the following form:

$$Ed_{irt} = \beta_0 + \beta_1 Y_{irt} + \beta_2 Hh_{irt} + \beta_3 Mem_{irt} + \beta_4 Pro_i + \varepsilon_{irt} \quad (1)$$

$$H_{irt} = \alpha_0 + \alpha_1 Y_{irt} + \alpha_2 Hh_{irt} + \alpha_3 Mem_{irt} + \alpha_4 Pro_i + u_{irt} \quad (2)$$

where Ed_{irt} denotes the educational expenditure of households i in region r at time t respectively; H_{irt} is health expenditure, Y_{irt} is household income, Hh_{irt} is a set of household head characteristic variables, Mem_{irt} is a set of other household member characteristic variables, Pro_i is provincial fixed effect, and ε_{irt} as well as u_{irt} are error terms.

Nevertheless, the main objective of this paper dictated the initial need to generate income shock and income uncertainty due to rainfall variation. To construct household income shock, this

Table 1. Mean value and standard deviation of main variables for the entire sample.

<i>Variable</i>	<i>Variable description</i>	<i>Mean</i>	<i>Std. Dev.</i>
Income	Farm and nonfarm income	133383.800	168439.600
Educational expenditure	Expenditure on education	551.0667	1282.997
Health expenditure	Expenditures on health	139.5692	497.73
Household's land	Land of household which is not rented land, public land or conserved forest	16.396	48.790
Rented and other land	Rented land and public land including conserved forest	4.550	42.231
Soil's types	Dummy variable for types of soil(equal to 1 if households locate in Central ,Eastern ,Western or Northern regions where have a good quality of soil)	0.3689	0.483
HH's illness	Illness of household's head	0.019	0.136
HH's age	Age of household's head	52.276	13.060
Dev_rain	The deviation of rainfall	45.570	226.972
Dev_rain_squared	Squared of the deviation of rainfall	53583.950	108914.200
Land ⊗ dev	The interaction term between household land and the deviation of rainfall	629.158	10795.650
Rented land ⊗ dev	The interaction term between rented and other land and the deviation of rainfall	238.847	3925.317
HH's age ⊗ dev	The interaction term between age of household's head and the deviation of rainfall	2445.239	12268.300

paper adopted the approach of Paxson (1992), and Kazianga and Udry (2006) by setting the following income regression:

$$Y_{irt} = \gamma_0 + \gamma_1 X_{irt} + \gamma_2 R_{rt} + \gamma_3 R_{rt} \otimes Q_{irt} + \eta_{vt} + \lambda_i + v_{irt} \quad (3)$$

where X_{irt} represents a vector of household characteristic variables, R_{rt} is the deviation of rainfall from the long-run regional mean, Q_{irt} is the land and household head characteristic that determines income and is related to rainfall, η_{vt} is a village-year fixed effect,⁵ λ_i is a household fixed effect, and v_{irt} denotes a random component.

Using estimates from Equation (3), transitory income shock is given as

$$Y_{irt}^T = \hat{\gamma}_2 R_{rt} + \hat{\gamma}_3 R_{rt} \otimes Q_{irt} \quad (4)$$

In addition to examining the effect of transitory income shocks on household human capital formation, forward-looking households should also accumulate wealth (or lower expenses) as a way to shield future consumption against the effects of future income uncertainty since households are

assumed to be a rational behavior unit (Kimball, 1991; Carroll et al., 1992). Therefore, this paper also examines the impact of income uncertainty on educational and health expenditure. The paper applies the approach of Kazianga and Udry (2006) to generate income uncertainty for a case of short panel data. Using estimates from Equation (3) again, the formula for income uncertainty used in this paper is defined as:

$$\hat{\text{Var}} \left(Y_{irt+1}^T \right) = \frac{1}{16} \sum_{t=1988}^{2004} \left[\hat{\eta}_2 R_{rt} \otimes \bar{Q}_{irt} + \hat{\eta}_3 R_{rt} - \left(\hat{\eta}_2 \bar{R}_r \otimes \bar{Q}_{irt} + \hat{\eta}_3 \bar{R}_r \right) \right]^2 \quad (5)$$

where $\hat{\text{Var}} \left(Y_{irt+1}^T \right)$ is the estimated income variance which obtained from combining our estimates $\hat{\gamma}_2$ ($\hat{\eta}_2$) and $\hat{\gamma}_3$ ($\hat{\eta}_3$) from equation (3) with historical rainfall data (R_{rt}) and the land characteristics ($\bar{Q}_{irt}$) data that is the number of landholdings from our sample. The land characteristics can be expressed as: $\bar{Q}_{ir} = \frac{1}{3} \sum_{t=2005}^{2007} Q_{irt}$. Substituting transitory income shock (Equation (4)) and income uncertainty (Equation (5)) into the two baseline models provides the final empirical model used in this paper as:

$$Ed_{irt} = \beta_0 + \beta_1 \hat{Y}_{irt}^T + \beta_2 \hat{\text{Var}} \left(Y_{irt+1}^T \right) + \beta_3 Hh_{irt} + \beta_4 Mem_{irt} + \beta_5 Pro_i + \varepsilon_{irt} \quad (6)$$

$$H_{irt} = \alpha_0 + \alpha_1 \hat{Y}_{irt}^T + \alpha_2 \hat{\text{Var}} \left(Y_{irt+1}^T \right) + \alpha_3 Hh_{irt} + \beta_4 Mem_{irt} + \beta_5 Pro_i + u_{irt} \quad (7)$$

Unlike with income regression, there is a large fraction of households that do not report the amount of educational and health expenditures. Thus, this paper uses the Tobit maximum likelihood estimator for the estimation process.

5. EMPIRICAL RESULTS

Three regression models are reported in this section, including income regression, educational expenditure regression and the regression for health expenditure. Table 2 shows the results of fixed effect income regression for each region. As anticipated, owned land highly influenced household income in most regions following earning function. Its coefficient was positive with a large magnitude for the case of the northeastern region, a group of central, eastern and western region, and the entire country. The direct effect of rainfall on household income is unclear, especially in the case of rainfall deviation. Only the square of rainfall deviation has a significant impact on household income for some regions. However, the paper found that some of the interaction between farm characteristics and rainfall deviation had a significant effect on household income in most regions. According to the results for these rainfall effects, rainfall affects income directly as well as affecting income indirectly through farm and land characteristics.

Table 2. Estimated fixed-effect models of household income.

Dependent variable: household income

<i>Regions:</i>	<i>All regions</i>	<i>Northern</i>	<i>Northeastern</i>	<i>Southern</i>	<i>Central Eastern and Western</i>
<i>Variable</i>					
Household land	204.656 (74.979)***	418.871 (543.859)	101.010 (33.367)***	585.647 (676.505)	2390.422 (835.398)**
Rented and other land	-20.984 (65.944)	-787.761 (677.432)	40.671 (75.935)	-742.239 (2505.049)	14.369 (1048.843)
Dev_rain	485.024 (159.392)***	-100.016 (130.162)	132.9676 (86.838)	-1200.979 (1064.290)	-127.245 (133.151)
Dev_rain_squared	-0.345 (0.106)***	0.073 (0.160)	0.722 (0.214)***	-1.720 (1.805)	-0.438 (0.171)***
Land ⊗ dev	-1.007 (0.334)***	-1.104 (1.193)	-0.566 (0.143)***	-1.166 (2.176)	-2.738 (1.904)
Rented land ⊗ dev	-0.191 (0.983)	-1.742 (0.954)**	-1.052 (1.194)	0.056 (5.046)	0.108 (3.406)
Head's age ⊗ dev	-0.576 (0.674)	0.202 (1.486)	-1.038 (0.935)	-2.267 (1.331)*	2.427 (2.521)
Soil types ⊗ dev	-458.516 (177.354)***	-	-	-	-
Cons	12996.530 (68567.570)	85769.9 (134714.000)	-40978.240 (74975.200)	438502.100 (294323.300)	-219212.200 (211614.500)
Number of observations	5648	1325	2819	745	759
R-squared	0.053	0.053	0.126	0.001	0.310
F-tests:	2.9e+07***	2.0e+04***	1.4e+04***	3338.881***	2.3e+04***
Test 1:	5.460***	1.250	8.410***	1.230	5.000***
Test 2:	10602.580***	2.1e+07***	486.430***	61410.870***	230.560***

Notes: 1.) Robust standard errors in brackets under coefficients. 2.) * significant at 10%; ** significant at 5%; ***significant at 1%. 3.) Test 1: rainfall variables jointly insignificant. Test 2: tambon (sub-district)-years dummies jointly insignificant. 4.) Regressions also include control variables (household head characteristics: household head's illness, age of household head, age of household head square, other member characteristics: boys, girl, adult males with different of education level, adult females with different of education level, and elders) but coefficients are not reported. 5.) The interaction term between soil fertility and deviation of rainfall is dropped in each regional regression due to perfect multicollinearity problem.

Random effect Tobit estimation results of educational expenditure are reported in Table 3. Accounting for household head characteristics, household member characteristics and idiosyncratic shock such as a households head's illness, the paper finds that transitory income shock due to rainfall variation is associated with lower educational expenditure for the case of entire sample households and households in the northeastern region. This is consistent with the findings from several studies (e.g. Jacoby and Skoufias, 1997; Sawada, 2003; Beegle et al., 2005; Kazianga, 2012). It was also found that income uncertainty has a significant impact on household income. However, its sign is not in accordance with the hypothesis. Similarly, only for the case of all samples and northeastern region, a relationship was found between head of household characteristics such as age and educational expenditure. Additionally, the paper also finds that the coefficient for head of household head illness, which is a proxy of idiosyncratic shock, is negative and significant for the entire sample case. Educational expenditure is consistently related to household member characteristics in every region. Households spend on education for household members who have ages in compulsory education much more than other age spans for household members.

Table 4 presents the impact of two forms of income shock on health expenditure. As with Table 3, the paper finds that transitory income shock has a significant effect on health expenditure for only two region groups. Transitory income shock is negatively associated with health expenditure only in the entire sample case and a group of central, eastern, and western region. The paper finds no relationship between income uncertainty and health expenditure in any region. Rainfall deviation can both directly and indirectly result in health expenditures. Rainfall deviation has a direct effect on health expenditures because rainfall deviation can cause illness. Consequently, households should spend for remedy household members. However, in case of Thailand, Thai government has launched universal health care program. Thai households can be cared without cost. Hence, it is possible that there may be little of increasing in health expenditures due to illness. Indirectly, rainfall variation can cause household income shocks, especially in case of flood and drought. In this case, it is possible that some households need to find some mechanisms to smooth their consumption. Lower health expenditures may be one of consumption smoothing mechanisms for some households, especially poor households. Households which have no medicine, especially in case of trivial illness, can survive, but households have no food cannot survive. Therefore, in case of poor households, decreasing in health expenditures may help them survive. Illness of the head of household is found to have a positive impact on health expenditure for the case of the entire sample in the northeastern and northern regions. There is little effect for head of household and household member characteristics on health expenditure. Only household members aged over 17 years have a positive relationship with health expenditure for most regions.

6. CONCLUDING REMARKS

This paper examines the impact of rainfall variation on household human capital formation through household income. Becker's economic theory of households (Becker, 1965) was adapted and hypothesized that households may lower their educational and health expenditure when facing transitory income shock and income uncertainty due to rainfall fluctuation. Combining the Thai

Table 3. Estimated random Tobit model of educational expenditure.

Dependent variable: educational expenditure (in log)

<i>Regions:</i>	<i>All regions</i>	<i>Northern</i>	<i>Northeastern</i>	<i>Southern</i>	<i>Central ,Eastern and Western</i>
<i>Variable</i>					
Transitory income	-1.58e-06	3.99e-06	-2.77e-06	2.35e-07	1.53e-06
shock	(5.56e-07)***	(3.65e-06)	(8.09e-07)***	(2.51e-07)	(1.70e-06)
Income uncertainty	2.81e-18	1.07e-13	8.17e-19	2.20e-12	-1.47e-11
	(1.44e-18)*	(5.12e-14)**	(2.42e-18)	(1.27e-12)*	(6.93e-11)
HH's illness	-0.623	-0.725	-0.518	-0.813	-0.472
	(0.362)*	(0.729)	(0.474)	(1.071)	(1.312)
HH's age	-0.111	-0.023	-0.146	-0.022	-0.232
	(0.032)***	(0.073)	(0.037)***	(0.122)	(0.149)
HH 's age square	0.0001	-0.0002	0.001	-0.0003	0.001
	(0.0003)**	(0.0007)	(0.0003)***	(0.001)	(0.001)
Members 0_5	0.955	1.323	0.795	1.697	0.765
	(0.105)***	(0.249)***	(0.126)***	(0.344)***	(0.365)**
Male 6_11	2.586	3.213	2.346	2.830	2.764
	(0.120)***	(0.301)***	(0.146)***	(0.395)***	(0.368)***
Female 6_11	2.391	2.855	2.109	2.581	2.986
	(0.126)***	(0.292)***	(0.152)***	(0.399)***	(0.485)***
Male 12_17	2.672	2.846	2.557	2.373	3.436
	(0.124)***	(0.300)***	(0.158)***	(0.363)***	(0.382)***
Female 12_17	2.692	3.511	2.401	2.219	3.091
	(0.129)***	(0.275)***	(0.164)***	(0.370)***	(0.485)***
Members 18_60	0.618	0.972	0.418	0.764	0.639
	(0.057)***	(0.125)***	(0.075)***	(0.178)***	(0.172)***
Members 61_up	0.231	0.556	-0.004	-0.266	0.802
	(0.127)*	(0.265)**	(0.169)	(0.385)	(0.380)**
Provincial dummy	Yes	Yes	Yes	Yes	Yes
Year dummy	Yes	Yes	Yes	Yes	Yes
Cons	3.859	0.368	4.068	-0.347	6.595
	(3.859)**	(2.009)	(1.010)***	(3.167)	(4.409)
Number of observations	5648	1325	2819	745	759
Log likelihood	-10550.944	-2458.849	-5330.9794	-1350.8042	-1349.855

Notes: 1.) Standard errors in brackets under coefficients. 2.) * significant at 10%; ** significant at 5%; ***significant at 1%. 3.) Members0_5 to Members61_up represent number of household members in each span of age.

Table 4. Estimated random Tobit model of health expenditure.

Dependent variable: health expenditure (in log)

<i>Regions:</i>	<i>All regions</i>	<i>Northern</i>	<i>Northeastern</i>	<i>Southern</i>	<i>Central ,Eastern and Western</i>
<i>Variable</i>					
Transitory income	-1.24e-06	-2.47e-06	-5.37e-07	3.95e-08	-3.04e-06
shock	(6.56e-07)*	(4.03e-06)	(1.08e-06)	(2.82e-07)	(1.81e-06)*
Income uncertainty	-8.58e-19	-2.42e-14	-8.93e-19	-9.43e-13	2.50e-10
	(1.15e-18)	(3.76e-14)	(2.11e-18)	(1.00e-12)	(7.03e-11)***
Head_illness	1.014	1.227	1.160	0.086	1.129
	(0.354)***	(0.63)*	(0.511)**	(1.048)	(1.112)
Head_age	-0.003	-0.023	0.004	0.019	-0.042
	(0.026)	(0.054)	(0.034)	(0.081)	(0.103)
Head_age_square	-0.00003	0.00003	-0.00006	-0.0004	0.0005
	(0.0002)	(0.0005)	(0.0003)	(0.0007)	(0.0009)
Members 0_5	-0.141	-0.127	-0.122	-0.423	0.014
	(0.096)	(0.210)	(0.126)	(0.309)	(0.303)
Male 6_11	-0.001	0.0004	0.102	-0.214	-0.258
	(0.107)	(0.249)	(0.142)	(0.347)	(0.294)
Female 6_11	0.004	-0.308	0.068	0.275	0.094
	(0.113)	(0.240)	(0.146)	(0.345)	(0.407)
Male 12_17	-0.011	-0.337	0.005	0.193	0.041
	(0.112)	(0.246)	(0.154)	(0.299)	(0.320)
Female 12_17	0.005	-0.434	0.063	0.384	0.342
	(0.113)	(0.223)*	(0.157)	(0.294)	(0.398)
Members 18_60	0.404	0.298	0.425	0.454	0.363
	(0.049)***	(0.097)***	(0.072)***	(0.141)***	(0.134)***
Members 61_up	0.418	0.356	0.423	0.862	0.352
	(0.104)***	(0.197)*	(0.154)***	(0.296)***	(0.285)
Provincial dummy	Yes	Yes	Yes	Yes	Yes
Year dummy	Yes	Yes	Yes	Yes	Yes
Cons	5.667	3.089	1.791	0.599	5.784
	(1.149)***	(1.497)**	(0.932)*	(2.149)	(3.073)*
Number of observations	5648	1325	2819	745	759
Log likelihood	-10850.422	-2585.641	-5256.423	-1465.132	-1498.374

Notes: 1.) Standard errors in brackets under coefficients. 2.) * significant at 10%; ** significant at 5%;

***significant at 1%. 3.) Members0_5 to Members61_up represent number of household members in each span of age.

household Socio-Economic Panel Survey with the regional rainfall data and adopting the method of Paxson (1997), and Kazianga and Udry (2006), transitory income shock and income uncertainty have been constructed.

The empirical results showed that transitory income shock had a mild negative impact on human capital formation while income uncertainty had a positive impact on demand for human capital. Transitory income shock slightly reduced educational expenditure when households in all regions and in the Northeastern region were used as a sample. Meanwhile, health expenditure is negatively associated with transitory income shock for the case of households in the entire country and in the Central, Eastern and Western regions. These imply that climate change has a negative effect on the formation of human capital for some Thai households, especially those in the agricultural sector. Climate change highly accounts for the well-being of Thai agricultural households. To smooth their consumption some households may lower on household human capital development expenditures such as education and health expenditures when they face income shocks due to either flood or drought from rainfall variations. Additionally, these imply that government assistance is still lacking and the Thai credit market is still inadequate. Consequently, some Thai households have eliminated educational and health expenditures as consumption smoothing mechanisms when they are faced with income shocks. Moreover, the negative impact on human capital formation may be more severe in the case of permanent adverse shocks; such as, long flooding and drought periods. Further research thus should be undertaken.

Notes

¹ Becker's household economic theory is based on neoclassical models of consumer behavior, but adds a time resource and considers a household as both a consumption and production unit in the model (Mattila-Wiro, 1999)

² There are at least two approaches to measure human capital investment: the educational-based approach and the cost-based approach. The former approach measures human capital investment through such as schooling years, schooling enrolment, educational attainment. The later approach measures through any expenditure which contributes human capital. These expenditures include, for example, educational expenditures, training expenditures, and health expenditures. However, much of researches examine human capital investment through the educational-based approach, but little attention has investigated through the cost-based approach. Therefore, this paper adds another study of human capital investment by using the cost-based approach. Apart from little attention, the cost-based approach is interesting because it is a good measurement of household human capital investment. Increasing and decreasing either educational expenditures, or health expenditures of household members can directly and evidently reflect household human capital investment.

³ In economic perspectives, the concept of human capital can probably be traced back to the classical economist era. The popular concept nevertheless is defined by Mincer (1958) and Becker (1962, 1964).

⁴ The Thai Household Socio-Economic Panel Survey collected by the National Statistical Office (NSO) provides the socioeconomic data on Thai households, just as Thai Socio-Economic Surveys (SES)

did, but with fewer details. It composes of two main groups of question: household questions and households member questions. Household questions include questions about general information of household members, household characteristics and assets, and income from agriculture. Household member questions include, for example, education, health care, employment, and income.

⁵ Since this paper uses a large data set covering all provinces inclusive of a large number of villages in Thailand, sub-district-year fixed effect is employed for speed of data processing.

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