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Local infrastructure, resilience capacity and poverty in rural Southeast Asia

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The Thailand Vietnam Socio Economic Panel (TVSEP) is a long-term research project for data collection and scientific analysis funded by the Deutsche Forschungsgemeinschaft (DFG). The high quality panel data sets have been collected in rural areas of Thailand and Vietnam since 2007. The panels cover many important aspects of living standard measures, demography, geography, shocks, risks, expectations and behavioural traits of individuals. TVSEP data is available for scientific research purposes free of charge.

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Local infrastructure, resilience capacity and poverty in rural Southeast Asia

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Abstract

We examine the association between infrastructure and a household's resilience capacity against shocks and the impacts of a household's resilience capacity on household consumption and poverty. We use panel data (collected in 2010, 2013, and 2016) from 1,698 households in Thailand and 1,701 households in Vietnam and employ an instrumental variable approach. We find that transportation and information and communication technology infrastructure help improve households' absorptive capacity in coping with shocks. Furthermore, this capacity can prevent households from reducing consumption and falling into poverty. Thus, rural development policies should attend to transportation and information and communication technology infrastructure.

Keywords: Infrastructure, resilience capacity, poverty, instrumental variable, Thailand, Vietnam.

JEL: D01, O12, Q12

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1. Introduction

Infrastructure development is a topic of paramount interest regarding national, regional, and local economic growth. Infrastructure plays a vital role in enabling economic activities in the first place (Esfahani and Ramírez, 2003; Calderón and Servén, 2004; Égert et al., 2009; Chatterjee and Turnovsky, 2012; Daido and Tabata, 2013). In the course of development, the concern about infrastructure and its role in poverty reduction has also been raised (Ali and Pernia, 2003). In developing countries, infrastructure investments are expanding dramatically to boost economic growth and reduce poverty. For instance, Southeast Asia is one of the regions in the world advancing the fastest, both in terms of infrastructure- and economic development, and countries in this region, such as Thailand and Vietnam, have experienced rapid economic growth in the last decades (World Bank, 2021a).

However, growth in national products per capita does not necessarily imply widespread economic integration across a country or region (Calderón and Servén, 2010), especially in emerging economies. For example, the metropolitan areas in Thailand saw steady wealth creation and poverty alleviation, while the rural areas profited much less from this development (FAO, 1998). About 20 years ago, 75 % of the Vietnamese lived in rural areas, respectively 69 % of the Thai population. Today, roughly 65 % of the Vietnamese population lives in rural areas, respectively 49 % in Thailand. As a result, a clear trend of urbanization has been observed in these countries since the share of people living in rural areas is declining significantly (World Bank, 2021b). On the other hand, this trend increases the inequality and gap between rural and urban areas in terms of income, consumption, and living conditions (Do and Park, 2019; Hoang, 2020; Obermann et al., 2020).

This situation could even be worsened through exposure to various exogenous shocks with severe economic impacts, especially in Southeast Asia (Nguyen and Nguyen, 2020; Nguyen et al., 2020a; Nguyen et al., 2020b). This region is severely affected by natural disasters. US$ 91 billion equivalent losses are estimated alone due to natural disasters like storms, floods, or droughts between 2004 and 2014 (ADB, 2021). Economic shocks, like the Asian financial crisis or the world financial crisis, drove millions who had been lifted out of poverty years ago back into it (Habib et al., 2010). The extraordinary events, such as the Covid-19 pandemic, have forced millions of people in the greater Mekong

area, who had migrated from rural areas to the cities for working opportunities, to return to their home villages (Waibel et al., 2020). As a result, demand for food and other necessities in rural areas has grown, while remittances from migrant workers have been decreasing.

Since monetary means are scarce, especially in rural areas, finding a good way of steering the available resources to help build resilience against exogenous shocks while at the same time not hampering but rather fueling long-term economic development is of critical importance. The available capital stock should be employed so that money is spent in the most efficient way possible. One promising area of investment, therefore, is infrastructure development. By building the backbone of every advanced economy, infrastructure plays a crucial role in fighting poverty and lifting the standard of living of people and households. Evidence suggests that roads and extended irrigation mainly contribute to poverty reduction and economic development (Ali and Pernia, 2003). Nevertheless, it is crucial to highlight how infrastructure development can help improve a household's resilience capacity to fight against these exogenous shocks.

While studies on investments in infrastructure contribute and economic development are rich, evidence on the association between infrastructure, household resilience capacity, and poverty is still nearly unexplored. Examining this association is essential. Since high volatility in income and consumption can put significant stress on the well-being of the affected population, they may seek less profitable and less volatile income sources, which leads to smoothened consumption and a lower standard of living (Klasen and Waibel, 2015). Furthermore, monitoring the present state of poverty is an essential practice to tailor poverty reduction policies. Against this background, this study aims at answering two research questions (i) how infrastructure has an impact on a household's resilience capacity against shocks, and (ii) how infrastructure and household's resilience capacity affect poverty and vulnerability to poverty.

The remaining of this paper is organized as follows. Section 2 describes the conceptual framework and reviews the related literature. Section 3 introduces the study sites and describes the data. Section 4 explains our research methods. Section 5 presents key results and discusses the findings. Finally, Section 6 concludes with policy implications.

2. Conceptual framework and literature review

2.1. Conceptual framework

This study relies on the sustainable livelihoods framework proposed by Ashley and Carney (1999) and Ali and Pernia (2003) to link local infrastructure development to household livelihood strategies and poverty. In this regard, under the context of shocks, infrastructure development can assist rural households in improving their resilience capacity to deal with shocks, sustain consumption, and prevent them from falling into poverty. Neuman (2006) describes infrastructure as a physical network that enables a substance or information to flow to a place of human activity. It connects producers, service providers, and users and uses standardized technologies, pricing, and controls. While infrastructure undoubtedly builds the backbone of every advanced economy, the causal links between infrastructure and economic development have been discussed until today (Välilä, 2020). Although numerous studies have analyzed the links between infrastructure and economic growth and development, the evidence on this relationship remains mixed. This problem can be attributed to multiple obstacles that emerge when analyzing infrastructure and its impact on economic outcomes (Du et al., 2022).

New infrastructure may seem to have little to do with rural development since it requires heavy investment and a well-developed infrastructure foundation, even though there are conclusions that could also be driven by rural development. First, quality economic growth as the desired outcome is highly relevant for rural development since growth in terms of gross domestic products (GDP) per capita does not always imply inter-regional growth and economic integration but can sometimes be attributed to, for example, growth in urban areas but not the rural areas (OECD, 2022). Second, technological innovation and productivity growth as channels for economic development are promising tools when trying to alleviate poverty (World Bank, 2020). Therefore, incorporating these dimensions when conceptualizing the link between infrastructure and rural development may show important interlinkages incorporated in this relationship. Infrastructure investments are thereby subdivided into economic and social infrastructure, reducing poverty through productivity gains and social welfare (Fagbemi et al., 2022). Public investments in economic- and social infrastructure, especially in an economy characterized by imperfect markets like they often occur in developing- and transition countries, should lift national income and employment and improve social welfare. The

results imply that public infrastructure investments help fight poverty, and in turn, lower poverty enhances performance in the public sector, leading to complementary effects (Jiang et al., 2020).

2.2. Literature review

Empirical evidence on infrastructure and its effect on rural development is somewhat mixed. Infrastructure investments can help fuel economic growth and regional economic development and reduce poverty (Esfahani and Ramírez, 2003; Chatterjee and Turnovsky, 2012; Daido and Tabata, 2013). However, economic growth does not always imply economic integration across all regions inside an economy. For example, sub-Saharan Africa saw steady GDP per capita growth in recent decades. However, the share of the population employed in agriculture, manufacturing, and services remained nearly the same as before the economic expansion. The cost of doing business is among the highest in the world, implying the regional lack of economic transformation (Ajakaiye and Ncube, 2010). Higher investments in infrastructure development, such as transportation networks or non-farm employment opportunities, and more government oversight in the construction of infrastructure projects may present a viable source of economic transformation, which would also benefit the poor and lead to sustainable economic growth, as it has been shown in Southeast Asia (Do et al., 2022). Investments in other types of infrastructure should also be considered besides electrification (Fan et al., 2004).

Studies on the linkage between infrastructure and household resilience are relatively scarce. From the literature, the dominant conceptualization of resilience considers it as a capacity with *ex-ante* attributes (Béné et al., 2012), and the vulnerable context, especially in rural areas, influences households' strategies to build up their resilience capacity to prevent, mitigate, or cope with risks (Meybeck et al., 2012). These resilience strategies help rural households sustain their welfare in the short term, prevent them from falling into poverty, and reduce their vulnerability to poverty in the long term.

At this point, it is essential to point out the difference between poverty and vulnerability to poverty since these are interlinked but very different concepts. Absolute poverty is an income below a fixed poverty line, while relative poverty refers to an income below a certain level in an economy (Foster, 1998). While the first can be used to measure poverty

on a global scale, the latter is useful when examining poverty, especially in developed nations, since people living in the developed world can be non-poor by international standards but be counted as disadvantaged by different country standards. On the other hand, vulnerability to poverty is different from that concept. It could be defined as the *"ex-ante risk that a household will, if currently non-poor, fall below the poverty line, or if currently poor, will remain in poverty"* (Jalan et al., 2002, p. 4).

This study contributes to the filling of the following research gaps. First, rich findings are attained for irrigation-related infrastructure (Adetoro et al., 2022; Biru et al., 2020; Fischer et al., 2022). However, rural infrastructure includes a broader range of facilities such as roads, electricity, and information and communication technology (ICT). We enrich the literature by using more comprehensive indicators of local infrastructure. Second, we offer the first effort to consider the impacts of infrastructure on multidimensional poverty based on the Multidimensional Poverty Measure (MPM) established by the World Bank (2022). Besides the poverty indicators using absolute and relative terms, multidimensional poverty provides a complete picture of the effects of infrastructure development on rural households' welfare. Last, even though some studies have documented a statistically significant influence of infrastructure development on vulnerability to poverty (Leichenko and Silva, 2014; Herrera et al., 2018), these studies mainly case studies within a country. Our study is from two countries' rural areas, thus allowing for a better generalization of the findings.

3. Study sites and data description

3.1. Study sites

This study uses the data from the Thailand-Vietnam Socio-Economic Panel: Poverty dynamics and sustainable development (TVSEP) project (www.tvsep.de) funded by the German Research Foundation (DFG) to provide high-quality data on livelihoods and poverty dynamics in the rural areas of the two emerging economies of Thailand and Vietnam. The data include about 4,400 households from three provinces in Thailand, namely Buri Ram, Ubon Ratchathani, and Nakhon Phanom, and three provinces in Vietnam, namely Ha Tinh, Thua Thien Hue, and Dak Lak (Figure 1). The sampling is based on the guidelines of the UN Department of Economic and Social Affairs (Nguyen et al., 2021; Nguyen and Do, 2022). The survey instruments include a household

questionnaire and a village questionnaire which are available on the project's webpage.

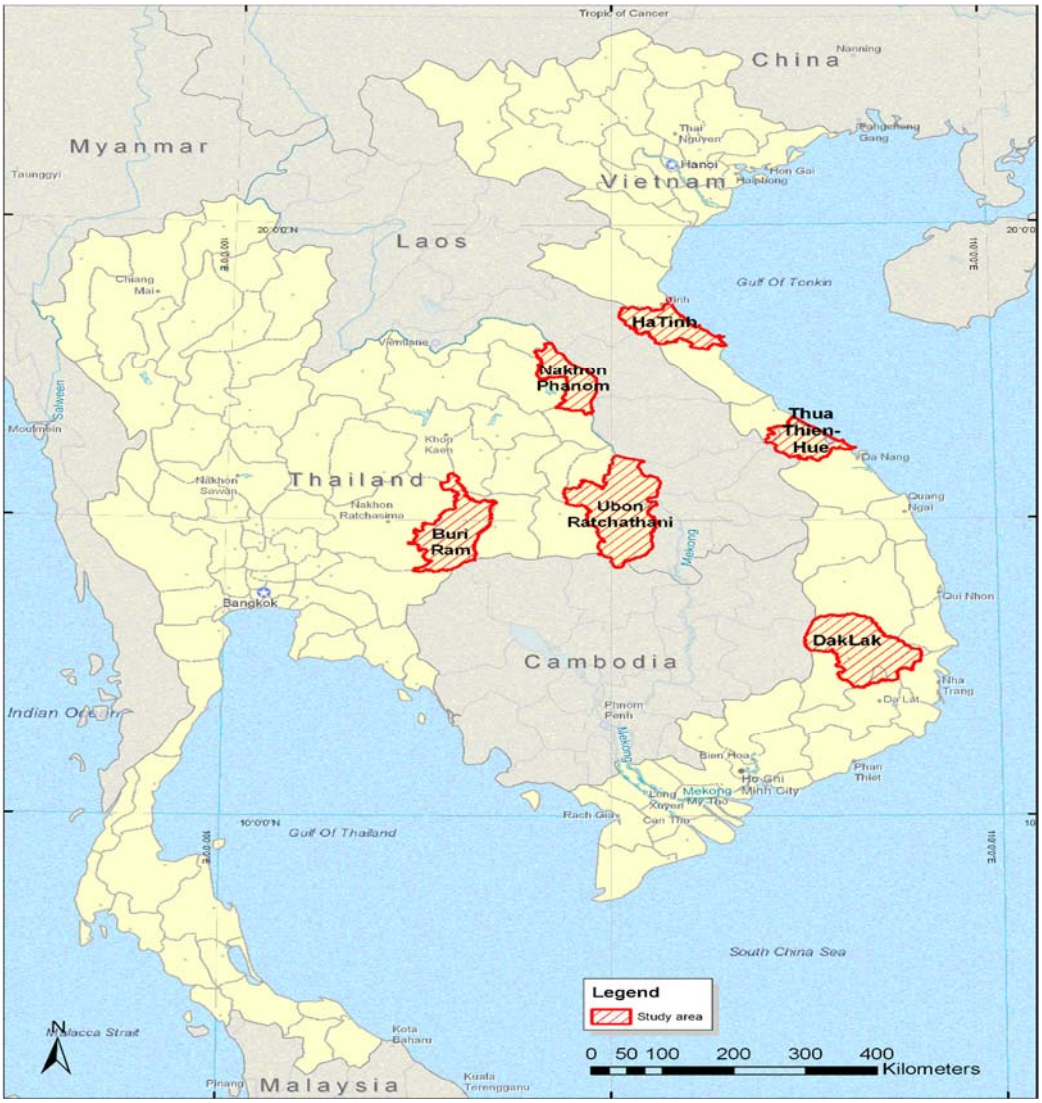

Figure 1: Survey sites of the Thailand-Vietnam Socio-Economic Panel (TVSEP) (Source: Nguyen et al., 2020b)

The survey sites in Thailand and Vietnam are economically dominated by agriculture. Necessary infrastructure like roads is not well-established. Therefore, economic integration is inadequate and is doomed to produce poverty. Furthermore, the Vietnamese regions are regularly subject to natural disasters like floods and storms, which further fuels economic deterioration (Nguyen et al., 2022a; Nguyen et al., 2022b). The final sample for this study consists of 1,698 households in Thailand and 1,701 households in Vietnam from three survey waves conducted in 2010, 2013, and 2016. This makes a total of 5,094 observations for Thailand and 5,103 for Vietnam. Therefore, the whole data set includes 10,197 observations.

In addition to the TVSEP data, we use the rainfall data from the Tropical Rainfall Measuring Mission (TRMM). The resolution of the TRMM rainfall data is highly spatial and temporal and available from 1998 to 2014. Since our household and village data are from 2010, 2013, and 2016 (a three-year gap), we follow Do et al. (2022) to use the lagged three-time period (t-3) of rainfall as an instrumental variable.

3.2. Data description

There are no missing entries for the variables of interest, and the dataset is therefore balanced (see Appendix 1 for the definition and measurement of variables). Panel A1 of Table 1 shows household income and consumption statistics. On average, Vietnamese households have lower living standards than Thai households. Panel A2 of Table 1 shows that Vietnamese- and Thai households differ substantially in several aspects. Vietnamese households are more likely to be male-headed than Thai households. Furthermore, household members' average age and health status are higher in Thailand than in Vietnam. The average year of education for > 15-year-old household members are also higher in Thailand. The total land area and asset per capita are significantly better in Thailand.

Table 1: Descriptive statistics of surveyed households and villages

	Whole sample (n =10197)	**2010**		**2013**		**2016**	
		Thailand (n = 1698)	**Vietnam (n = 1701)**	**Thailand (n = 1698)**	**Vietnam (n = 1701)**	**Thailand (n = 1698)**	**Vietnam (n = 1701)**
A. Household variables							
A1. Consumption and income							
Reduced consumption due to shocks (yes = 1)	0.31	0.16	0.54$^{***, b}$	0.13	0.45$^{***, b}$	0.18	0.39$^{***, b}$
	(0.46)	(0.37)	(0.50)	(0.33)	(0.50)	(0.39)	(0.49)
Daily consumption per capita (PPP$)	5.03	4.71	3.41$^{***, a}$	5.70	4.05$^{***, a}$	7.20	5.10$^{***, a}$
	(4.28)	(3.90)	(2.36)	(4.65)	(3.15)	(5.63)	(4.13)
Daily income per capita (PPP$)	6.77	6.53	3.90$^{***, a}$	7.48	4.84$^{***, a}$	10.44	7.4$^{***, a}$
	(20.34)	(19.45)	(5.52)	(23.27)	(6.46)	(37.38)	(8.30)
A2. Household characteristics							
Gender of household head (male = 1)	0.77	0.74	0.85$^{***, b}$	0.71	0.82$^{***, b}$	0.67	0.80$^{***, b}$
	(0.42)	(0.44)	(0.35)	(0.45)	(0.38)	(0.47)	(0.40)
Age of household head (years)	56.07	57.26	50.23$^{***, a}$	59.35	53.21$^{***, a}$	61.08	55.29$^{***, a}$
	(12.91)	(12.36)	(12.85)	(12.16)	(12.78)	(11.63)	(12.47)
Health status of household head (healthy = 1)	0.81	0.85	0.74$^{***, b}$	0.84	0.66$^{***, b}$	0.92	0.83$^{***, b}$
	(0.40)	(0.35)	(0.44)	(0.36)	(0.47)	(0.28)	(0.37)
Local household (yes = 1)	0.63	0.60	0.63$^{*, b}$	0.61	0.64$^{**, b}$	0.63	0.64 ^{b}
	(0.48)	(0.49)	(0.48)	(0.49)	(0.48)	(0.48)	(0.48)
Mean schooling years of adult members (years)	5.69	6.26	6.14 ^{a}	5.83	5.33$^{***, a}$	5.40	5.18$^{**, a}$
	(2.66)	(2.14)	(2.78)	(2.39)	(2.84)	(2.67)	(2.90)
Household size (number of persons)	4.01	4.14	4.34$^{***, a}$	3.98	4.06 ^{a}	3.75	3.82 ^{a}
	(1.70)	(1.73)	(1.72)	(1.70)	(1.72)	(1.64)	(1.64)

Share of laborers (%)	74.93	70.75	70.62 [a]	72.02	74.11*** [a]	83.10	78.97*** [a]
	(23.03)	(22.36)	(23.14)	(22.74)	(23.13)	(22.02)	(21.96)
Household land area per capita (hectares)	0.65	0.98	0.25*** [a]	1.13	0.31*** [a]	0.86	0.35*** [a]
	(1.04)	(1.17)	(0.71)	(1.42)	(0.65)	(1.04)	(0.55)
Agricultural machines (yes = 1)	0.57	0.46	0.64*** [b]	0.45	0.65*** [b]	0.55	0.69*** [b]
	(0.49)	(0.50)	(0.48)	(0.50)	(0.48)	(0.50)	(0.46)
Number of motorcycles	1.34	1.31	0.98*** [a]	1.47	1.25*** [a]	1.51	1.52 [a]
	(0.99)	(0.87)	(0.85)	(1.00)	(1.01)	(1.00)	(1.07)
Asset per capita (PPP$)	1531.65	1675.06	591.65*** [a]	2399.09	871.64*** [a]	2705.70	950.6*** [a]
	(3341.52)	(3383.15)	(760.68)	(5048.09)	(1359.12)	(4648.95)	(1515.72)
B. Village variables							
Number of enterprises	0.46	0.12	0.13 [a]	0.46	0.99*** [a]	0.28	0.79*** [a]
	(1.62)	(0.59)	(0.56)	(1.98)	(2.51)	(0.88)	(1.88)
Having made roads instead of dirt roads (yes = 1)	0.84	0.89	0.67*** [b]	0.97	0.64*** [b]	0.96	0.89*** [b]
	(0.37)	(0.32)	(0.47)	(0.18)	(0.48)	(0.20)	(0.31)
Share of households with electricity at home (%)	98.50	98.72	98.30** [a]	98.65	97.53*** [a]	99.06	98.75 [a]
	(7.30)	(4.14)	(7.35)	(6.88)	(10.86)	(4.18)	(8.02)
Share of households with a phone line at home (%)	82.60	37.28	79.27*** [a]	98.89	88.03*** [a]	99.06	93.02*** [a]
	(31.24)	(46.34)	(19.74)	(5.84)	(18.75)	(4.77)	(13.26)
Share of households with cable internet at home (%)	4.45	1.91	1.92 [a]	3.51	4.91*** [a]	4.09	10.37*** [a]
	(9.50)	(5.00)	(6.02)	(10.46)	(7.86)	(7.19)	(14.44)
Having access to public water supply (yes = 1)	0.59	0.95	0.30*** [b]	0.92	0.20*** [b]	0.95	0.21*** [b]
	(0.49)	(0.22)	(0.46)	(0.28)	(0.40)	(0.22)	(0.41)
Having a bank agency in village (yes = 1)	0.06	0.00	0.07*** [b]	0.09	0.06*** [b]	0.06	0.05 [b]
	(0.23)	(0.00)	(0.26)	(0.29)	(0.23)	(0.25)	(0.23)
Distance to next market (kilometers)	5.97	8.94	2.98*** [a]	8.96	2.98*** [a]	8.96	3.00*** [a]
	(6.93)	(7.86)	(4.40)	(7.85)	(4.40)	(7.33)	(4.41)

Note: Standard deviations in parentheses; [a]: Two-sample t-test; [b]: Non-parametric rank-sum test; *** $p<0.01$, ** $p<0.05$, * $p<0.1$.

Panel B of Table 1 shows the descriptive summary of village characteristics. On the one hand, Thai households are more likely to have a public water supply available in their villages and have more made roads instead of dirt roads than Vietnamese households. On the other hand, Vietnamese households are slightly more likely to have a bank office in their villages. Furthermore, Thailand's average distance from the villages to the next market is higher. Other differences in village characteristics are not statistically significant. In sum, with a few exceptions, Thai households have better access to basic infrastructure than Vietnamese households.

3.3. Poverty measurement

We rely on consumption data to measure the poverty of rural households following Haughton and Khandker (2009), Nguyen et al. (2022a), and Forster (1998). We use several indicators of absolute poverty, relative poverty, and multidimensional poverty. An absolute poverty threshold of PPP$ 3.20 per capita daily is applied, as the World Bank (2022) suggested for middle-income countries. A household with expenditure per capita 30% lower than the average per capita is classified as relatively poor. The

multidimensional poverty in our study is adjusted from the multidimensional poverty developed by the World Bank (World Bank, 2022). It covers four dimensions, monetary poverty, education poverty, lacking access to basic infrastructure, and housing poverty. Each dimension is thereby weighted with 1/4. The cut-off value for poverty is set to 0.25, implying that a household is multidimensionally poor if its parameters add up to 0.25 or higher (see Appendix 2 for detailed parameters and weights).

Table 2 presents the descriptive summary of multidimensional poverty and poverty indicators. In terms of multidimensional poverty, Thai households have more proper sanitation or access to drinking water than Vietnamese households. However, Vietnamese households have better access to education, at least in quantitative terms. Vietnamese households are less likely to have at least one school-age child who is not enrolled in school or to have at least one adult who has not completed primary education.

Table 2: Descriptive statistics on multidimensional poverty and poverty indicators

	Whole sample (n =10197)	**2010**		**2013**		**2016**	
		Thailand (n = 1698)	**Vietnam (n = 1701)**	**Thailand (n = 1698)**	**Vietnam (n = 1701)**	**Thailand (n = 1698)**	**Vietnam (n = 1701)**
MPI indicators							
No child education (yes = 1)	0.06	0.06	0.05 [b]	0.11	0.08***, [b]	0.02	0.03 [b]
	(0.24)	(0.24)	(0.22)	(0.31)	(0.27)	(0.15)	(0.16)
No adult education (yes = 1)	0.02	0.04	0.02***, [b]	0.03	0.01***, [b]	0.02	0.01***, [b]
	(0.15)	(0.20)	(0.14)	(0.18)	(0.11)	(0.13)	(0.09)
No safe drinking water (yes = 1)	0.38	0.16	0.67***, [b]	0.12	0.69***, [b]	0.04	0.60***, [b]
	(0.49)	(0.37)	(0.47)	(0.33)	(0.46)	(0.20)	(0.49)
No improved sanitation (yes = 1)	0.30	0.03	0.70***, [b]	0.02	0.59***, [b]	0.01	0.45***, [b]
	(0.46)	(0.17)	(0.46)	(0.15)	(0.49)	(0.09)	(0.50)
No access to electricity for lighting (yes = 1)	0.02	0.02	0.01**, [b]	0.04	0.02**, [b]	0.01	0.02***, [b]
	(0.14)	(0.15)	(0.11)	(0.18)	(0.15)	(0.10)	(0.15)
No appropriate housing condition (yes = 1)	0.16	0.11	0.30***, [b]	0.20	0.19 [b]	0.05	0.11***, [b]
	(0.37)	(0.31)	(0.46)	(0.40)	(0.39)	(0.23)	(0.31)
No appropriate nutrition for children (yes = 1)	0.12	0.14	0.18***, [b]	0.11	0.15***, [b]	0.07	0.10***, [b]
	(0.33)	(0.34)	(0.38)	(0.31)	(0.36)	(0.25)	(0.30)
Poverty indicators							
Absolute consumption poverty (yes = 1)	0.37	0.39	0.55***, [b]	0.28	0.46***, [b]	0.17	0.35***, [b]
	(0.48)	(0.49)	(0.50)	(0.45)	(0.50)	(0.37)	(0.48)
Relative consumption poverty (yes = 1)	0.39	0.41	0.35***, [b]	0.41	0.39 [b]	0.42	0.39*, [b]
	(0.49)	(0.49)	(0.48)	(0.49)	(0.49)	(0.49)	(0.49)
Multidimensional poverty (yes = 1)	0.40	0.41	0.61***, [b]	0.31	0.53***, [b]	0.17	0.38***, [b]
	(0.49)	(0.49)	(0.49)	(0.46)	(0.50)	(0.38)	(0.49)

Note: Standard deviations in parentheses; [a]: Two-sample t-test; [b]: Non-parametric rank-sum test; *** $p<0.01$, ** $p<0.05$, * $p<0.1$.

4. Methodology

4.1. Determining the association between infrastructure and household's resilience capacity

We focus on the absorptive capacity of rural households. This resilience capacity denotes the households' ability to prevent potential shocks, mitigate shock impacts, and recover quickly from shocks (Béné et al., 2016; Meybeck et al., 2012). Theoretically, consumption smoothing is essential in dealing with shocks. Thus, we assume that a good approximation for the ability to cope with shocks is whether the household had to reduce its consumption due to shocks or not (Nguyen et al., 2022a). In other words, if a household has a resilience capacity to deal with shocks, it does not have to reduce consumption when faced with shocks. Besides, the economic capital of households might play a role in dealing with shocks. For this purpose, two dummy variables are employed to capture households' absorptive capacity, namely (i) reduced consumption due to shocks (if a household had to reduce its consumption to cope with shock = 1; otherwise = 1), and (ii) weak economic capacity (if the ratio of household income to poverty threshold (at PPP$ 3.20 per capita per day) is less than one = 1; otherwise = 0). The model of infrastructure and household's resilience capacity can then be expressed as follows:

$$R_{it} = \alpha_1 + \alpha_2 H_{it} + \alpha_3 V_{it} + \varepsilon_{it} \quad (1)$$

where R_{it} represents the ability to cope with shocks of household *i* at time *t*; R_{it} includes two dummy variables: reduced consumption due to shocks and weak economic capacity. H_{it} is the group of household characteristics including gender, age, health status of the household head, whether the head was born in the same (as current) village, mean schooling years of household's adult members, share of laborers, land area per capita, whether the household has productive machines and motorcycles, and whether it is asset-poor (belonging to the 20% poorest of asset value per capita); V_{it} captures the village's infrastructure characteristics which include the number of enterprises in village that provide off-farm employment opportunities, whether the village has made roads instead of dirt roads, the share of households with electricity at home, share of households with a phone line at home, share of households with cable internet at home, whether the village has public water supply, whether there is a bank office/branch in the village, and the distance from the village to the closest market. These households and village variables

have been found to influence on rural households' livelihood strategies significantly (Do et al., 2022; Nguyen et al., 2020a; Nguyen et al., 2022c); and ε_{it} is the error term.

There might be a concern with using a fixed-effects linear probability model (FE-LPM) for a binary dependent variable. However, FE-LPM has been found to yield better results in rare events where the number of observations with values of one is smaller than 25% (Timoneda, 2021). Since our descriptive statistics have shown that only 16% of all households had reduced consumption due to shocks in the case of Thailand, the FE-LPM might outperform logistic regressions. As a robustness check, we also run equation (1) with a random-effects Probit model (RE-Probit). We check multicollinearity with the Variance Inflation Factors (VIF) values. The results of VIF values show no significant signs of this problem (see column (1) of Appendix 2 for the detailed results of VIF values). We cluster our estimations at the village level.

4.2. Examining the impacts of resilience capacity on consumption and poverty

In this step, we estimate the impact of resilience capacity on consumption, poverty, and vulnerability to poverty. The dependent variables include daily household expenditure per capita, household poverty (in absolute poverty, relative poverty, and multidimensional poverty), and household vulnerability to poverty. While using the first two groups of dependent variables is clear, we need to construct the indicators of household vulnerability to poverty. Since vulnerability to poverty is an *ex-ante* measure, a multi-period measure is added, i.e., whether a household, which is currently poor, has been poor in the previous period. Therefore, three dummy variables are generated, namely (i) chronic absolute poverty, (ii) chronic relative poverty, and (iii) chronic multidimensional poverty (yes = 1; otherwise = 0). The fixed-effects model to evaluate the impacts of households' resilience capacity can be specified as follows:

$$Y_{it} = \beta_1 + \beta_2 R_{it} + \beta_3 H_{it} + \beta_4 V_{it} + \epsilon_{it} \quad (2)$$

where Y_{it} denotes three groups of households' welfare, namely (i) household daily expenditure per capita, (ii) household poverty (in absolute poverty, relative poverty, and multidimensional poverty), and (iii) household vulnerability to poverty (chronic absolute poverty, chronic relative poverty, and chronic multidimensional poverty); R_{it} is a vector of the two variables of resilience capacity; H_{it} and V_{it} represent household and village characteristics; and ϵ_{it} is the error term.

Since R_{it} is apparently endogenous. We address this problem by using an instrumental approach (IV). We use a fixed-effects estimation with IV to estimate equation (2). To instrument R_{it}, we use the lagged three-year months with extreme precipitation from the TRMM data. We conduct two quality tests to check whether the IV is appropriate: weak identification (Stock and Yogo, 2005) and under-identification (Cragg and Donald, 1993). The results of these tests presented in the post-estimation part of Table 4, Appendices 4, 5, and 6 show that our IV estimations do not suffer the problem of under-identification and weak-identification. We further check for the multicollinearity problem of independent variables using the VIF values. The results of VIF values do not imply this problem in our model (see columns (2) and (3) of Appendix 3). We cluster our estimations at the village level.

5. Results and discussion

5.1. Association between infrastructure and resilience capacity

Table 3 shows the estimation results from FE-LPM and RE-Probit models. The FE-LPM estimation results show statistically significant evidence for the number of enterprises in villages if the village has made roads instead of dirt roads, the share of households with a phone line at home, and the share of households having cable internet at home. All significant coefficients have a negative sign, implying they have a negative association with consumption reduction due to shocks. These results align with previous studies on the role of transportation and ICT infrastructure (Do et al., 2022; Nguyen et al., 2022c). The influence of electricity is, however, less pronounced. This could be because almost all villages in these countries already have access to electricity. Access to public water supply also negatively correlates with consumption reduction in RE-Probit estimations. Our results imply that infrastructure development should focus on transportation, ICT, and living facilities.

Table 3: Association between infrastructure development and resilience capacity

	Reduced consumption due to shocks		Weak economic capacity	
	FE-LPM	RE-Probit	FE-LPM	RE-Probit
Male head†	-0.017	0.007	0.043	-0.000
	(0.027)	(0.040)	(0.030)	(0.037)
Age of head	-0.002*	-0.012***	-0.007***	-0.007***
	(0.001)	(0.001)	(0.001)	(0.001)
Healthy head†	-0.066***	-0.316***	-0.053***	-0.250***
	(0.016)	(0.040)	(0.015)	(0.040)
Head born in the village†	0.010	0.030	-0.007	0.098***
	(0.028)	(0.037)	(0.031)	(0.034)
Mean schooling years of adult members	0.002	-0.014**	-0.005*	-0.059***
	(0.003)	(0.006)	(0.003)	(0.007)
Household size	0.016***	0.068***	0.047***	0.137***
	(0.005)	(0.011)	(0.006)	(0.012)
Share of laborers	-0.000	0.002***	-0.002***	-0.006***
	(0.000)	(0.001)	(0.000)	(0.001)
Land area per capita	-0.014*	-0.060***	0.003	-0.082***
	(0.007)	(0.023)	(0.007)	(0.021)
Having productive machines†	0.030**	0.112***	-0.024*	-0.130***
	(0.014)	(0.039)	(0.015)	(0.033)
Number of motorcycles	-0.006	-0.103***	-0.062***	-0.326***
	(0.007)	(0.020)	(0.008)	(0.020)
Asset poor†	0.011	0.098**	0.051***	0.381***
	(0.017)	(0.044)	(0.017)	(0.041)
Number of enterprises	-0.005*	-0.007	0.002	-0.007
	(0.003)	(0.010)	(0.004)	(0.011)
Having made roads instead of dirt roads†	-0.042*	-0.208***	-0.074***	-0.237***
	(0.023)	(0.052)	(0.023)	(0.055)
Share of households with electricity at home (%)	0.000	-0.003	0.000	-0.001
	(0.001)	(0.002)	(0.001)	(0.002)
Share of households with a phone line at home (%)	-0.000**	-0.001**	-0.000	-0.001***
	(0.000)	(0.001)	(0.000)	(0.001)
Share of households with cable internet at home (%)	-0.002***	-0.008***	-0.002**	-0.009***
	(0.001)	(0.002)	(0.001)	(0.002)
Having access to public water supply†	0.012	-0.508***	0.022	-0.121***
	(0.023)	(0.046)	(0.025)	(0.043)
Having a bank agency in village†	-0.032	-0.050	0.024	0.053
	(0.029)	(0.071)	(0.039)	(0.086)
Distance to the closest market	0.001	-0.011***	0.002	0.002
	(0.003)	(0.004)	(0.002)	(0.003)
Constant	0.432***	1.010***	0.959***	1.558***
	(0.123)	(0.275)	(0.104)	(0.238)
Number of observations	10197	10197	10197	10197
Prob > F	0.000		0.000	
Prob > chi2		0.000		0.000

Note: Robust standard errors clustered at village level; †: Dummy; *** $p<0.01$, ** $p<0.05$, * $p<0.1$.

Regarding household variables, household head age, whether the head is healthy, mean schooling years of adult members, owning more motorcycles, and the land area per capita have a significant negative association with consumption reduction due to shocks. This implies that improving these characteristics of households helps improve their capacity to cope with shocks. The important role of education in rural households is consistent with that of Ninh (2021). Large household size and asset-poor households appear to have a significant and positive correlation between consumption reduction due to shock. This denotes that these households should be supported to improve their resilience capacity.

5.2. Impacts of resilience capacity on consumption and poverty

Infrastructure development increases the ability to cope with shocks by improving their resilience capacity. The increased ability to cope with shocks then reduces the vulnerability to poverty. In this way, the impact of infrastructure development on households' vulnerability to poverty is estimated. Panel A of Table 4 depicts the impact of reduced consumption due to shocks on daily expenditure per capita (in logarithm), absolute expenditure poverty, relative expenditure poverty, and multidimensional poverty. It appears that having weak resilience capacity in the form of reduced consumption to cope with shocks negatively affects household expenditure per capita and positively affects poverty indicators.

Similarly, the results of the impact of a weak economic capacity in Panel B of Table 4 remain consistent, implying that households' absorptive capacity is essential to prevent them from reducing their consumption and falling into poverty in different measures. The importance of improving resilience capacity is consistent with the previous studies (Arslan et al., 2018; Khandker, 2012). The impacts on chronic poverty are reported in Appendix 6 and are in line with those from Ansah et al. (2021), DeLoach and Smith-Lin (2018), and Yilma et al. (2014) regarding the role of the economic capacity of rural households in coping with shocks. Therefore, supportive policies on improving household's absorptive capacity are strongly recommended.

Table 4: Impact of resilience capacity on household consumption and poverty

	Expenditure per capita (ln)	Absolute expenditure poverty	Relative expenditure poverty	Multidimensional poverty
A. Estimations on reduced consumption against shocks				
Reduced consumption due to shocks†	-0.942***	0.969***	0.478***	0.910***
	(0.278)	(0.253)	(0.179)	(0.256)
Household variables	*Yes*	*Yes*	*Yes*	*Yes*
Village variables	*Yes*	*Yes*	*Yes*	*Yes*
Constant	1.365***	-0.019	-0.398***	0.070
	(0.191)	(0.166)	(0.133)	(0.171)
Number of observations	10197	10197	10197	10197
Wald chi2(20)	1301.342	485.681	526.866	520.477
Prob > chi2	0.000	0.000	0.000	0.000
Under-identification	0.000	0.000	0.000	0.000
Weak-identification	23.318	23.318	23.318	23.318
B. Estimations on weak economic capacity				
Weak economic capacity†	-0.697***	0.717***	0.353***	0.673***
	(0.150)	(0.141)	(0.127)	(0.143)
Household variables	*Yes*	*Yes*	*Yes*	*Yes*
Village variables	*Yes*	*Yes*	*Yes*	*Yes*
Constant	1.627***	-0.289*	-0.531***	-0.183
	(0.183)	(0.167)	(0.158)	(0.162)
Number of observations	10197	10197	10197	10197
Wald chi2(20)	2434.245	800.012	606.026	907.550
Prob > chi2	0.000	0.000	0.000	0.000
Under-identification	0.000	0.000	0.000	0.000
Weak-identification	42.942	42.942	42.942	42.942

Note: Robust standard errors clustered at village level; †: Dummy; ln: natural logarithm; *** $p<0.01$, ** $p<0.05$, * $p<0.1$; The under-identification test is a LM test based on the rk LM statistics. The null hypothesis of this LM test is that the model is under-identified. The reported weak-identification test is the Kleibergen-Paap rk Wald F statistic. Full results presented in Appendices 4 – 5.

6. Summary and policy implications

In this study, we examined the correlation of infrastructure with a household's resilience capacity (absorptive capacity) against shocks and the impacts of this resilience capacity on household consumption and poverty. We used a sample of 1,698 households in Thailand and 1,701 households in Vietnam, the two emerging economies in Southeast Asia. Our study points out some significant findings.

First, the infrastructure helps improve a household's resilience capacity. Particularly, access to cable internet is estimated to have the largest positive influence on coping with shocks, both in terms of weak economic ability and whether a household had to reduce consumption due to shocks. This relationship, however, is likely to be magnified for the already better-off household. Besides, access to cable internet, made roads and phone lines significantly increased a household's ability to cope with shocks. Since especially

made roads have also been shown to decrease poverty and fuel long-term economic development, increasing efforts to enhance the road network could improve household's ability to cope with shocks in the worse-off remote areas. Therefore, infrastructure development projects should pay more attention to transportation and ICT facilities, especially in those countries with widespread access to electricity. Second, better education of adult members improves the household's resilience capacity, while a larger household size and asset-poor decrease the capacity of rural households to deal with shocks. Therefore, it is recommended that rural education be promoted, and focuses should be placed on poor households vulnerable to shocks and unable to cope with shocks. Third, the impacts of weak economic ability on chronic poverty are positive and significant in the case of absolute and multidimensional poverty. Hence, infrastructure development is recommended to provide job opportunities, generate household income, and improve economic capita.

Our study still has a number of limitations. First, we employed fixed-effects estimations with an instrumental variable to account for unobserved heterogeneity of household characteristics and endogeneity of the household's resilience capacity. However, the use of fixed-effects linear probability models limits the interpretation of our results, for example, the magnitude of the impacts of better resilience capacity on household consumption and poverty. Second, we used individual indicators to represent the absorptive capacity of a household's resilience, while there are several distinct capacities. Therefore, future studies should consider both absorptive capacity and other capacities, such as adaptive or transformative capacity.

Declaration of Competing Interest

The authors declare that they have no conflict of interest in this research.

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Appendix 1: Definition and measurement of household and village characteristics

Variables	Measurement	Definition
A. Consumption- and income variables		
Reduced consumption due to shocks	Dummy	If the household had to reduce consumption due to shocks in the current year = 1; otherwise = 0
Daily consumption per capita	PPP$ (adjusted to 2005 prices)	The daily consumption per capita of household
Daily income per capita	PPP$ (adjusted to 2005 prices)	The daily income per capita of household
B. Multidimensional poverty indicators		
No child education	Dummy	At least one school-age child up to the age of grade 8 is not enrolled in school = 1; otherwise = 0
No adult education	Dummy	No adult in the household (age of grade 9 or above) has completed primary education = 1; otherwise = 0
Unsafe drinking water	Dummy	The household has drinking water from well, river, lake, and pond = 1; otherwise = 0
No improved sanitation	Dummy	The household has no flush toilets = 1; otherwise = 0
No access to electricity	Dummy	The household has no access to electricity for lighting = 1; otherwise = 0
No appropriate housing condition	Dummy	The household has dwelling size per capita less than 10 m^2 = 1; otherwise = 0
No appropriate nutrition for children	Dummy	The household has malnourished child = 1; otherwise = 0
C. Household characteristics		
Gender of household head	Dummy	Gender of the household head. Male household head = 1; otherwise = 0
Age of household head	Years	Age of the household head
Health status of household head	Dummy	If household head is healthy or "can manage" = 1; otherwise = 0
Local household	Dummy	If the household head was born in the same as the current village = 1; otherwise = 0
Mean schooling years of adult members	Years	Average years of schooling of adult members in the household
Household size	Quantity	Number of members in the household
Share of laborers	Percentage	Share of members in working ages (from 15 to 64 years old) in the household
Household land area per capita	Hectares	Land area per capita of the household
Agricultural machines	Dummy	If the household has agricultural machines including 4-wheel tractors, engine sprayers, pumps, tanks, rice mill, and threshing machines = 1; otherwise = 0
Number of motorcycles	Quantity	Number of motorcycles that the household owns
Asset per capita	PPP$ (adjusted to 2005 prices)	Total accumulated asset value per capita of the household
D. Village characteristics		
Number of enterprises	Quantity	Number of enterprises with more than nine employees in the village
Having made roads instead of dirt roads	Dummy	If the main roads in the village are made roads (instead of dirt roads) = 1; otherwise = 0
Share of households with electricity at home	Percentage	The percentage of households with electricity at home in the village
Share of households with a phone line at home	Percentage	The percentage of households with a phone line at home in the village
Share of households with cable internet at home	Percentage	The percentage of households with cable internet at home in the village
Having access to public water supply	Dummy	If the village has public water supply available = 1; otherwise = 0
Having a bank agency in village	Dummy	If the village has a bank agency available = 1; otherwise = 0
Distance to next market	Kilometers	The distance from the household to the next market if in village

Appendix 2*:* Adjusted Multidimensional Poverty Measure (Source: based on World Bank, 2022)

Dimension	Parameter	Weight
Monetary	Daily consumption is less than US$3.20 PPP per capita.	1/4
Education	At least one school-age child up to the age of grade 8 is not enrolled in school.	1/8
	No adult in the household (age of grade 9 or above) has completed primary education.	1/8
Access to basic infrastructure	The household lacks access to safe sources for drinking water.	1/12
	The household lacks access to flush toilets.	1/12
	The household has no access to electricity for lighting,	1/12
Housing	The household has a dwelling size of less than 10m² per capita.	1/8
	The household has a malnourished child.	1/8

Appendix 3: Variance inflator factors (VIF) of independent variables

	Correlation of infrastructure and household's resilience capacity	Impacts of household resilience capacity on poverty	
		Reduced consumption due to shocks	Weak economic capacity
	(1)	(2)	(3)
Reduced consumption due to shocks		1.12	
Weak economic capacity			1.21
Male head	1.08	1.08	1.08
Age of head	1.18	1.19	1.18
Healthy head	1.11	1.11	1.11
Head born in the village	1.09	1.09	1.09
Mean schooling years of adult members	1.11	1.11	1.12
Household size	1.40	1.41	1.43
Share of laborers	1.23	1.23	1.24
Land area per capita	1.16	1.16	1.17
Having productive machines	1.20	1.20	1.20
Number of motorcycles	1.37	1.38	1.41
Asset poor	1.25	1.25	1.27
Number of enterprises	1.05	1.05	1.05
Having made roads instead of dirt roads	1.22	1.22	1.22
Share of households with electricity at home	1.02	1.02	1.02
Share of households with a phone line at home	1.08	1.08	1.08
Share of households with cable internet at home	1.10	1.10	1.10
Having access to public water supply	1.31	1.34	1.31
Having access to a bank agency in village	1.02	1.02	1.02
Distance to the closest market	1.18	1.19	1.18
Mean VIF	**1.17**	**1.17**	**1.18**

Appendix 4: The influence of reduced consumption due to shocks on household consumption and poverty

	Expenditure per capita (ln)	Absolute expenditure poverty	Relative expenditure poverty	Multidimensional poverty
Reduced consumption due to shocks†	-0.942***	0.969***	0.478***	0.910***
	(0.278)	(0.253)	(0.179)	(0.256)
Male head†	-0.021	0.014	-0.003	0.023
	(0.037)	(0.035)	(0.030)	(0.034)
Age of head	0.002	0.001	0.006***	-0.001
	(0.001)	(0.001)	(0.001)	(0.001)
Healthy head†	-0.034	0.034	0.047**	0.010
	(0.027)	(0.025)	(0.019)	(0.025)
Head born in the village†	0.009	-0.008	0.025	-0.003
	(0.039)	(0.034)	(0.029)	(0.033)
Mean schooling years of adult members	-0.005	0.002	-0.006**	-0.000
	(0.004)	(0.004)	(0.003)	(0.004)
Household size	-0.128***	0.073***	0.072***	0.083***
	(0.008)	(0.008)	(0.006)	(0.008)
Share of laborers	0.003***	-0.002***	-0.001**	-0.001***
	(0.000)	(0.000)	(0.000)	(0.000)
Land area per capita	-0.001	0.012	-0.003	0.012
	(0.011)	(0.009)	(0.007)	(0.008)
Having productive machines†	0.107***	-0.055***	-0.028*	-0.059***
	(0.021)	(0.020)	(0.015)	(0.019)
Number of motorcycles	0.119***	-0.072***	-0.043***	-0.077***
	(0.011)	(0.009)	(0.007)	(0.009)
Asset poor†	-0.128***	0.089***	0.139***	0.072***
	(0.022)	(0.023)	(0.018)	(0.022)
Number of enterprises	-0.001	0.005	0.005*	0.003
	(0.004)	(0.004)	(0.003)	(0.004)
Having made roads instead of dirt roads†	-0.008	0.037	0.048**	0.034
	(0.031)	(0.030)	(0.020)	(0.029)
Share of households with electricity at home (%)	0.000	-0.000	0.000	-0.000
	(0.001)	(0.001)	(0.001)	(0.001)
Share of households with a phone line at home (%)	0.001***	-0.001***	0.000**	-0.001**
	(0.000)	(0.000)	(0.000)	(0.000)
Share of households with cable internet at home (%)	0.001	0.001	0.002***	0.001
	(0.001)	(0.001)	(0.001)	(0.001)
Having access to public water supply†	0.012	0.002	-0.021	0.001
	(0.028)	(0.025)	(0.020)	(0.026)
Having a bank agency in village†	-0.020	0.015	-0.002	0.011
	(0.051)	(0.042)	(0.032)	(0.039)
Distance to the closest market	0.003	-0.000	0.002	0.001
	(0.004)	(0.003)	(0.002)	(0.003)
Constant	1.365***	-0.019	-0.398***	0.070
	(0.191)	(0.166)	(0.133)	(0.171)
Number of observations	10197	10197	10197	10197
Wald chi2(20)	1301.342	485.681	526.866	520.477
Prob > chi2	0.000	0.000	0.000	0.000
Under-identification	0.000	0.000	0.000	0.000
Weak-identification	23.318	23.318	23.318	23.318

Note: Robust standard errors clustered at village level; †: Dummy; ln: natural logarithm; *** $p<0.01$, ** $p<0.05$, * $p<0.1$; The under-identification test is a LM test based on the rk LM statistics. The null hypothesis of this LM test is that the model is under-identified. The reported weak-identification test is the Kleibergen-Paap rk Wald F statistic.

Appendix 5: The influence of weak economic capacity on household consumption and poverty

	Expenditure per capita (ln)	Absolute expenditure poverty	Relative expenditure poverty	Multidimensional poverty
Weak economic capacity†	-0.697***	0.717***	0.353***	0.673***
	(0.150)	(0.141)	(0.127)	(0.143)
Male head†	0.026	-0.033	-0.027	-0.022
	(0.033)	(0.030)	(0.029)	(0.029)
Age of head	-0.001	0.004**	0.008***	0.002
	(0.002)	(0.001)	(0.001)	(0.001)
Healthy head†	-0.008	0.007	0.034**	-0.015
	(0.019)	(0.018)	(0.016)	(0.017)
Head born in the village†	-0.006	0.007	0.032	0.012
	(0.032)	(0.027)	(0.026)	(0.028)
Mean schooling years of adult members	-0.010***	0.007***	-0.003	0.005*
	(0.003)	(0.003)	(0.002)	(0.003)
Household size	-0.110***	0.054***	0.063***	0.066***
	(0.009)	(0.009)	(0.008)	(0.009)
Share of laborers	0.001***	-0.000	0.000	-0.000
	(0.000)	(0.000)	(0.000)	(0.000)
Land area per capita	0.014	-0.004	-0.010	-0.002
	(0.009)	(0.006)	(0.006)	(0.006)
Having productive machines†	0.062***	-0.008	-0.006	-0.015
	(0.015)	(0.015)	(0.013)	(0.014)
Number of motorcycles	0.082***	-0.033***	-0.024**	-0.040***
	(0.013)	(0.011)	(0.010)	(0.011)
Asset poor†	-0.102***	0.062***	0.126***	0.047**
	(0.018)	(0.020)	(0.018)	(0.019)
Number of enterprises	0.005	-0.001	0.002	-0.003
	(0.004)	(0.003)	(0.003)	(0.003)
Having made roads instead of dirt roads†	-0.021	0.049**	0.055***	0.046**
	(0.026)	(0.023)	(0.020)	(0.023)
Share of households with electricity at home (%)	-0.000	-0.000	0.000	0.000
	(0.001)	(0.001)	(0.001)	(0.001)
Share of households with a phone line at home (%)	0.002***	-0.001***	0.000*	-0.001***
	(0.000)	(0.000)	(0.000)	(0.000)
Share of households with cable internet at home (%)	0.002***	-0.000	0.002**	-0.000
	(0.001)	(0.001)	(0.001)	(0.001)
Having access to public water supply†	0.016	-0.002	-0.023	-0.003
	(0.023)	(0.021)	(0.019)	(0.021)
Having a bank agency in village†	0.026	-0.033	-0.026	-0.034
	(0.031)	(0.027)	(0.026)	(0.026)
Distance to the closest market	0.003	-0.000	0.002	0.001
	(0.003)	(0.002)	(0.002)	(0.002)
Constant	1.627***	-0.289*	-0.531***	-0.183
	(0.183)	(0.167)	(0.158)	(0.162)
Number of observations	10197	10197	10197	10197
Wald chi2(20)	2434.245	800.012	606.026	907.550
Prob > chi2	0.000	0.000	0.000	0.000
Under-identification	0.000	0.000	0.000	0.000
Weak-identification	42.942	42.942	42.942	42.942

Note: Robust standard errors clustered at village level; †: Dummy; ln: natural logarithm; *** $p<0.01$, ** $p<0.05$, * $p<0.1$; The under-identification test is a LM test based on the rk LM statistics. The null hypothesis of this LM test is that the model is under-identified. The reported weak-identification test is the Kleibergen-Paap rk Wald F statistic.

Appendix 6: The influence of the ability to cope with shocks on the vulnerability to poverty

	Chronic absolute poverty	Chronic relative poverty	Chronic multi-dimensional poverty	Chronic absolute poverty	Chronic relative poverty	Chronic multi-dimensional poverty
Reduced consumption due to shocks†	1.370	-0.471	1.570			
	(1.018)	(0.495)	(1.163)			
Weak economic capacity†				0.362***	-0.125	0.418***
				(0.101)	(0.094)	(0.113)
Male head†	0.091	-0.042	0.114	-0.001	-0.011	0.008
	(0.082)	(0.043)	(0.095)	(0.026)	(0.027)	(0.028)
Age of head	-0.002	0.002*	-0.002	0.001	0.001	0.001
	(0.002)	(0.001)	(0.003)	(0.001)	(0.001)	(0.001)
Healthy head†	0.025	-0.006	0.020	-0.008	0.006	-0.017
	(0.054)	(0.025)	(0.061)	(0.016)	(0.014)	(0.018)
Head born in the village†	-0.057	0.021	-0.053	0.012	-0.003	0.026
	(0.069)	(0.042)	(0.079)	(0.027)	(0.030)	(0.029)
Mean schooling years of adult members	0.011	-0.002	0.011	0.004*	0.000	0.003
	(0.007)	(0.003)	(0.008)	(0.002)	(0.002)	(0.003)
Household size	0.026*	0.022***	0.031*	0.027***	0.022***	0.032***
	(0.015)	(0.008)	(0.017)	(0.007)	(0.006)	(0.007)
Share of laborers	-0.001	-0.001*	-0.001	-0.000	-0.001**	-0.000
	(0.001)	(0.000)	(0.001)	(0.000)	(0.000)	(0.000)
Land area per capita	0.021	-0.001	0.025	0.003	0.006	0.004
	(0.017)	(0.009)	(0.019)	(0.005)	(0.006)	(0.007)
Having productive machines†	-0.086*	0.011	-0.089	-0.019	-0.012	-0.012
	(0.051)	(0.024)	(0.057)	(0.014)	(0.013)	(0.015)
Number of motorcycles	-0.053***	-0.009	-0.056***	-0.026***	-0.018**	-0.027***
	(0.017)	(0.008)	(0.019)	(0.008)	(0.007)	(0.009)
Asset poor†	0.017	0.076***	0.010	0.042*	0.068***	0.034
	(0.055)	(0.029)	(0.062)	(0.022)	(0.020)	(0.021)
Number of enterprises	0.003	-0.000	0.003	0.001	0.000	0.001
	(0.005)	(0.002)	(0.005)	(0.003)	(0.002)	(0.003)
Having made roads instead of dirt roads†	0.089	0.014	0.087	0.059**	0.024	0.054**
	(0.078)	(0.038)	(0.091)	(0.024)	(0.020)	(0.026)
Share of households with electricity at home (%)	-0.001	-0.000	-0.001	-0.000	-0.001	-0.000
	(0.002)	(0.001)	(0.002)	(0.000)	(0.000)	(0.001)
Share of households with a phone line at home (%)	0.002	-0.001	0.002	-0.000	0.000	-0.000
	(0.002)	(0.001)	(0.002)	(0.000)	(0.000)	(0.000)
Share of households with cable internet at home (%)	0.001	-0.001	0.002	-0.000	0.000	-0.000
	(0.002)	(0.001)	(0.002)	(0.001)	(0.000)	(0.001)
Having access to public water supply†	-0.007	0.012	-0.027	0.000	0.010	-0.018
	(0.066)	(0.029)	(0.079)	(0.024)	(0.021)	(0.030)
Having a bank agency in village†	-0.055	-0.006	-0.054	-0.034	-0.013	-0.031
	(0.090)	(0.031)	(0.096)	(0.035)	(0.032)	(0.038)
Distance to the closest market	-0.007	0.002	-0.006	-0.004**	0.001	-0.002
	(0.005)	(0.003)	(0.006)	(0.002)	(0.001)	(0.002)
Constant	-0.219	0.324	-0.283	0.013	0.244*	-0.019
	(0.540)	(0.252)	(0.610)	(0.149)	(0.139)	(0.171)
Number of observations	6798	6798	6798	6798	6798	6798
Wald chi2(20)	58.358	62.408	53.553	282.626	96.175	293.167
Prob > chi2	0.000	0.000	0.000	0.000	0.000	0.000
Under-identification	0.151	0.151	0.151	0.000	0.000	0.000
Weak-identification	2.083	2.083	2.083	31.931	31.931	31.931

Note: Robust standard errors clustered at village level; †: Dummy; ln: natural logarithm; *** $p<0.01$, ** $p<0.05$, * $p<0.1$; The under-identification test is a LM test based on the rk LM statistics. The null hypothesis of this LM test is that the model is under-identified. The reported weak-identification test is the Kleibergen-Paap rk Wald F statistic.