PHANWIN YOKYING
Curriculum Vitae

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Education

American University, Washington, DC, USA

Ph.D., Economics, May 2018

Main Theory Track: Microeconomics

Research Fields: Development, Labor, and Agricultural Economics

Dissertation: Three Essays on Women's Empowerment: Lessons from Ghana and Thailand

Randolph College, Lynchburg, VA, USA

B.A., Economics, May 2011, *Magna Cum Laude*

Minors: Mathematics and International Relations

Thesis: Effects of 9/11 on Earnings of Muslim Women: Difference in Difference Analysis

Fellowships, Honors, and Awards

American University

Dissertation Fellowship, Spring 2017

Association of Social Economics's Summer School Travel Grant, Summer 2016

College of Arts and Science Travel Grants, Summer 2015 and Summer 2016

Mellon Research Award, April 2016

Full Tuition Remission and Graduate Assistanceship, 2012-2016

Vollmer Foundation Scholarship, Summer 2014-Fall 2015

P.E.O. International Peace Scholarship, August 2012-April 2013 (declined)

Institute of International Education Student Fund, 2012

Randolph College

Randolph's Innovative Student Experience Award, Spring 2011

Dean's list, three semesters (GPA of 3.7 or higher)

Randolph International Grant, 2007-2011

Randolph Founders Scholar, 2007-2011

Doris Buffett's Sunshine Lady Foundation Scholar, 2007-2011

Omicron Delta Epsilon, April 2010

Outstanding Position Papers and Honorable Mention for Delegation Performance, National Model United Nations Annual Conference, the United Nations Headquarters, April 2009

Publications

Phanwin Yokying, Sumeet Saksena, and Jefferson Fox (2023). Impacts of Migration on Time Allocation of Those Who Remain at Home in Rural Nepal, *Journal of International Development*.

Phanwin Yokying (2022).Why India Must Make Gender Equity a Top Priority, *Policy Forum*.

Ram Chhetri, **Phanwin Yokying**, Alexander Smith, Jamon Van Den Hoek, Kaspar Hurni, Sumeet Saksena, and Jefferson Fox (2021). Forest, Agriculture, and Migration: Comtemplating the Future of Forestry and Agriculture in the Middle-Hills of Nepal, *Journal of Peasant Studies*.

Phanwin Yokying and Isabel Lambrecht (2020).Landownership and the Gender Gap in Agriculture: Insights from northern Ghana, *Land Use Policy*.

Phanwin Yokying and Maria Floro (2020). Parents' Labour Force Participation and Children's Involvement in Work Activities: Evidence from Thailand, *Oxford Development Studies*.

Jefferson Fox, **Phanwin Yokying**, Naya Sharma Paudel, and Ram Chhetri (2020). Another Possible Cost of COVID-19: Returning Workers May Lead to Deforestation in Nepal, *East-West Wire*.

Jefferson Fox, Arunee Promkhambut, and **Phanwin Yokying** (2020). Impact of COVID-19 on Rice Farmers in Southeast Asia, *East-West Wire*.

Phanwin Yokying (2018). South Korea's Time Use Survey and Care Policies. In Invisible no more? Report and Country Case Studies on Time Use and Unpaid Work (pp. 78-84). Washington, DC: Data2X.

Phanwin Yokying (2018). Thailand's Time Use Survey and Care Policies. In Invisible no more? Report and Country Case Studies on Time Use and Unpaid Work (pp. 91-97). Washington, DC: Data2X.

Daniel Kuehn and **Phanwin Yokying** (2017). In R. Lerman and E. A. Okoli (Eds.), *Apprenticeship Formalization and Gender in Ghana*. Paper presented at the International Network on Innovative Apprenticeship Conference, Washington, DC, 2-3 October, pp. 123-127.

Phanwin Yokying, Budsara Sangaroon, Tassanee Sushevagul, and Maria Floro (2016). Work-Life Balance and Time Use: Lessons from Thailand, *Asia-Pacific Population Journal*.

Working Papers

Land, labor, capital, and rice farming in Thailand *(with Arunee Promkhambut; Kevin Woods; Micah Fisher; Ming Li Yong; Kanokwan Manorom; Ian G. Baird; Jefferson Fox)*. Revised and resubmitted.

Employment of rural and urban women and domestic violence in Pakistan. Submitted.

Work in Progress

Migration, remittances, and rice farming in Cambodia *(with Jefferson Fox)*. Revision in progress.

Research Grants

Proposal Writer and Co-Principal Investigator, State of Social Inclusion in Nepal: A Study of Time Allocation (SOSIN-SOTA). LASER PULSE/USAID. P.I: Mukta Singh Lama-Tamang. January 2022-April 2023: 199,821.68 USD. Funded.

Co-Principal Investigator, Impacts of Climate Variability on Time Use in the Chao Phraya Delta, In Vulnerable Deltas in Southeast Asia: Climate Change, Water Pollution, and Socio-Economic Transformation Initiative. Henry Luce Foundation. May 2022- May 2025: 945,000 USD. Funded.

Collaborator, Forced and Truncated Agrarian Transitions in Asia Through the Lens of Field Size Change. NASA. P.I: Lin Yan and Co-I: Jefferson Fox. January 2020-December 2023: 321,542 USD.

Collaborator, The Agrarian Transition in Mainland Southeast Asia: Changes in Rice Farming–1995 to 2018. NASA. P.I: Jefferson Fox and Co-I: Sumeet Saksena. January 2018-December 2022: 750,000 USD.

Collaborator, Human Capital Development Project. U.S.'s Department of State. P.I: Jake Hamstra. October 2020-September 2021: 1 million USD (Research Cooperative Agreement).

Collaborator, Twenty-Five Years of Community Forestry: Mapping Forest Dynamics in the Middle Hills of Nepal. NASA. P.I: Jefferson Fox and Co-I: Sumeet Saksena. April 2015-March 2020: 750,000 USD.

Research Experience

Fellow, Research Program, East-West Center, August 2018-Present

Research Assistant, Professor Maria Floro, Department of Economics, American University, June 2017-September 2017

Graduate Advising Fellow, Office of Merit Awards, American University, August 2012-April 2016

Contractor, United Nations Economic and Social Commission for Asia and the Pacific, October 2014-March 2016

Short-Term Consultant, International Food Policy Research Institute, July 2015-September 2015

Research Intern, International Food Policy Research Institute, June 2014-August 2014

Research Assistant, Professor Mary Hansen, American University, January 2012-July 2013

Research Intern, Deutsches Institut fur Wirtschaftsforschung, Washington, DC, May 2010-July 2010

Associate Editor, Undergraduate Economic Review, Illinois Wesleyan University, September 2010-May 2011

Research Intern, Royal Thai Embassy, Washington, DC, May 2009-July 2009

Professional Activities

Host, 2022 EWC/EWCA International Conference, Honolulu, HI, USA, June 30-July 1, 2022

Moderator, EWC Insights: Asia-Pacific Transitions,virtual, March 2021-Present

Presenter, EWC Friday Noon Meeting, Honolulu, HI, USA, May 2022

Panelist, EWC Briefing for U.S. Indo-Pacific Command's International Fellows Program, Honolulu, HI, USA, May 2022

Panelist, EWC Briefing for Incoming Consul General to Chiang Mai, Honolulu, HI, USA, May 2022

Panelist, EWC Briefing for Air War College, Honolulu, HI, USA, March 2022.

Presenter, LASER GRCD-Nepal USAID Mission Quarterly Check In, virtual, February 2022

Lead Discussant, EWC Briefing for the School of Advanced Military Studies, Advanced Strategic Leadership Studies Program, Honolulu, HI, USA, February 2022

Presenter, EWC Insights: Migration and Family Left Behind, virtual, July 2021

Presenter, American Association of Geographers Annual Meeting, virtual, April 2021

Panel Speaker, Mekong, China, and Southeast Asian Transitions Series: Migration, Mobility and the Mekong, Honolulu, HI, USA, February 2021

Senior Abstract Reviewer, 20th East-West Center International Graduate Student Conference, Honolulu, HI, USA, November 2020

Presenter, 46th Eastern Economic Association Annual Conference, Boston, MA, USA, February 2020

Participant, UN Women/UNDP Thinkshop, Bangkok, Thailand, July 2019

Discussant, Care Work and the Economy Annual Meeting, Glasgow, Scotland, June- July, 2019

Session Organizer, Chair, Presenter, and Discussant, Midwest Economics Association Annual Meeting, St.Louis, MO, USA, March 2019

Presenter, Pathways to Gender Equality Conference, Washington, DC, USA, November 2018

Presenter, International Center for Research on Women's Meeting on Women's Reproductive Health and Childcare, Washington, DC, USA, June 2017

Poster Presenter, International Monetary Fund's Gender and Macroeconomics Conference, Washington, DC, USA, March 2017

Presenter and Discussant, Southern Economic Association 86th Annual Meetings, Washington DC, USA, November 2016

Summer School Participant, Association of Social Economics, University of the Basque Country, Spain, June 2016

Presenter, 13th International Conference Development in Economic Theory and Policy, University of the Basque Country, Spain, June 2016

Presenter, Discussant, and Session Chair, 42nd Eastern Economic Association Annual Conference, Washington, DC, USA, February 2016

Presenter, 37th International Association for Time Use Research Conference, Ankara University, Turkey, August 2015

Presenter, Society of Government's 2015 Annual Conference, George Washington University, USA, May 2015

Discussant, Virginia Association of Economists, Federal Reserve Bank of Richmond, USA, March 2011

Participant, Economic and Finance Council of Model European Union, Washington, DC, USA, October 2009

Participant, Economics and Financial Committee of National Model United Nations, United Nations Headquarters, New York, USA, April 2009

Other Professional Activities

Referee for *World Development* and *GeoJournal*.

Member of the *American Economic Association*, *International Association for Time Use Research*, and *Eastern Economic Association*

Skills

Computer Skills

Stata, LaTex, Python, Eviews, Mathematica, Derive, and Microsoft Office

Language Skills

Thai (native), English (fluent)

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Migration, remittances, and rice farming: Evidence from Cambodia

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Abstract

Migration out of agriculture has been a dominant survival strategy among rice farming households in Cambodia. Using Cambodia's Feed the Future data, we examine the effects of domestic and international migration along with remittances on production, sales, and income generated from rice farming during the wet season. Based on a recursive system of equations, we show that withdrawal of household farm labor due to both domestic and international migration exerts negative and significant effects on rice production. Domestic migration also depresses rice sales. Remittance earnings, on the other hand, do not have any influence on rice production, sales, and income. As Cambodia continues to enhance its rice productivity and improve its export competitiveness, our findings highlight the need for targeted policies that aim to counteract the lost-labor effect caused by both domestic and international migration in Cambodia's rice sector.

Keywords: domestic migration, international migration, remittances, rice farming, Cambodia

1. Introduction

Migration out of agriculture has long been a prevalent livelihood and investment strategy among farming households and is considered as an important mechanism in reducing poverty and promoting growth in Cambodia—one of the poorest countries in Southeast Asia (Roth and Tiberti, 2017; IMF, 2018). Its economy has experienced more than two decades of accelerating growth after the war-time devastation of the 1970s and 1980s, averaging 7.4% over the period 1998-2020 (World Bank, 2021). Even though Cambodia remains an agrarian economy, with approximately 80% of Cambodians residing in rural areas, its urbanization rate is recognized as one of the world's fastest, namely in Phnom Penh, whose population has tripled in the past two decades (Mishra et al., 2018; Peou, 2016; World Bank, 2015). Due to uneven growth resulting in wage differentials between rural and urban areas and among neighboring Southeast Asian countries (Rigg, 2004), almost one in four Cambodian households has at least one migrant (Peou, 2016; MOP, 2012). Most of its migrants or about 70% remit money back home, making Cambodia among the top four remittance-receiving countries in ASEAN (OECD, 2017; IFAD, 2013). Remittances from Cambodian migrants has increased steadily in volume since 1997 and started to grow rapidly in 2010, when Southeast Asia emerged from the global financial crisis (World Bank, 2021). As Cambodia's economy continues to develop, both rural outmigration and remittances are expected to grow, generating a critical concern on their effects on the backbone of its agricultural sector—rice cultivation.

Rice cultivation remains a key source of livelihoods for most rural households. Many of them are smallholders and are impoverished. Although roughly 75% of its 3.7 million hectares of cultivated land is devoted to rice production and although its rice sector has been undergoing rapid development in terms of mechanization and adoption of improved varieties and increased use of fertilizer (Cramb et al., 2020), its productivity remains the lowest among rice-growing countries in Southeast Asia (Mishra et al., 2018). To shed lights on the understudied implications of migration and remittances on agricultural development, this paper examines the impact of domestic and international migration on rice production, sales, and income and study whether remittance earnings worsen or compensate for the withdrawal of household

farm labor due to migration. These research objectives have received less scholarly attention in the literatures focused on migration, especially in the context of Cambodia. Answers to these questions will provide important and needed evidence for reformation and formulation of policies aiming to boost rice production, enhance competitiveness of rice exports, and uplift the well-being of migrant-sending and rice farming households.

Even though the continued absorption of rural labor force into expanding industrial and service sectors as well as the growth of remittances are a key feature of economic development and even though the impact of migration and remittances on migrants' home communities has attracted increasing empirical attention, there remains little analysis focusing on agriculture. The New Economics of Labor Migration (NELM) provides a relevant theoretical framework to explore how migration influences farm productivity in migrant-sending communities. The NELM posits that migration boost productivity by relaxing household credit constraints and allowing households to better manage risks, yet migration can trigger shortages in the supply of farm workers, which can hinder productivity and income (Stark, 1991). The existing studies that have empirically tested the applicability of the NELM theory include Lucas (1987), Taylor and Wyatt (1996), Rozelle et al. (1999), Taylor et al. (2003), Atamanov and Van Den Berg, (2012), Tuladhar et al. (2014), Shi (2018), and Zhunusova and Herrman, (2018).

This paper contributes to the literature in several ways. First, this paper focuses on Cambodia's dominant food and cash crop: rice. Most of the existing studies focuses on other types of cash crops such as maize, wheat, tea, and tobacco (Lucas, 1987; Rozelle et al., 1999; Atamanov and Van Den Berg, 2012; Zhunusova and Herrman, 2018), and a few studies focuses on rice yields and income (Taylor et al., 2003; Shi, 2018). Given that rice contributes around 25% of the total agricultural gross domestic product and employs around 20% of Cambodia's total population, changes in or shocks to rice cultivation can affect its agricultural sector along with well-being of smallholder Cambodians. It is therefore essential to understand how rice farming at the household level is affected by outmigration and remittance transfers. Second, we incorporate not only rice production, but also rice sales and income in our analysis because these outcomes are all vital and interrelated aspects of agricultural and rural development. Except for

Taylor et al., (2003), other studies focus solely on either crop yield (Rozelle et al., 1999; Shi, 2018) or income (Atamanov and Van Den Berg, 2012; Zhunusova and Herrman, 2018). By considering rice production, sales, together with income, this paper provides a well-rounded quantitative analysis on their impact on household rice farming.

Third, this analysis provides new empirical evidence on the effect of migration on rice farming by making a distinction between domestic and international migration. To the best of our knowledge, none of the related empirical studies such as Rozelle et al. (1999) and Taylor et al. (2003) have made such distinction, while other studies focus exclusively either on domestic migration (Shi, 2018) or international migration (Atamanov and Van Den Berg, 2012; Zhunusova and Herrman, 2018). Given that international migration incurs higher costs and risks but yields high economic returns when compared to domestic migration (MOP, 2012), considering both types of migration enable this study to provide new evidence on the effect of domestic and international migration on household rice farming.

The structure of this paper is the following. Section 2 provides background information on migration, remittances, credit access in rice farming communities in Cambodia. Section 3 discusses the NELM framework, and section 4 explains the data. In Section 5, we explain the econometric methodology. Section 6 discusses the descriptive and regression results. Section 7 concludes.

2. Background: Migration, rice farming, and credit access in Cambodia

2.1 Migration in Cambodia

Cambodia has experienced increasing levels of domestic and international migration in recent years owning to various development challenges including poverty, landlessness, raising household debt, natural disasters, poor access to education and social protection (e.g. healthcare), and lack of employment for its rapidly growing youth population (Peou, 2015; Bylander, 2014; Bylander, 2017; OECD, 2017). About 10% of Cambodians over the age of 15—most of whom are low-skilled workers— plan to migrate away from agriculture (OECD, 2017). Fueled by stories and wealth brought to the countryside by former migrants as well as by images of the city and modernity illustrated through the media, the hope for upward social mobility or modern lifestyles coupled with the desire to gain financial independence also

motivates many rural young Cambodians to migrate into the city or neighboring countries (Peou, 2015). Growing number of rural Cambodians leave their communities seasonally or permanently to Phnom Penh and other economically active provinces, namely Battambang, Kampong Cham, and Siem Reap (Roth and Tiberti, 2017). Most domestic migrants are employed in the manufacturing and service sectors (Marchetta and Sim, 2021). Rapid urbanization and development in Phnom Penh attract rural Cambodians to its garment factories, while the expanding tourism industry that drives establishments of hotels, restaurants, and shops also require labor sourced from rural Cambodia (NIS, 2019).

International migration has also soared during the past decades, with 1.19 million Cambodians estimated to be living abroad in 2015, which represents about 7.6% of the total population, when compared to 3.7% in 2000 (Bylander, 2017; Marchetta and Sim, 2021). Thailand is the most common destination country and hosts about 93% of Cambodian emigrants (NIS, 2019). Although opportunities for legal migration to Thailand began in 2003 with a Memorandum of Understanding between Cambodia and Thailand, many Cambodian migrants to Thailand are undocumented due to Thailand's porous and long borders with Cambodia, low cost of migration, and lack of formalization (Bylander, 2017; Marchetta and Sim, 2021). Cambodian migrants in Thailand are typically employed as construction workers, while some work as agricultural workers. After Thailand, Malaysia and South Korea are major destinations. Most migration to these countries occurs through regular channels, and about 87% of migrants who legally worked in Malaysia are women, and many of these women are employed in domestic work while some are in manufacturing (Tunon and Rim, 2013).

With about 70% of Cambodian migrants send money home, remittances constitute an important source of income for many households. While many remittances are small averaging 23 USD per month, the amount varies depending on the destination areas and type of work (NIS, 2012). For example, housemaids in Thailand remit roughly 334 USD a year on average, compared to 265 USD among those in the construction sector (OCED, 2017). Remittances from Cambodian migrants have been increasing in volume over time from 142 million USD in 2009 to 1.272 billion in 2020 (World Bank, 2021). Some remittance-receiving households use the remittance income to invest in agriculture by, for instance,

purchasing labor-saving machines for rice farming (Rigg et al., 2016). Yet, remittances may not necessarily be used productively (OECD, 2017). Remittances sent home from family members working in urban areas or abroad are often used to purchase consumer goods including television, cell phones, and motorbikes (World Bank, 2014) or finance household debt (Bylander, 2014). In particular, many agrarian households face difficulty in repaying their loans and are trapped in a vicious cycle of high-interest indebtedness due to unchecked expansion of formal microfinance lending (Bylander, 2014; Seng, 2018). The over-indebtedness crisis creates a pressure for young and working-age Cambodians to migrate and remit to help their families repay their debt (Seng, 2018).

2.2 Cambodian rice sector: An overview

About 1.0 million smallholder households are engaged in rice cultivation (Mishra et al., 2018). The largest concentration of rice production in Cambodia is centered around the Tonle Sap and the south-eastern lowlands (Cramb et al., 2020). As rainfed lowland rice remains the mainstay of Cambodia's rural economy, the rice sub-sector has been an important driver of growth in agriculture (Cramb et al., 2020). The development of the rice sector that started in the 1990s attributed to a substantial increase in yields and production as well as a decline in poverty (Mishra et al., 2018). About two-thirds of the reduction in poverty during 1990 to 2017 was attributable to agricultural growth such that higher rice prices leaded to increased production and farm income and wages (Cramb et al., 2020). About 85% of the total rice is cultivated during wet season, which depends on rainfall from May to October, and the rest is grown in dry season, which relies on full or supplementary irrigation or in receding floodwater from November to April (Cramb et al., 2020). Many rice-growing households in south-eastern lowlands have rice lands of less than one hectare, but for the country as a whole the average rice land increased from 1.9 hectares in 2008 to 2.1 hectares in 2012, reflecting outmigration from the populated south-east and in-migration in the north and north-west (Cramb et al., 2020).

With expansion of cultivated area, increasing trade liberalization, strong government support, along with enhanced access to improved varieties and other essential inputs, the development in rice production has generated a rice surplus, allowing the export of rice to raise sharply (World Bank, 2015).

The rice surplus increased from 1.44 million t of milled rice in 2008 to 2.38 million t in 2013 (Cramb et al., 2020). Since 2005, Cambodia has been a net rice exporter and exports two types of white and fragrant rice. (Mishra et al., 2018). Major importers of Cambodia's premium fragrant rice are China and Hong Kong, Cote d'Ivoire, France, Germany, Singapore, and the US (World Bank, 2015). In 2013, the country formally exported 378,850 t to over 50 countries, and 91% of which were in the EU or Asia. In the same year, informal cross-border trade of milled and unmilled rice to Vietnam and Thailand was around 1.5 million t. A large part of the paddy produced in Cambodia is exported to Thailand and Vietnam, where it is milled and either locally distributed or further exported to other countries. This process represents a significant lost opportunity for Cambodian rice millers to add value, expert directly, and create employment locally (World Bank, 2015).

Despite a decade of rapid growth in the rice sector, Cambodia's rice yield remains the lowest in Southeast Asia (Mishra et al., 2018; ADB, 2012). Factors threatening Cambodian farmers' productivity include poor soil quality, lack of access to commercial credit, high interest rates, poor irrigation, high costs of fertilizers and pesticides, limited use of improved high-yielding varieties, and biotic and abiotic stresses (e.g. drought, flood, and climate change) (Mishra et al., 2018; ADB, 2012). These challenges can have severe consequences on agricultural development, food security, and poverty reduction for Cambodia where roughly three million people relies on agriculture as their main income source and where rice constitutes most of the total agricultural output (ADB, 2012).

2 New Economics of Labor Migration Theories

The NELM pioneered by Stark (1982) provides a theoretical foundation for examining how outmigration and remittance transfers can influence agricultural development. The NELM considers two important features of rural areas in developing countries. First, the NELM recognizes that rural insurance, labor markets, and credit markets in rural economies of developing countries are missing and imperfect (Stark, 1982). In the absence of perfect credit markets, rural households lack capacity to invest in output-enhancing modern technology or shift to commercial production due to limited access to cash or a loan from a bank or to prohibitive loan conditions imposed by local moneylenders (Taylor, 1992; Taylor,

2006). Imperfections in local institutions necessitate agricultural households to self-finance production and self-insurance against production and income risks through migration and remittance transfers (Taylor and Wyatt, 1996). Second, the NELM views migration decisions as a calculated household strategy made jointly by migrant and non-migrant family members to overcome market and institutional failures impeding production and uplift the households' welfare (Stark and Bloom, 1985). As such, migration-related costs and returns (transportation, maintenance of migrant until s/he becomes financially independent in the new community, and patterns of remittances) are shared within the household under an implicit contractual agreement guiding their distribution (Stark and Bloom, 1985).

Migration inevitably serves as a household financial intermediary in the presence of imperfect markets or credit constraints (Stark,1991; Taylor et al., 2003). That is, a migrant can help relax the household's credit or liquidity constraint and provide the household with essential capital and income security that can stimulate production by sending back remittances or by being willing to remit in the event of adverse income shocks (Stark and Bloom, 1985; Stark, 1991; Taylor, 2006). As a substitute for formal insurance or formal and informal credit, remittances can accommodate adoption of new agricultural technologies, facilitate investments in farm inputs, and foster diversification in farm activities (Wouterse and Taylor, 2008). This allows the rural household to overcome risk and credit constraints on its ability to achieve transition from subsistence to commercial production or to simply invest on their farms (Taylor et al., 2003). Consequently, the NELM hypothesizes that migration and remittances can positively affect agricultural output and income.

However, as underlined by Taylor et al. (2003), migration and its credit-relaxing impact do not come without a cost under the NELM. When faced with an imperfect labor market limiting access to farm workers, rural households are unavoidably dependent on their family labor. The withdrawal of household labor from agriculture reduces the supply of household labor and restricts the amount of the fixed resources that can be allocated to household agricultural production, causing farm labor shortages for migrant-sending households and communities. Hence, migration can hamper agricultural production and income, signifying that the potential effect of migration on agricultural production could be negative

(Taylor et al., 2003). Additionally, remittance income may serve primarily to enhance consumption or non-agricultural activities as opposed to facilitating productive agricultural investments (Taylor, 2006; Wouterse and Taylor, 2008). Remittances as a result may not have any significant influence or a negative impact on household rice production, sales, and income.

Several empirical studies have tested the NELM theory. Providing evidence in favor of the NELM, Lucas (1987) examines temporary labor migration from five African countries to South Africa's mines and shows that emigration diminishes domestic crop production in the short run. In the long run, it enhances crop productivity and cattle accumulation through invested remittances and raises domestic plantation wages. Similarly, Taylor (1992) finds that migrant remittances have positive short-term and long-term asset-accumulation effects on household farm income and that they affect income and inequality over time by increasing investments in Mexico. Substantiating the results of earlier studies, Rozelle, Taylor, and De Brauw (1999) show that yields fall sharply as each family member leaves the farm in China, implying that on-farm labor markets are conspicuously absent and that migration generates lost-labor effects depressing yields. Their results also show that remittances loosen constraints on crop production and stimulate productivity— an indication that the negative effect from less family labor is in part compensated by access to capital through increased remittances. The above studies, however, do not consider how agricultural production and income may differ depending on the types of migration.

A few related studies have acknowledged that a distinction needs to be made between different types of migration since the consequences of migration can be heterogeneous depending on the type of migration. For instance, Wouterse and Taylor (2008) test the impact of inter-continental and continental migration on activity choice and rural households' incomes. Their econometric evidence shows that continental migration has no significant effect on agricultural or livestock activities, yet inter-continental migration (which is more likely to be long-term and yields higher remittances) increases livestock production. Atamanov and Van Den Berg (2012) hypothesize that permanent and seasonal migration may impact differently on local activities. Their results indicate that migration has a significant negative impact on crop income for only households with permanent migrants, not those with seasonal migrants.

Remittances partially compensate for the negative lost-labor effect, but their positive impact reduces with agricultural land size.

Following Wouterse and Taylor (2008) and Atamanov and Van Den Berg (2012), we distinguish between two forms of migration—domestic and international migration. These two types of migration can have different impacts on farm households' risk, insurance, credit, and labor constraints. As described by Taylor (2006), international migration to distant labor market entails long periods of withdrawal of family farm labor and involves higher costs (for example, border crossing and visa fees) and risks (that they may fail to find jobs or remit) than domestic migration. Individuals who migrated abroad tend to be relatively more educated and skilled than those who migrated domestically. If labor markets in rural areas do not operate well and households lack access to input substitutes in a form of hired labor or labor-saving inputs, international migration can considerably diminish production. Domestic migrants may be able to return to their home communities at harvest time when labor is most needed, while international migrants may not be able to. Nonetheless, international migration generates higher returns; remittances from an international migrant are several times larger than those from a domestic migrant and serves as a more favorable "insurance policy" because it is less associated with local earnings and labor markets.

Overall, the net effect of migration on agricultural production and earnings remains uncertain since the relative strength and magnitudes of the above positive and negative effects are ambiguous depending on the context. In line with the NELM theory, we hypothesize that migration, especially international migration, induces lost-labor effect, impeding rice production, sales, and income. Under an assumption that households use remittances on rice-related expenses, we predict that such lost-labor effect is compensated by remittances.

3 Data

Data for this study comes from Cambodia's Feed the Future Survey, which was collected from four provinces—Battambang, Pursat, Siem Reap, and Kampong Thom—during August-September 2016 by the Cambodia Development Resource Institute (USAID, 2017). Following a two-stage stratified sampling design, a total of 93 villages were selected randomly from lists of villages during the first stage, and in the

second stage 25 households were randomly selected from each selected village (USAID, 2017). This results in a sample of 2,325 households.

The data provides comprehensive information on socio-economic and demographic characteristics of the sample households, including the household head's characteristics and outmigration of household members, their destinations, and reasons for migrating. It also includes information on remittance earnings, along with production, sales, and income generated from rice and vegetable farming during the wet and dry seasons. Additionally, the survey contains socio-economic characteristics of each selected village, such as village size, migration patterns, distance to a paved road, access to services and infrastructure, and incidences of natural disaster such as drought.

In our analysis, we consider only households that cultivate rice during the wet season since most of the sample households (86%) do not grow rice during the dry season. We exclude farming households that do not grow rice or do not grow rice during the wet season from our sample. Our analysis sample, as a result, consists of 1,665 rice-growing households.

4 Methodology

5.1 Main analyses

Two econometric issues arise when estimating the impact of migration and remittances on rice production, sales, and income. First, migration (both domestic and international) and remittances are endogenous because of the potential reverse causality issue may arise among migration, remittances, and rice-related outcomes, as households may experience reduced migration and declined remittances in response to an increase in wet rice production, sales, and income owning to an increase in the market price of rice, for example. Second, cross-equation error correlation is plausible since domestic and international migration, remittances, and household rice farming can be subject to the same stochastic, unobserved, and exogenous shocks, such as economic downturn, pandemic, or political and civil unrest.

To account for endogeneity and contemporaneous correlation, we estimate the migration, remittance, and rice farming equations simultaneously as a recursive system of equations[1].

The core specification of our model can be written mathematically as follows:

$$Y_j = \varphi_1 + \varphi_2 M_{dj} + \varphi_3 M_{ij} + \varphi_4 R_j + \varphi_5 C_{Yj} + \epsilon_{Yj} \quad (1)$$

$$R_j = \delta_1 + \delta_2 M_{dj} + \delta_3 M_{ij} + \delta_4 C_j + \delta_5 Z_{Rj} + \epsilon_{Rj} \quad (2)$$

$$M_{dj} = \alpha_1 + \alpha_2 C_j + \alpha_3 Z_{dj} + \epsilon_{dj} \quad (3)$$

$$M_{ij} = \beta_1 + \beta_2 C_j + \beta_3 Z_{ij} + \epsilon_{ij} \quad (4)$$

Y_j is the outcome vector of household *j* expressed in its logarithm form.[2] These outcomes include total amount of rice harvested in kilograms during the wet season from October 2015 through January 2016; total amount of wet rice sold in kilograms, and amount of income in Riels earned from selling wet rice. R_j captures the total amount of remittances household *j* received from domestic and international migrants in Riel. M_{dj} and M_{ij} are the number of household members of household *j* who have migrated domestically and internationally, respectively. C_{Yj} is a vector of relevant household and community characteristics affecting production, sales, and earnings of wet rice. These characteristics include household head's age, gender, highest education attainment, household composition, household wealth, a dummy if the village has experienced drought during the past four years, and distance to the nearest paved road (in kilometers). Exogenous household wealth is proxied by the amount of agricultural land (in hectare) that is owned by household *j* in 2012. Additionally, C_{Yj} incorporates essential inputs household *j* used to cultivate rice. These farm inputs are categorical variables capturing adoption of improved seeds along with usage of fertilizer, pesticide, and hired farm workers. Similarly, C_j is a vector that incorporates only relevant household and community characteristics used to explain domestic and international migration and remittance transfers.

[1] We rely on Roodman (2011)'s cmp program to calculate fully observed recursive mixed-process model.
[2] Given that our dependent variables are log transformed, a one unit increase in an independent variable, ceteris paribus, would lead to a $(\exp(coefficient) - 1)100$ percentage change in the dependent variable.

Z_{dj}, Z_{ij}, and Z_{Rj} are vectors of instrumental variables. We instrument for domestic and international migration with information on migration networks. More specifically, the two variables used as proxies for domestic and international migration networks are the average shares of other households in the village with household members who have migrated internally within the country and internationally, excluding the observed household *j*. As explained by Taylor, Rozelle, and de Brauw (2003), migration networks are strong drivers of migration; members of the village who have already migrated can share information about jobs in migrant-receiving areas with their families and other members of the village, thereby reducing some of the highest costs of out-migration. Hence, households residing in villages with histories of migration are more likely to send out migrants. We instrument for household remittance income with the total amount of remittances household *j* received in 2012. We expect that the norm to remit in 2012 would influence the magnitude of remittances they receive in 2016 but not rice farming in the same year. These three instruments will be inspected to ascertain their correlation with endogenous variables and their exogeneity with respect to rice production, sales, and income. We also control for time-invariant village-level fixed effects in all equations to account for localized differences in rice cultivation along with migration and remittance patterns. The stochastic terms, ϵ_{xj}, where $x = Y_j, M_{dj}, M_{ij}, R_j$, are the error terms.

5.2 *Sensitivity analyses*

We conduct additional analyses to verify the robustness of the results of our main analyses by 1) estimating an OLS regression model, 2) calculating the gross effect of migration and remittances, 3) adding an interaction term between remittances and wealth, and 4) exploring how migration and remittances influence vegetable production.

In the first set of alternative analyses, we use an alternative estimation technique, the OLS model, to verify whether our main results are sensitive to the model specification. Although the OLS model does not address the above empirical challenges, we expect the OLS estimates to have similar signs as our main results. We also expect a downward bias in the OLS estimated coefficients for domestic and

international migration along with remittances. This is because, even though migration could reduce rice production, sales, and income and even though remittances could have an opposite effect, an increase in rice production, sales, or income is likely to reduce migration and remittance inflow. Similarly, the second set of sensitivity analysis also check whether the observed coefficients in our main analysis are sensitive to model specification by separately observing the gross effect of each main independent variable on the outcomes. That is, we estimate the gross effect of domestic and migration (without remittances) on the outcomes. By the same token, we calculate the gross effect of remittance earnings (without migration variables) on rice production, sales, and income. Simplification of the estimation strategy will help ascertain the (gross) impact of migration and remittances on rice farming outcomes.

The third set of sensitivity analysis includes an interaction between remittances and initial wealth proxied by the amount of agricultural land owned by each household in 2012. The rationale for this is that the effect of migration through remittances could differ depending on households' asset position (Taylor and Wyatt, 1996; Atamanov and Berg, 2012). For instance, remittances may have a small positive or no impact on well-endowed or land rich households, while the additional income in a form of remittance transfers could have a significant positive effect on poorer or land-poor families. Hence, such interaction will allow us to test whether the effect of remittances on the outcomes would differ by agricultural land size and whether the lost-labor effect are sensitive to the specification of main independent variables. The last set of robustness check focuses on vegetable cultivation, which tends to be less-labor intensive than rice cultivation in the context of Cambodia. Many of our sample rice-farming households or 72% diversify their farm income sources and increase their profit margins by cultivating vegetable crops, such as gourd, water spinach, and eggplants. To examine whether the lost-labor effect would hold for vegetable cultivation and explore the welfare implications of our main findings, we observe the impact of migration and remittances on the aggregated amount of vegetable harvested by rice-farming households.

5 Results

6.1 Descriptive results

Table 1 below reports mean values of wet rice production, sales, and income by household migration and remittance statuses. The average amount of rice harvested and sold and income earned is significantly lower for households with domestic migrants. This provides an initial indication that the withdrawal of household members due to domestic migration generates a loss of household farm labor supply, which in turns depresses rice production, sales, and income. Interestingly, the opposite is found for international migration. On average, the amount of wet rice production, sales, and income are higher in households with international migrants. A likely reason could be because households with international migration in our analysis sample have greater number of working-age family members who remain in home communities and thus higher supply of family farm workers than households with domestic migrants.[3] We, however, do not observe significant differences in remittances on the three outcomes. The statistically insignificant descriptive results point out that remittances have no effect on rice cultivation potentially because remittances may not be used for agricultural purposes.

Table 1. Mean values of production, sales, and income generated from rice farming during the wet season by household migration and remittance statuses

Outcome	Domestic migrants		International migrants		Remittances	
	Without	With	Without	With	Without	With
Wet rice harvested (kg)	6283.69	5081.39***	5512.38	7190.49***	5755.05	5774.18
Wet rice sold (kg)	4206.50	3007.16**	3468.91	4929.22**	3750.82	3581.70
Wet rice income (Riel)	410.00	292.86***	339.07	474.26**	368.36	344.32
Total:	943	722	1,417	248	1,031	634

Note: ***, **, and * denote statistical significance at the 1%, 5%, and 10% level for the difference in the given outcome (rice production, sales, or income) between households with and without a domestic migrant, between households with and without an international migrant, and between households with and without a remittance transfer. Income generated from rice cultivation during the wet season reported in the table has been abbreviated for simplicity. To get the full amount, multiply the income amount by 10,000 Riel.

[3] Among migrant households, households with international migrants have on average three working-age men and women, compared to two working-age men and women for households with domestic migrants. These differences are statistically significant.

Table 2 reports summary statistics for the explanatory variables by household migration and remittance statuses. Compared to no-migrant households, both types of migrant-sending households are more likely to have older household heads. For instance, 25% of household heads in households with domestic migrants are at least 46 years old, compared to 13% for no-migrant households. Similarly, the shares of household heads aged between 36-45 years old and older are higher in remittance-receiving households than in households with no remittance inflow. More than half of the sample households have household heads who have completed at least primary education. We observe no significant differences in education attainment among the heads in households with domestic migrants and those without migrants. On the other hand, the heads in households with no migrants are more likely to have completed at least lower middle school than those with at least one international migrant. Similar results are found between no-remittance and remittance-receiving households; the heads of no-remittance households are more likely to be better educated than those in remittance-receiving households.

Given that most migrants are men (OECD, 2017), the proportion of male-headed households is higher in no-migrant households and in no-remittance households while the share of households headed by women is higher in migrant-sending along with remittance-receiving households. For instance, 28% of households with an international migrant are female-headed households, compared to 15% for no-migrant households. The number of children in no-migrant households is significantly higher than that of households with at least a domestic migrant. No significant differences are found between households with international migrants and those with no migrants. On the other hand, migrant-sending households have greater number of working-age and elderly individuals than no-migrant households. Similar results are found for remittance-receiving and no-remittance households; remittance-receiving households have a lower number of children and higher number of working-age and elderly adults who remain at home.

Table 2. Summary statistics for explanatory variables by household migration and remittance statuses

	No migrants	With domestic migrants	With international migrants	Without remittances	With remittances
35 y/o and younger	0.42	0.10***	0.16***	0.35`	0.10***
36-45 y/o	0.45	0.65***	0.63***	0.51	0.62***
46 y/o and older	0.13	0.25***	0.21***	0.13	0.28***
No education	0.13	0.14	0.16	0.13	0.15
Primary school	0.57	0.56	0.65*	0.57	0.60
Lower middle school and up	0.30	0.30	0.19**	0.30	0.26**
Male	0.85	0.81**	0.72***	0.84	0.79**
Female	0.15	0.19**	0.28***	0.16	0.21**
No. boys 0-5 y/o	0.28	0.19***	0.25	0.26	0.21**
No. girls 0-5 y/o	0.25	0.16***	0.29	0.24	0.20*
No. boys 6-15 y/o	0.64	0.47***	0.60	0.60	0.53
No. girls 6-15 y/o	0.61	0.36***	0.63	0.55	0.47**
No. men 18-59 y/o	1.53	2.34***	2.22***	1.87	2.17***
No. women 18-59 y/o	1.51	2.31***	2.14***	1.77	2.22***
No. men 60 y/o and up	0.15	0.25***	0.20*	0.15	0.28***
No. women 60 y/o and up	0.26	0.33***	0.26	0.26	0.32**
Improved seeds:					
Did not use	0.32	0.34	0.26	0.34	0.29**
Used some plots	0.17	0.22**	0.18	0.16	0.23***
Used in all plots	0.51	0.44***	0.56	0.49	0.48
Used fertilizer:					
Did not use	0.15	0.15	0.08**	0.16	0.11**
Used some plots	0.12	0.17***	0.08	0.12	0.16**
Used in all plots	0.73	0.67**	0.84***	0.72	0.72
Used pesticide:					
Did not use	0.42	0.51***	0.25***	0.45	0.41
Used some plots	0.10	0.10	0.08	0.10	0.11
Used in all plots	0.48	0.39***	0.67***	0.46	0.48
Hired farm workers:					
Did not use	0.57	0.58	0.64	0.55	0.64***
Used some plots	0.17	0.17	0.15	0.16	0.17
Used in all plots	0.27	0.25	0.21	0.28	0.19***
Agricultural land size owned in 2012 (ha)	2.00	2.26*	2.26	2.10	2.22
Experienced drought	0.94	0.95	0.95	0.94	0.95
Distance to a paved road (km)	0.04	0.06	0.05	0.05	0.05
Total:	815	722	248	1,031	634

Note: ***, **, and * denote statistical significance at the 1%, 5%, and 10% level for the difference in each control variable between households with domestic/international migrants and those without a migrant and between households that did not and did receive remittance earnings.

In terms of inputs for wet rice farming, a greater share of no-migrant households uses improved seeds in all plots compared to households with a domestic migrant (51% versus 44%). We do not observe significant differences in the use of improved seeds between no-migrant households and households that

have international migrants. Compared to no-migrant households, households with domestic migrants are less likely to use fertilizer and pesticide in all plots for wet rice farming. The reverse is found for households with international migrants. These households are more likely to use fertilizer and pesticide in all plots. No significant differences in the use of fertilizer and pesticides in all plots are observed for households without and with remittances. Although more than half of the sample households do not rely on hired farm workers and although we do not observe significant differences in the use of hired farm workers between no-migrant and migrant-sending households, households with no remittance inflow are more likely to hire farm workers in all plots than remittance-receiving households. A likely reason could be because these households have lower supply of adult family farm workers and are thus more dependent on external labor.

The average size of agricultural land owned by households with domestic migrants is 2.29 hectares, which is significantly larger than that of no-migrant households at two hectares. We do not find significant difference in land size between no-migrant households and households with international migrants and between households without and with remittance earnings. Most households have experienced drought, regardless of their migration or remittance statuses. Distance to a paved road is between 0.04 and 0.06 kilometers, and we observe no significant differences such distance between households with and without migrants or remittance income.

6.2 Econometric results

Table 4 below presents the results derived from Equation 1 concerning the impact of migration and remittances on rice production, sale, and income based two different types of migration variables—1) total household migrants and 2) domestic and international migrants. The estimates for other equations (e.g. Equations 2-4) are available upon request.

Our instruments have the expected positive signs and are statistically significant across most specifications. More specifically, when focusing on total number of household migrants, its instrument proxied by the average share of households with migrants in the village has a positive and significant impact on total number of household migrants. When we disaggregate total number of household

migrants into domestic and international migrants, village-level domestic migration network used to predict domestic migration have the expected positive sign but is statistically insignificant while village-level international migration network predicting international migration is positive and statistically significant across all equations. Migration along with household remittance transfers in 2012 overall have the expected positive effect on household remittance earnings in 2016 across all equations. Although most instruments are significant and relevant[4], these results should be taken with caution given the weak performance of the instrument used for domestic migration.

Column 1 of Table 4 show that an increase in the total number of household migrants decreases the amount of wet rice harvested by about eight percent. We find insignificant impact of total number of household migrants on rice sales and income, and we also do not find a significant effect of remittances on these three outcomes. When we distinguish between domestic and international migration, Column 2 indicates that both domestic and international migration has a lost-labor effect on the amount of wet rice harvested and sold. More specifically, an increase in domestic migration decreases household rice production and sales by 7% and 8%, respectively. International migration also reduces the amount of wet rice production by 11%. Both domestic and international migration have the expected lost-labor effect on household rice income, and international migration also had a negative impact on wet rice sales. Yet, these estimated coefficients are statistically insignificant.

[4] Given that the recursive model estimated by cmp program developed by Roodman (2009) lacks the capacity to check instrument validity, we resort to 2SLS model to observe the relevance of our instruments. The Kleibergan-Paap rk Wald F-statistics for regressing domestic migration on its instrument (village-level domestic migration network) are 58.33 (Prob>F=0.00) for the rice production equation, 60.21 (Prob>F=0.00) for the rice sale equation, and 25.73 (Prob>F=0.00) for rice income equation. The F-statistics for regressing international migration on its instrument (village-level international migration network) are 176.62 (Prob>F=0.00) for rice production equation, 85.92 (Prob>F=0.00) for the rice sale equation, and 85.92 (Prob>F=0.00) for the income equation.
For remittance earnings, their F-statistics are 13.93 (Prob>F=0.00) for rice production equation and 9.93 (Prob>F=0.00) for the rice sale and income equations.

Table 3. Recursive system regression estimates predicting total wet rice harvested, sales, and income for the full analysis sample

Variables	Total rice harvested (log)		Total rice sold (log)		Total rice income (log)	
No. of total migrants	-0.08***		-0.09		-0.08	
	(0.02)		(0.23)		(0.23)	
No. of domestic migrants		-0.07***		-0.09**		-0.08
		(0.03)		(0.03)		(0.05)
No. of international migrants		-0.12**		-0.09		-0.08
		(0.05)		(0.06)		(0.07)
Total amount of remittance received (Riel)	0.00	0.00	0.00	0.00	0.00	0.00
	(0.00)	(0.00)	0.00	(0.00)	0.00	(0.00)
Household head is between 36-45 y/o	-0.15*	-0.14*	-0.288**	-0.29***	-0.29**	-0.29***
	(0.08)	(0.08)	(0.12)	(0.10)	(0.12)	(0.11)
Household head is 46 y/o and older	-0.20**	-0.20***	-0.22	-0.22**	-0.20	-0.20*
	(0.08)	(0.08)	(0.17)	(0.10)	(0.17)	(0.10)
Female headed household	-0.17***	-0.16***	-0.33***	-0.33***	-0.34***	-0.34***
	(0.06)	(0.06)	(0.09)	(0.09)	(0.09)	(0.09)
Head's highest education: primary school	0.09	0.09	0.09	0.09	0.12	0.12
	(0.06)	(0.06)	(0.09)	(0.09)	(0.09)	(0.09)
Head's highest education: lower middle school or up	0.20***	0.20***	0.25**	0.25**	0.28***	0.28***
	(0.07)	(0.07)	(0.10)	(0.10)	(0.10)	(0.11)
No. boys 0-5 y/o	-0.02	-0.02	-0.05	-0.05	-0.06	-0.06
	(0.04)	(0.04)	(0.05)	(0.05)	(0.05)	(0.05)
No. girls 0-5 y/o	-0.05	-0.05	-0.11	-0.11	-0.11	-0.10
	(0.05)	(0.05)	(0.08)	(0.07)	(0.08)	(0.08)
No. boys 6-15 y/o	0.08***	0.08***	0.07*	0.07*	0.08*	0.08**
	(0.03)	(0.03)	(0.04)	(0.04)	(0.04)	(0.04)
No. girls 6-15 y/o	-0.01	-0.01	0.01	0.01	0.01	0.01
	(0.03)	(0.03)	(0.04)	(0.04)	(0.04)	(0.04)
No. men 18-59 y/o	0.12***	0.12***	0.11	0.11***	0.12	0.12***
	(0.02)	(0.02)	(0.09)	(0.04)	(0.10)	(0.03)
No. women 18-59 y/o	0.13***	0.13***	0.09	0.09**	0.09	0.09**

	(0.03)	(0.02)	(0.14)	(0.04)	(0.14)	(0.04)
No. men 61 y/o and up	0.05	0.05	-0.00	-0.00	-0.02	-0.02
	(0.07)	(0.07)	(0.10)	(0.10)	(0.10)	(0.10)
No. women 61 y/o and up	0.11**	0.11**	0.02	0.02	0.02	0.01
	(0.04)	(0.04)	(0.06)	(0.06)	(0.06)	(0.06)
Improved seeds in some plots	0.35***	0.35***	0.30***	0.30***	0.34***	0.34***
	(0.06)	(0.06)	(0.10)	(0.10)	0.10	(0.10)
Improved seeds in all plots	0.11*	0.11*	0.21**	0.21**	0.24***	0.24***
	(0.06)	(0.06)	(0.09)	(0.09)	(0.09)	(0.09)
Fertilizer in some plots	0.57***	0.57***	0.34*	0.34*	0.35*	0.35*
	(0.10)	(0.10)	(0.19)	(0.19)	(0.19)	(0.19)
Fertilizer in all plots	0.40***	0.40***	0.28*	0.28*	0.29*	0.29*
	(0.08)	(0.08)	(0.17)	(0.17)	(0.17)	(0.17)
Pesticides in some plots	0.46***	0.46***	0.28**	0.28**	0.30***	0.30***
	(0.06)	(0.06)	(0.11)	(0.11)	(0.11)	(0.11)
Pesticides in all plots	0.40***	0.40***	0.32***	0.32***	0.31***	0.31***
	(0.06)	(0.06)	(0.11)	(0.11)	(0.11)	(0.11)
Hired workers in some plots	0.28***	0.28***	0.24***	0.24***	0.26***	0.26***
	(0.06)	(0.06)	(0.10)	(0.09)	(0.09)	(0.09)
Hired workers in all plots	0.21***	0.21***	0.10	0.09	0.13	0.13
	(0.07)	(0.07)	(0.08)	(0.08)	(0.08)	(0.08)
Agricultural land size owned in 2012 (ha)	0.11***	0.11***	0.12***	0.12***	0.12***	0.12***
	(0.03)	(0.02)	(0.03)	(0.03)	(0.03)	(0.03)
Experienced drought	-0.02	-0.01	-0.21**	-0.21**	-0.37***	-0.37***
	(0.06)	(0.06)	(0.10)	(0.08)	(0.10)	(0.09)
Distance to a paved road (km)	-0.03	-0.03	-0.04	-0.04	-0.05	-0.05
	(0.04)	(0.04)	(0.05)	(0.05)	(0.06)	(0.06)
Constant	6.64***	6.63***	6.52	6.52***	4.29	4.29***
	(0.15)	(0.15)	(.)	(0.24)	(.)	(0.24)
Location fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1,665	1,665	1,665	1,665	1,665	1,665

Notes: Robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1. Formula used to interpret our estimated coefficients that are associated with the logged transformed dependent variables is $(\exp(coefficient) - 1)$.

Table 4 further shows that remittance earnings have the expected positive signs but are statistically insignificant across all specifications, even if we differentiate between domestic and international migration. A plausible reason could be that, although remittance earnings may allow households to overcome liquidity constraints, remittance-receiving households may use these extra non-labor incomes for non-agricultural or non-rice related activities or simply for basic subsistence needs. For instance, household remittance earnings are often used to finance material goods, repay debt, or facilitate investments in non-farm microenterprises in Cambodia (World Bank, 2014; Peou, 2015; Bylander and Hamilton, 2015). Unfortunately, we are unable to further test these reasoning as we lack data on how remittance earnings are used or whether they are used for agricultural or rice-related activities.

Other variables in the equations behave as expected. In particular, households with older household heads (those aged at least 36 years old) or female household heads have a lower amount of rice production, sales, and income when compared to households with younger heads and to those with male household heads. For example, the amount of income generated form rice farming in households with household heads aged 46 years old or older is 18% lower than those with household heads aged 35 or younger. On the other hand, household heads' education has a positive impact on household rice production, sales, and income. The amount of rice harvested by households with household heads who have completed at least lower middle school is 22% higher than those with household heads who did not attend school. The number of boys aged between 6-15 years old, working-age adults, and elderly women aged 61 and older have a positive impact on rice production, sales, and income. Compared to rice farming households that did not use improved seed, fertilizer, and pesticides to cultivate wet rice, households that use these essential inputs in some or all plots generate higher amount of rice harvested, sold, and income. Agricultural land size owned by rice farming households has a positive impact on rice production, sales, and income, while drought can reduce rice sales and income by 20% and 31%, respectively.

6.3 Sensitivity Analysis

Table 5 presents key estimates of our sensitivity analyses. Panel A reports the OLS estimates of the impact of migration and remittances on the outcomes. The OLS estimates are in line with our main results

and show that both domestic and international migration have a negative impact on wet rice production. The estimated coefficients for remittances are positive and statistically significant, indicating that remittance earnings could partially compensate for the lost-labor effect by increasing rice production, sales, and income. However, the magnitude of the impact of remittances is miniscule. Panel B shows the gross effect of migration and of remittances on the three outcomes. Although remittance income is excluded from the analysis, we continue to observe the negative impact of domestic and international migration on rice production. The effect of both types of migration on sales and income remains negative and statistically insignificant. Likewise, remittances continue to have no effect on rice production, sales, and income even when migration variables are dropped from the model. These simpler estimation techniques help confirm the lost-labor effect of domestic and international migration on rice farming.

With an interaction between initial wealth and remittances is incorporated into the model, Panel C shows that domestic and international migration continue to have a negative impact on rice production. We also observe the lost-labor effect of domestic and international migration on rice sales and income. While farmland size has a positive and significant effect on rice production, sales, and income among households that do not receive remittances as expected, changes in remittance earnings in households that do not own farmland do not have any effect on the outcomes. The net effect of remittances on rice production, sales, and income is also statically insignificant across different values of initial wealth or farmland size. Thus, the effect of remittances does not differ by initial asset endowment in the context of Cambodia.

When focusing on vegetable cultivation, our estimated coefficients for domestic and international migration in Panel D are negative but statistically insignificant. The statistically insignificant estimates are important as they demonstrate that withdrawal of household members due to both domestic and international migration does not affect vegetable farming but does adversely impact rice farming. This may be because vegetable farming is less labor intensive when compared to rice farming. These results are indicative that the lost-labor effect of both domestic and international migration could be compensated by growing vegetable crops.

Table 4. Key estimates of the sensitivity analyses

	Total rice harvested (log)	Total rice sold (log)	Total rice income (log)
Panel A: OLS regression estimates			
No. of domestic migrants	-0.07***	-0.08***	-0.08**
	(0.02)	(0.03)	(0.03)
No. of international migrants	-0.12***	-0.08*	-0.10**
	(0.03)	(0.05)	(0.04)
Total amount of remittance received (Riel)	0.00***	0.00***	0.00***
	(0.00)	(0.00)	(0.00)
Panel B: Gross effect of migration and remittances			
No. of domestic migrants	-0.07***	-0.08	-0.08
	(0.02)	(.)	(0.63)
No. of international migrants	-0.10***	-0.05	-0.06
	(0.02)	(0.55)	(0.43)
Total amount of remittance received (Riel)	0.00	0.00	0.00
	(0.00)	(0.00)	(0.00)
Panel C: Recursive estimates with land size interacted with remittances			
No. of domestic migrants	-0.07***	-0.09**	-0.08**
	(0.02)	(0.03)	(0.04)
No. of international migrants	-0.12**	-0.11*	-0.10*
	(0.05)	(0.06)	(0.06)
Total amount of remittance received (Riel)	0.00	0.00	0.00
	(0.00)	(0.00)	(0.00)
Total remittance received*land size owned in 2012	-0.00	0.00	0.00
	(0.00)	(0.00)	(0.00)
Panel D: Recursive estimates predicting the effect of migration and remittances on total amount of vegetable produced (log)			
No. of domestic migrants	-0.02	-0.02	
	(0.04)	(0.03)	
No. of international migrants	-0.03	-0.02	
	(0.08)	(0.08)	
Total amount of remittance received (Riel)	0.00	0.00	
	(0.00)	(0.00)	
Total remittance received*land size owned in 2012		-0.00	
		(0.00)	

Notes: Robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1. The dependent variable for estimates in Panel D is total amount of vegetable our rice-farming households produced. Given that our dependent variables are log transformed, a one unit increase in an independent variable, ceteris paribus, would lead to a $(\exp(coefficient) - 1)100$ percentage change in the dependent variable. Full results can be found in the appendix.

7. **Conclusions and policy implications**

Although Cambodia has undergone a significant transformation from being a war-torn country into a free market and a more industrialized and service economy at the beginning of the 21st century, its rapid urbanization rate, limited rural employment opportunities, and relatively low wages have propelled a growing number of Cambodians to migrate away from its agricultural sector (Peou, 2017). In this analysis, we rely on the New Economics of Labor Migration framework and contribute to the migration literature by examining the impact of domestic and international migration along with remittances on production, sales, and income generated from rice cultivation during the wet season in Battambang, Pursat, Siem Reap, and Kampong Thom. Evaluating the impact of both domestic and international migration and remittance transfers on agriculture is particularly critical given the academic and policy discourse on the complex implications of migration on livelihoods of farm households especially in the context of Cambodia, where rice farming remains a fundamental driver of growth and development and a critical source of income for many rural households.

The results of our study reveal that both domestic and international migration reduces the supply of household farm labor and dampens rice production. Domestic migration also has a negative impact on rice sales. Our results substantiate the NELM framework and are consistent with the findings of previous studies on migration (Atamanov and Van Den Berg, 2012; Tuladhar et al., 2014; Shi, 2018; and Zhunusova and Herrman, 2018). Remittance transfers have no influence on wet rice production, sales, or income, irrelative of alternative specifications of regression model and initial wealth endowment proxied by agricultural land size. Although remittances are found in other developing countries to mitigate credit and financial constraints and compensate for the lost-labor effect by stimulating crop income (Atamanov and Van Den Berg, 2012), rice productivity (Shi, 2018), and non-agricultural income (Zhunusova and Herrman, 2018), the insignificant impact of remittance inflow could reflect the prevailing trend in Cambodia that remittances are used to finance consumer goods and non-agricultural expenses (World Bank, 2014). In particular, due to rapid expansion of microfinance lending that traps many households in

vicious cycle of debt crisis, many farm households in Cambodia have been increasing reliant remittance earnings to repay for their debt, rather than investing in rice farming (Bylander, 2014; Seng, 2018).

Our findings have essential implications for Cambodia's agricultural policies. Rice in the context of Cambodia is perceived as more than a subsistence crop or a staple for domestic consumption but as "white gold" to epitome as a commodity with major commercial values and as the traditional basis of Cambodian households' wealth and well-being (Cramb et al, 2020). As such, the Cambodian government places a strong emphasis on agricultural development with essential national development objectives of promoting rice production and transforming the country into a key exporter of rice in the global market (Mishra et al., 2018). Advancement of Cambodia's rice sector is however constrained by its dwindling supply and rising wages of agricultural labor caused by migration and its remittance transfers, which inevitably accelerate a transition out of agriculture. While a strategy to counteract the lost-labor effect may not necessarily be to increase farm labor supply by curbing domestic or international migration since migration and its transfers are both bound to play an essential role in alleviating poverty and uplifting well-being of agrarian households, policies that promote wider use of mechanized farm inputs and strengthen infrastructure used for rice cultivation can help address farm labor shortage and boost labor productivity, especially in rice-farming communities with high proportion of domestic and international migrants. Based on our results and sensitive analyses, investing in human capital can also help enhance production, sales, and income, while fostering high-value vegetable cultivation (which we found is insensitive to both domestic and international migration) among rice-farming households can be an ideal strategy to mitigate the lost-labor effect and improve their profit margins and welfare.

Furthermore, given that rice farming households are not seeing any impact of remittance inflow on rice cultivation, policies that identify shortfalls in and regulate the country's microfinance industry and address the growing household debt burdens could reduce the need to use remittances for non-agricultural purposes and thereby propel remittance-receiving households to use their remittance transfers to invest in agricultural inputs and capital. Reducing costs associated with remitting and investing in education of potential migrants can also help facilitate greater inflow of remittances into Cambodia.

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