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論文題目 Adoption and Diffusion of New Rice Technologies in Tanzania: Prospects and Challenges

(タンザニアにおける稲作新技術の採用と拡大：可能性と課題)

Rice cultivation is emerging as the most important staple crop in Sub-Saharan Africa (SSA) due to its growing demand. In efforts to improve rice production and productivity, several initiatives have been implemented. These include introducing the high-yielding modern varieties developed in Asia, promoting the use of agro-chemicals, and improved agronomic cultivation methods. However, despite their high potentials, these technologies are not widely adopted in SSA. Several constraints, including the lack of access to credit, the lack of training on rice cultivation, and labor shortage during cultivation seasons, are identified as possible reasons for the low adoption rate. Yet, it is still an empirical question if the adoption of technologies and productivity would increase if these constraints are relaxed. This study focused on two aspects: microcredit and mechanization of rice cultivation.

Regarding microcredit, adopting new agricultural technologies is often labor-intensive, and the initial costs tend to be high. While credit access can reduce this constraint, many smallholder farmers in SSA lack the collateral required to secure loans from formal financial institutions, such as commercial banks. When microfinance institutions (MFIs) arrived in Africa in the 1990s, they were regarded as a solution in ensuring the provision of financial service to the poor due to their low levels of interest rates and collateral-free loans. While microcredit's impact on the investment in non-farm activities has been widely discussed, there is a limited number of empirical studies evaluating the impact of microcredit on the adoption of agricultural technology and productivity. Lack of reliable evidence on the impact of microcredit on agricultural production weakens the efforts of enhancing financial inclusion, especially in rural areas where the majority of the potential clients are farmers.

Turning to mechanization, agricultural production in SSA has mostly continued to rely on manual and animal power, as mechanization in the region remains to be the lowest in the world. The past initiatives to promote mechanization, particularly tractors in the 1960s and 1970s, failed to materialize due to poor management and lack of adequate demand. There was also a growing concern that tractors will encourage large-scale farmers to expand their farms and displace smallholder farmers. This resulted in the perception that mechanization is not a suitable tool for agricultural development, which led to a further decline in SSA tractors. In the past two decades, however, the interest in mechanization began to emerge again in SSA, partly due to the rise of global food prices in 2008 and the arrival of new suppliers of machinery and repair services. Despite the recent increase in the use of four-wheeled tractors and power tillers

among rice farmers, studies on the effects of mechanization on rice production in SSA remain scant.

This study explores the role of microcredit and mechanization in improving rice productivity using data collected in Tanzania, one of the major rice-producing countries in SSA. Specifically, this study aims to: (i) Assess rice technologies promoted in Tanzania and their recent adoption trend. (ii) To evaluate the impact of microcredit on the adoption of rice technologies, rice productivity, and overall household income. (iii) To examine the effects of mechanization on the expansion of the cultivated area, land productivity, and labor productivity. We explore these objectives in Chapters 3, 4, and 5.

Chapter 3 discusses various efforts to improve rice production, including introducing different rice technologies such as MV, chemical fertilizer, and improved agronomic practices. We applied the household-level data to descriptively show how the adoption of these technologies has changed over time. The descriptive results show that adoption rates for these technologies have gradually increased from 2009 to 2018. But the adoption pattern varies across agro-ecological zones. Irrigated areas appear to have high adoption rates and relatively higher yields, indicating the possibility of rice Green Revolution in irrigated lowlands. However, only a small proportion of the total rice area is under irrigation, undermining the potential influence of such yield on country-level productivity. Our results show a similar pattern to previous studies that empirically examined factors associated with the adoption of rice technologies in Tanzania. Our results suggest that to achieve the rice Green Revolution in Tanzania, policies that aim to increase irrigation infrastructures and those seeking to improve productivity in rainfed remains essential.

Chapter 4 analyzes the impact of microcredit on technology adoption and land productivity. We use data from the randomized control trial (RCT) of the microcredit intervention conducted in Tanzania. In the intervention, we offered microcredit to randomly selected farmers and investigated its impact on adopting technologies such as high-yielding modern varieties, chemical fertilizer, other agronomic practices, and land productivity. We first estimate the intention-to-treat (ITT) effect of farmers eligible to borrow credit from the program. In addition to ITT, we estimate the local average treatment effects (LATE) of the program, using eligibility status as an IV. We also apply the ANCOVA approach to increase estimation power. Overall, we do not observe any significant impact on technology adoption or increased paddy yield, profit, or household income. Lack of significant effect of credit on fertilizer use or paddy yield is consistent with the previous studies, which found that credit use did not increase chemical fertilizer or paddy yield.

We explore further by conducting sub-sample analyses comparing borrowers and non-borrowers in the irrigation scheme with better access to irrigation water and extension services against those without better access to irrigation water and extension services. Our results show that those farmers in the irrigation scheme with good access to water and extension services have applied a relatively high amount of chemical fertilizer, which is near the recommended level, even without credit use. Therefore, even after some of them borrowed credit, they did not increase chemical fertilizer use. On the other hand, farmers without better access to irrigation water and extension services usually do not apply a high chemical fertilizer quantity. Therefore, when they borrowed credit, they significantly increased chemical fertilizer. However, the increased use of fertilizer did not increase yield or profit for these farmers. Although this is not

conclusive, low rates of yield response to an application of chemical fertilizer can be one of the possible reasons. If this is the case, our results support the argument that emphasizes the importance of the extension services before the input and credit market development. Our results suggest that it is crucial to understand clients' characteristics and their socioeconomic environment when MFIs design their loan products targeting clients in agricultural communities. Additionally, our findings suggest that credit access may not be the only constraint on rural households.

Chapter 5 examines the effects of mechanization on expanding cultivated area, land productivity, and labor productivity. We use three-year panel data from two regions of Tanzania. We focused on the use of four-wheeled tractors (TR) and power tillers (PT) for land preparation activities in rice plots. Descriptive results show that in recent years, mechanization has been increasing in Tanzania and gradually changed how farmers prepare their rice plots. We applied the multinomial endogenous treatment effect (METE) model accounting for unobservable household heterogeneity to analyze the effects of mechanization.

In our empirical estimations, we found that large-size TR contributes to the expansion of area under rice cultivation both within a plot and household level but does not increase paddy yield. On the other hand, PT users adopt yield-enhancing agronomic practices more often and apply a more chemical fertilizer, insecticides, and herbicides, resulting in high paddy yield, revenues, and profit per hectare. Our results are partially consistent with previous empirical studies, which report the positive relationship between agricultural mechanization and intensification, although we do not observe such a tendency for large-scale mechanization. Despite these differences, we find that both PTs and TRs significantly reduce labor use, resulting in increased labor productivity. We also find evidence suggesting that the labor force freed from rice cultivation was reallocated to the cultivation of other crops, resulting in high household income among PT users. Our results would contribute to the recent policy debates that aim to promote mechanization among small-scale farmers in SSA.

The research topics covered in this thesis provide empirical evidence to support future policies aiming to improve agricultural production and productivity through the adoption and diffusion of new agricultural technologies in developing countries.