ESSAYS ON THE SUSTAINABLE DEVELOPMENT OF SMALLHOLDER FARMERS' WELFARE OF RURAL BANGLADESH.

A Dissertation

Submitted to the National Graduate Institute for Policy Studies (GRIPS)

in partial Fulfillment of the Requirements for the Degree of

Ph.D. in International Development Studies

by

TAREQUE MOHAMMAD

April 2024

Abstract

This dissertation examines the different strategies to increase the welfare of small farm households in the rural areas of Bangladesh. It aims to examine (i) the sustainable strategy to promote crop diversification and informal input credit of smallholder farmers which are considered as the important tools to achieve SDG1 and SDG2 by 2030; and (ii) the strategies to decrease the child malnutrition among rural farm households which is pre-requisite to achieve SDG2.

In the first main chapter (chapter 2), I examine the impact of multifaceted interventions on the crop diversification and use of informal input credit of smallholder farmers in rural Bangladesh. I conduct the study using the data from a cluster randomized control trial (RCT) to facilitate jute value chains among smallholder farmers. Taking the facility of an RCT, I apply intention-to-treat estimates with OLS and Tobit for crop diversification and OLS and Probit for informal input credit. The estimation results indicate that the multifaceted interventions enhance the crop diversification in the relatively long-term (two years after interventions) and informal input credit use in both the very short-term (one year after interventions) and relatively longer-term. The results are consistent between the OLS and Tobit for crop diversification and OLS and Probit for informal input credit. Moreover, positive results of the extended analysis on the modern technology adoption represented by the intensity of fertilizer use suggest that the impact of multifaceted interventions on crop diversification and informal input credit are not just a coincidence.

In the second main chapter (chapter 3), I investigate the association of maternal autonomy in workforce participation decision on child nutrition indicators. I utilize the pooled cross-sectional data from Bangladesh integrated household survey (BIHS) collected by IFPRI to conduct econometric analysis. The study sample consists of working mothers having children under age 5 years. I identify the causality in the analysis applying an instrumental variable approach. I test the

robustness of the results using alternative variables such as maternal autonomy in household food decisions and composite maternal autonomy score. I also check the generalizability of the main results including non-working mothers into the sample. The estimation results indicate that maternal autonomy in workforce participation decisions decreases the child malnutrition (stunting, wasting, and underweight). These effects are robust under two alternative variables such as maternal autonomy in food decisions, and composite maternal autonomy score. Moreover, the generalizability test is also consistent with the main results. However, heterogeneity test showed that mothers who work at home have children with better nutrition indicators.

The findings of this dissertation contribute to the growing literature on the crop diversification and access to credit among smallholder farmers of rural areas of developing countries as well as promotion of child nutrition among rural farm household of low and-lower-middle income countries. It indicates that multifaceted interventions addressing constraints of smallholder farmers in crop diversification can be a strategy to increase crop diversification and informal input credit among smallholder farmers. Besides, maternal autonomy in workforce participation decisions (a new dimension of female autonomy) can be a considerable tool that can contribute to the child nutrition.

Dedication

To my beloved parents, wife, and kids – Tazwar Ul Hasan Zahee & Tanjeeb Ul Hasan Zakee.

Besides, all the underprivileged people of the world for whom I want a healthy and happy life.

Acknowledgement

All glory to Allah, the Most Merciful, Compassionate, and the Sovereign Lord of all the universe, who gave me the courage, patience, and wisdom to compile a dissertation paper containing useful policy recommendations to support most disadvantaged people of the world.

This is a remarkable journey full of excitement of new discovery, learning new ideas with practical experience as well as full of uncertainty and stress. It was impossible to complete this journey without the support and encouragement of several people, to whom I would like to give my special gratitude. At first, I would like to express my sincere thanks to my dissertation committee members, Professor Takahashi Kazushi, Professor Yoko Kijima, G-cube Program, Professor Veerayooth Kanchoochat, Public Policy Program, National Graduate Institute for Policy Studies (GRIPS), and Momoe Makino sensei from IDE – Japan for their impactful comments, suggestions, and guidance throughout this PhD journey.

Most significantly, I am indebted to my principal advisor, Prof. Takahashi Kazushi, for keeping faith in me. Thank you so much dear Takahashi Sensei for your tireless and consistent support, time and energy, patience with me, for your kindness, and expertise feedback that has upgrade my analytical, research and writing skills as well as boost my confidence. I learned a lot from him especially, the ways of finding new ideas and dedication to quality work. His motivation and guidance drive me to find different windows of development research that make me confident and enthusiastic for further research in this field. He not only support me in study but also in every important situations - such as writing recommendation letter for scholarship, extension of my scholarship duration, my personal issues with my employer, and so on, he extended his helping

hand without hesitation. I have always thought of him as my local guardian. I wish that almighty Allah will give him all the success he deserves and fulfill his good desires.

I would like to extend my sincere gratitude to my sub-supervisor Prof. Yoko Kijima for her insightful comments on my research which add meaningful value in my findings and recommendations. Besides, I learnt a lot from her development econometrics course which made me confident in econometric analysis. Thank you very much Kijima sensei. My gratitude also extends to Prof. Chikako Yamauchi for her comments and suggestions at the oral qualification examination, helped me better structure my analyses.

My special thanks to the entire GCUBE faculty and staff members. I would like to thanks Professor Yusuke Takagi for arranging G-cube workshop with Kijima sensei and Takahashi sensei, which is very helpful for taking preparation for final dissertation defense. Thanks are also due to all the GRIPS administrative staff, especially my GCUBE Course Coordinator Mrs. Mori Satomi. I am also thankful to the G-cube students and my batch mates (Susumu, Aika, and Carl) for their support and worm wishes in completing my thesis.

At this stage, I would like to give special thanks to the operating committee of Japanese Grant Aid for Human Resource Development Scholarship (JDS) for awarding me the scholarship to continue my study in Japan. In this regard, I would like to extend my thanks to staffs of Japan International Cooperation Center (JICE) Bangladesh office and Head office, Tokyo for their support from the very beginning of the scholarship nomination procedure to the smooth settlement in Tokyo amid Covid-19 restrictions. There are a lot who helped me from JICE during my PhD journey. It is

impossible mention all the names of JICE staffs, just thank you very much all. See you in near future!

I would like to give special gratitude to the Governor of Bangladesh, head of my employer, for giving me deputation to pursue my PhD degree in a prestigious Japanese institution. I am also grateful to my colleagues – Mrs. Sabers Sultana, Mr. Abdullah Al Amin, Mr. Saleh Imtiaj, and Mr. Iftakher Chowdhury (all are Additional Director of Bangladesh Bank) to kindly be my guarantor for my deputation. I also would like to thanks Mr. Asim Kumar Chowdhury (Director, Bangladesh Bank) for helping me in my deputation process. I also like to thanks to all the HRD2 officials (from Assistant Director to Deputy Governor) who work for approving my deputation. It is really tough to mention all the names of the Bangladesh Bank staffs who helped and inspired me in pursuing my PhD, thank you very much all the staffs of Bangladesh Bank.

Finally, and most notably, I am grateful to my family for their love, immense support, and encouragement. Thanks to my brothers, sisters, brothers-in-law, and sister-in-law who have taken good care of my parents, wife, and children during my absence. I am highly indebted to my father-in-law and mother-in-law for taking special care of my children and let not understand them my absence. Thanks to my parents, nephew, and niece who always make me happy with their activities. Special and heartiest thanks to my beloved better half who unconditionally support me during full of my PhD journey. No matter whether the situation is good and or bad she always be with me. It could not be easy to complete this Ph.D. program without her acquaintance. There is no way for me to adequately convey my thankfulness to my entire family through words. All I can say is that I appreciate everything you have done for me and your constant faith and encouragement in all I do.

Table of contents

List of Tables

List of abbreviations

ANCOVA	Analysis of Covariance
AVC	Agricultural value chain
BAVC	Bangladesh agricultural value chain
BDT	Bangladeshi Taka
BIHS	Bangladesh integrated household survey
BRAC	Building Resources across Communities
DAI	Development Alternatives International
FAO	Food and Agricultural Organization
HAZ	Height-for-age z-score
HIS	Hyperbolic sine
IFFRI	Implemented by International Food Policy Research Institute
IPV	Intimate partner violence
ITT	Intent-to-treat
IV	Instrumental variable
KGs	Kilograms
MFI	Micro-finance Institution
NAAFCO	NAAFCO Group - Agricultural Input Supplier of Bangladesh
NFD	Nutritional functional diversity
NGO	Non-governmental Organization

NIPORT	National Institute for Population Research and Training
OLS	Ordinary least square
OPHI	Oxford Poverty and Human Development Index
PCA	Principal Component analysis
PSUs	Primary sampling units
RCT	Randomized Control Trial
SA	South Asia
SD	Standard deviation
SDGs	Sustainable development goals
SDI	Simpson's diversity index
SSA	Sub-Saharan Africa
UNDP	United Nations Development Program
USAID	United States Aid for International Development
USD	US Dollar
WAZ	Weight-for-age z-score
WFP	Workforce participation
WHO	World Health Organization
WHZ	Weight-for-height z-score

Chapter 1

1. Introduction

1.1 Background of the Study

Sustainable development goals (SDGs) are said to be a stepping stone to the new era of civilization. According to the World Bank report[1] achieving SDG1 and SDG2 by 2030 is challenging due to the disruption in poverty reduction at midpoint in around three years between 2020 and 2022. There has been an increase in the number of people living in extreme poverty for the first time in a generation[2]. According to the UNDP and OPHI (2023) report, 1.1 billion people out of 6.1 billion are in multidimensional poverty in 2023 and the home of around 5 out of 6 of the world's poor are in sub-Saharan Africa (SSA) and South Asia (SA), and 84% of the poor live in rural areas[3]. The report also reveals that half of the 1.1 billion poor are children under age 18, and 600 million people suffer from undernourishment who are mainly from rural areas of low and lower-middle-income countries of SSA and SA. According to FAO, most people living in rural areas are smallholder farmers who provide 80% of the food supply in SSA and SA. Those smallholder are often vulnerable to poverty and constrained from input and output supply chains and finance[4]. Besides, Swinnen & Vos, (2021) found that due to income shocks and disruption in supply chains, those smallholders are affected most by food security. SDG1[5] and SDG2[6] progress reports stated that the current rate of improvement in the indicators of SDG1 and SDG2 leave around 7% (575 million) population of the world in extreme poverty and 8% (670 million) in food insecure. Thus,

[1] https://www.worldbank.org/en/topic/poverty/overview
[2] https://www.undp.org/press-releases/165-million-people-fell-poverty-between-2020-2023-debt-servicing-crowded-out-social-protection-health-and-education-expenditures
[3] The reports showed that out of 1.1 billion poor in the world, 534 million (47.8%) live in SSA and 389 million (34.9%) live in SA.
[4] https://www.wiego.org/informal-economy/occupational-groups/smallholder-farmers
[5] https://sdgs.un.org/goals/goal1#progress_and_info
[6] https://sdgs.un.org/goals/goal2#progress_and_info

accomplishing SDG1 and SDG2 by 2030 requires decisive actions to boost the welfare of smallholder farmers, particularly in SSA and SA.

Governments and international donors are taking various development projects and investing in research and development (R&D) globally to find sustainable strategies to achieve SDGs by 2030. In particular, to achieve SDG1 and SDG2, concerned authorities are implementing different types of social safety net programs (conditional cash transfer, unconditional cash transfer, vulnerable group feeding, employment generation for ultra-poor in particular for women, etc.); training and agricultural extension programs (training on sustainable agriculture management and food and nutrition management, agricultural value chain development, input subsidy, promote crop diversification, etc.); and R&D (innovation of improved and climate-resilient crop varieties, capacity development of local stakeholders, etc.). Researchers and international donors continuously evaluate those projects by designing alternative objectives to look for a sustainable solution for SDG1 and SDG2 in low and lower-middle-income countries (especially from SSA and SA).

In this study, we focus on improving two areas of smallholder farmers' socio-economic activities such as eradication of poverty and hunger through crop diversification and reduction of child malnutrition through authority of maternal workforce participation decision. These are of importance because one of the main challenges in achieving SDG1 and SDG2 is to eradicate persistent poverty and ensure sufficient food and eradicate malnutrition for the smallholder farmers of developing world. Our study was conducted based on the household data collected from rural farm households in Bangladesh. This study area is appropriate to provide meaningful policy recommendations in the context of our research questions because Bangladesh is a country in SA

(home to 389 million poor) with the world's highest population density and is struggling to achieve SDG1 and SDG2.

1.2 Objectives and Major Findings of the Study

The main objectives of our study are to find sustainable ways of achieving SDG1 and SDG2, focusing on the welfare improvement of smallholder farmers living in rural areas of Bangladesh who are far behind in achieving the SDG1 and SGD2 targets.

Our study contains two research papers that answer several research questions about the welfare of smallholder farmers from rural Bangladesh. In the first paper (chapter 2), we address the agricultural development of smallholder farmers by focusing on the changes in crop diversification and informal input finance under the multifaceted agricultural value chain interventions in rural areas of Bangladesh. Given the scarcity of land and incompatible competition in the market, a group of researchers argues crop diversification is a promising strategy to eradicate poverty and sufficient food supply to smallholder farmers. Crop diversification increases the availability of different foods to fill nutritional needs and also provides extra cash and resilience to climate shocks to smallholder farmers. Besides, credit constraints are a long-standing obstacle in the agricultural development of smallholder farmers who live in remote areas. Promoting informal input credit (purchase input from local vendors) can be a sustainable instrument in combating credit constraints among smallholder farmers.

We use Bangladesh agricultural value chain (BAVC) data to test the impact of multifaceted interventions on crop diversification and informal input credit among stallholder farmers in rural Bangladesh. BAVC's interventions divided into two groups such as (a) training with linkage meetings and (b) agricultural fairs with crop clinic and a common treatment called trust game

received all the treated farmers. They also conducted a trust game between farmers and input sellers in both “a” & “b” group. According to treatment assignment we found three treatment arms (T1=received both “a” & “b”, T2 = received “a” only, T3 = received “b” only) and control group. We examine our study dividing into two periods – very short-term (immediately after BAVC interventions) and relatively longer-term (2 years after BAVC interventions) based on the randomized experiment design. We use two types of econometric model – ordinary least square (OLS) and Tobit estimation to check the robustness of the estimation results. We also use several indicators of crop diversity such as croup count, crop group count, high-value crop count, and Simpson’s index that represent the crop richness, crop evenness, and both respectively. In the very short-run we did not find any impact of multifaceted interventions on crop diversification. Moreover, for some indicators the results are not consistent between two types of econometric model. In contrast, in the relatively longer-term, results were consistent between OLS and Tobit and provide statistically significant positive impact on crop diversification. Besides, we also use two methods such as OLS and Probit estimation to test the changes in informal input credit use by the same project. The results showed statistically significant impacts of multifaceted interventions on informal input credit under both the very short-term and relatively longer-term, which were consistent between OLS and Probit. To see the sustainability of increased impacts of BAVC, we further check the amount of fertilizer used for diversified crops in the relatively long-term. Our results indicate that fertilizer adoption among treated farmers are positive and statistically significant. However, when we run the Wald test to find the equality of impacts between treatment arms, it indicates that there is no statistically significant difference among treatment arms. However, the impacts of T2 group show statistical significance under all the indicators of crop diversification while only crop count and crop group count are statistically significant under T1

and no outcome variables are statistically significant under T3. Besides, T2 group higher impacts statistically significant impacts on informal input credit. Hence, we can say that in the long-term farmers who receive T2 interventions produce more diversified crops and have more access to informal input credit compared to others.

In the second paper (chapter 3), we address the changes in child (under 5 years) nutrition indicators (stunting, wasting, and underweight) due to the maternal workforce participation decisions. Female work is considered an influential poverty eradication tool that can also associate child nutrition indicators because of mothers' leading role in childcare in developing countries, in particular, rural farm households where formal childcare facilities are scarce. Existing literature focuses on the impacts of maternal employment on child nutrition based on mothers' job characteristics (on-farm, off-farm), time allocation to jobs and childcare, income from employment, and so on. Due to the inconclusive results from the current literature, there is room for exploring the impacts of maternal employment on child nutrition because of confounding income effects (increased household income) and time effects (decreased maternal time to childcare) of maternal employment. We explore a new dimension of maternal employment (maternal autonomy in workforce participation decision) and examine its associations on child nutrition indicators using panel data from an integrated household survey.

We explore the maternal autonomy in workforce participation decision to child nutrition indicators using Bangladesh integrated household survey (BIHS) data collected in 2015-16 and 2018-19 segregating maternal autonomy into 1 if mother takes workforce participation decision by herself and 0 otherwise. We use IV estimation techniques to control for endogeneity arises from

unobserved heterogeneity. We use two samples such as working mothers who have child under age 5 years and all mothers (working + non-working) who have child under age 5 years. We use working mother sample for our main analysis and all mothers sample to test the robustness of the results. We also conduct the reduced form analysis of IV to child nutrition and pooled OLS estimation of maternal autonomy in workforce participation decision without IV to child nutrition to see the association of our IV and child nutrition. We further test the associations of maternal autonomy in food decision to check whether only labor force participation or any decision-making power matters. The main estimation results showed that the mothers' autonomy in work participation decisions positively affects the child nutrition indicators. The reduced form estimation show that IV has a negative association to child nutrition and maternal autonomy has a positive association to child nutrition. The outcomes from the robustness estimation for the working mother sample using maternal autonomy in food decisions (1 if mother take food purchase decision by herself and 0 otherwise) are consistent with the main results. Besides, the generalizability test using all mother sample (1 if mother take food purchase decision by herself and 0 otherwise) also confirms the consistency of our main results. Finally, we extend our study to see the heterogeneous associations of maternal work place such as work at home or outside. The results indicates that the child health indicators showed positive associations with mothers who work from home and no significant association with mothers who work outside. Hence, we can say that maternal autonomy in workforce participation decision is an important factors in child nutrition.

From the results we can summarize that for achieving SDG1 and SDG2 in rural areas of developing countries, promoting crop diversification among smallholder farmers through multifaceted

interventions and facilitating women employment opportunity and their motivation to take part in income generating activities can be viable tools.

1.3 Literature Review and Contribution of the Study

Our study can contribute several strands of the literature. First, we contribute to the literature on sustainable agricultural production of smallholder farmers of low and lower-middle-income countries. Researchers are working with different strategies to increase the welfare of the smallholder farmers of developing countries. A group of researchers support the commercialization of smallholder farming (Fan et al., 2013; Ogutu & Qaim, 2019), and others argue for crop diversification to eradicate persistent poverty and achieve food security (Asfaw et al., 2018; Makate et al., 2022). In the context of the developing world, commercialization of smallholder farming faces several challenges that limit their desired welfare, for instance, lack of agricultural land (Neme & Tefera, 2021), lower expected return (Fan et al., 2013; Ma & Sexton, 2021), financial constraints (Neme & Tefera, 2021; Fan et al., 2013), lack of bargaining power in the market (Reardon et al., 2009; Ma & Sexton, 2021), and limited knowledge of modern farming systems and extension services (Reardon et al., 2009). Pingali (2007) argued that commercialization of smallholder farming increases the regional inequality, land degradation due to extensive chemical use, and less returns due to the disproportionate market competition with large farm. Moreover, Ma et al. (2021) find that smallholder farmers typically do not benefit directly from conversion to commercial farming for a domestic staple commodity. The Bangladesh agricultural values chain (BAVC) - a development project promoting commercialization of jute in the rural smallholder farmers in Bangladesh found no significant impact on households' welfare at the midline.

In contrast, crop diversification contributes substantially to achieving SDGs, for instance, farmers can both consume and sale the surplus from different crops they produce from small piece of land that may increase their food security and additional cash in hand that help them to get out of poverty (Michler & Josephson, 2017; Waha et al., 2018; Mulwa & Visser, 2020). It also helps farmers' resilience during shocks that reduce the risk of their cultivation (Asfaw et al., 2018; Makate et al., 2022). Sometimes crop diversification helps to prevent soil degradation and increase the productivity of the land (Ghosh et al., 2017; Yan et al., 2023). There is strong evidence that crop diversification can enhance the agronomic, financial, and environmental resilience of farming systems (Reckling et al., 2023). Crop diversification among smallholder farmers has been a central strategy for sustainable agricultural development in Bangladesh due to the growing population and shrinking land per capita (Rahman, 2009; Planning Commission, 2011). However, smallholder farmers face several challenges that affect crop diversification for instance, insufficient market access, lack of expertise in agricultural management, barriers in access to modern inputs, and lack of access to credit (Rehan et al., 2017; Wreford A. et al., 2017; Burchfield & Poterie, 2018; Emmanuel Inoni et al., 2021). To overcome the challenges Antier et al. (2022) suggested for improving coordination and providing targeted support to the numerous actors that make up and contribute to new value chains are essential to the establishment and growth of agricultural diversification. Using the BAVC data, we find that interventions of T2 group (comprehensive agricultural management training, peer group formation, linkage meetings, and trust game) targeting constraints of the farmers have the potential to improve crop diversification and informal input credit among smallholder farmers in rural Bangladesh.

Second, we also contribute to the literature promoting credit to the rural farm household of developing countries. Access to sustainable credit sources is important because credit could improve smallholder farmers' productivity, income, and food security (Foltz, 2004; Adjognon et al., 2017; Khandker, 2020). However, smallholder farmers struggled to obtain formal credit due to transportation costs (distance), lack of collateral, lack of information, and required knowledge (Hussain & Thapa, 2012; Shahidur R., 2021). According to Hussain & Thapa, (2012), formal credit requires more time and complex process than informal credit, making smallholder farmers rely on informal credit in rural Pakistan. This study seek to find a sustainable way of spreading informal credit among smallholder farmers in rural Bangladesh. We find that multifaceted interventions including treatment that designed to build trust and intimacy among farmers and input sellers positively impact on the informal input credit (purchase input on credit from local vendors) and the impact persist in the relatively longer term. This findings have a good potential to increase smallholder farmers' access to financial resources due to its' lower cost, no processing time, and no complexity.

Finally, we contribute to the literature of maternal autonomy in household decision-making and child nutrition. Females' decision-making autonomy in the household has been studied in various contexts with various measures of children's health. Indeed, using a composite autonomy score of decision-making status, financial control, and prevention of domestic violence, Chilinda et al., (2021) revealed that maternal autonomy and child height-for-age z-score (HAZ) has a negative association. However, after controlling for the covariates such as family wealth and maternal education, the result no longer becomes statistically significant. In their test, Shroff et al., (2011) observed that the maternal ability to make household decisions was positively associated with

child WAZ and WLZ/WHZ but not LAZ/HAZ using the composite autonomy score. Examining data from the Bangladesh Demographic and Health Survey, Begum and Sen, (2009) did not find statistical significance between a composite decision-making autonomy score of mothers and their children's stunting, wasting, or underweight. Due to inconsistency in the results, Carlson et al., (2014) suggested more rigorous research on each autonomy dimension separately using longitudinal data, separating maternal authority between joint decision and self-decision, and robust statistical method to determine whether various factors affect child nutrition outcomes differently. In this study, we examine a new dimension of maternal autonomy (authority of employment decision) using panel data and segregating maternal decision authority into self and otherwise. To the best of our knowledge no studies concentrate on the impacts of authority of women's WFP decision on the child nutrition. We argued that given institutional childcare facility, such as kindergarten, is not readily available in many rural areas of the developing world (Taylor, 2021), the associations of maternal workforce participation (WFP) on child nutrition can be heterogeneous depending on the WFP decision authority. We find that maternal autonomy in workforce participation decision positively affect children's HAZ, WAZ, and WHZ. Our results reveal a new insight of abetting child malnutrition of rural farm households of low and lower-middle-income countries which indicate that mothers who take their workforce participation decision have children with good health compared to mothers who take decision otherwise.

1.4 Design of the Dissertation

Chapter 2 examines the impacts of multifaceted interventions deigned to develop jute value chain on crop diversification and informal input credit among smallholder farmers. We use two round of data from a cluster randomized control implemented in the rural area of Southern Bangladesh. We started the chapter with introduction in section 1 following describing the study design, randomization, interventions, data used for the study, and outcome variables section 2; estimation strategy and baseline statistics in Section 3, estimation results in section 4, and finally section 5 provides discussions and concludes the paper.

Chapter 3 focuses on the associations of maternal autonomy in the workforce participation decision on child nutrition outcomes. We use two round of survey data from Bangladesh integrated household survey data (BIHS) – a comprehensive survey conducted in the entire rural Bangladesh aiming to track the changes of smallholder farmers welfare over time. We started the chapter with introduction in section 1 following section 2 that describes the literature review of female autonomy and child nutrition, section 3 that describes the data used for analysis, section 4 that describes the estimation strategy, section 5 describes the results, and finally section 6 concludes the paper.

Chapter 4 draws conclusions, presents the policy implications of the findings from the two analytical chapters, limitations of the study and recommendations for further study.

Chapter 2

Do Multifaceted Interventions for Agricultural Value Chain Development Affect Crop Diversification and Informal Credit among Smallholder Farmers? Evidence from a Randomized Control Trial in Bangladesh.

2.1 Introduction

Governments and international donors are taking various strategies globally to achieve sustainable development goals (SDGs). Promoting crop diversification among smallholder farmers (especially in low and lower-middle-income countries) is one such strategy that gaining increasing attention because it is considered one of the influential tools to eradicate persistent poverty - SDG1 (Birthal et al., 2015; Michler & Josephson, 2017; Thapa et al., 2017), increasing food security - SDG2 (Njeru, 2013; Islam et al., 2018; Mango et al., 2018; Waha et al., 2018; Mulwa & Visser, 2020), better nutrition intake especially for children -SDG2 (Carletto et al., 2015; Kumar et al., 2015; Dillon et al., 2018; Khonje et al., 2022), improving dietary diversity - SDG12 (Jones et al., 2014; Hirvonen & Hoddinott, 2016; Islam et al., 2018; Ahmed et al., 2023; Alam et al., 2023), reduce soil degradation - SDG13 (Ghosh et al., 2017; Yan et al., 2023), and higher resilience to climate change - SDG13 (McCord et al., 2015; Makate et al., 2016; Arslan et al., 2017; Mulwa & Visser, 2020).

Crop diversification is a broad concept that includes techniques like increasing crop rotation, growing minor crops, cover crops, and intercropping (Brannan et al., 2023). Besides substantial contributions to SDGs, crop diversification is an influential component of smallholder farmers' resilience and adaptability to weather shocks (Asfaw et al., 2018; Makate et al., 2022). However,

crop diversification among smallholder farmers in the developing world remains low (Rahman, 2010; Ahmed & Ghostlaw, 2019). The significant barriers that affect crop diversification among smallholder farmers include insufficient market access due to competitive disadvantages from large farmers (Rehan et al., 2017; Burchfield & Poterie, 2018; Brannan et al., 2023), lack of knowledge of modern agricultural management (Rehan et al., 2017; Emmanuel Inoni et al., 2021), lack of access to modern inputs (Wreford A. et al., 2017; Burchfield & Poterie, 2018), and lack of access to credit (Rehan et al., 2017; Wreford A. et al., 2017; Emmanuel Inoni et al., 2021). To overcome the challenges, Antier et al. (2022) suggested that improving coordination and providing targeted support to the numerous actors that make up and contribute to new value chains are essential to promote agricultural diversification among smallholder farmers.

The multifaceted agricultural value chain (AVC) projects could be a potential channel to extend crop diversification among smallholder farmers in the developing world. Despite AVC projects generally targeting the value chain development of a single crop that can lead farmers to concentrate their all assets and efforts into one target crop, its multifaceted interventions, such as agricultural management training, facilitate access to inputs and output market, facilitate peer farmers information sharing, and facilitating input credit could enable farmers to cope with the constraints and may stimulate them to cultivate diversified crops along with targeted crop to satisfy nutritional need and having better dietary diversity as well as a source of additional cash.

The Bangladesh Agricultural Value Chain (BAVC) project is an example of a multifaceted AVC, which has been implemented in the rural areas of southern Bangladesh since 2016. It contains several unique features. First, it offers training to improve the knowledge of jute farmers on topics

such as plantation, weeding and pest management, post-harvest, and marketing strategy; second, it sets up linkage meetings with local input sellers, government officials, MFI officers, and buyers to increase farmers' knowledge about input availability and government policies for agriculture as well as improve credit availability; and third, private input sellers organize fairs and crop clinics to engage farmers and encourage them to adopt modern seed varieties and fertilizer. The impact evaluation report of BAVC found that farmers in the treatment group showed significant knowledge gain on the production and marketing of jute and higher adoption of modern technology (Alan et al., 2019). The report by Alan et al. (2019) also found a higher degree of reciprocity between farmers and input sellers, and even input sellers engaging in altruistic behavior towards farmers. However, BAVC impact evaluation report found no significant gain in production, productivity, and profitability of jute cultivation at the midline (Alan et al., 2019). Given no impacts on jute cultivation and the better knowledge of modern agricultural management, marketing and the availability of modern inputs, it may be possible that treated farmers will be inspired to cultivate diversified crops instead of commercialized production of jute for both consumption and extra cash.

This study, thus, seeks to explore side impacts of the BAVC project implemented in rural Bangladesh, with particular focus on the differential degree of crop diversification. While crop diversification can provide better nutrition and dietary diversity, it is declining gradually in Bangladesh (Rahman, 2009; Rahman, 2010). However, the current production of various crops (vegetables, spices, fruits, pulses, oilseed, etc.) that provide nutrition intake and dietary diversity is insufficient (Planning Commission, 2011). Thus, crop diversification among smallholder farmers has been a central strategy for sustainable agricultural development in Bangladesh

(Rahman, 2009; Planning Commission, 2011; Timsina et al., 2018)[7]. In this circumstance, it is of great interest to investigate the consequences of multifaceted interventions on the crop diversification among smallholder farmers in rural Bangladesh.

Several novel features strengthen our study. First, a cluster randomized trial design was implemented which help obtain clean causal impact of the BAVC; second, measurement of various outcomes that capture production diversity in multiple forms, such as total number of crops cultivated, total number of crop groups cultivated, total number of high-value crops cultivated, and Simpson's diversity index help us obtain insight into heterogeneous motives for crop diversification; and third, implementation of the BAVC interventions in diverge geographical locations in 50 distinct villages located away from each other in 9 sub-districts of 4 districts of Bangladesh helps give the generalizability of our results. One may argue that since BAVC focused on jute farmers, applicability of its interventions on other farmers may pause an issue. However, if we consider the nature of smallholder farmers in the rural areas of developing countries, it shows similar pattern of their socio-economic conditions and constraints of crop diversification such as lack of knowledge, limited access to market, imperfect market competition, unavailability of improved inputs, and lack of access to credit. Since smallholder farmers from entire rural Bangladesh also face similar constraints in increasing crop diversification, we expect that new extension project with multifaceted interventions designed to facilitate crop diversification may have similar impacts among non-jute farmers.

[7] For example: Agriculture, Gender, and Nutrition Linkages (ANGeL), a pilot project implemented by the Bangladesh government during 2015-2018 (Ahmed et al., 2018) and another ongoing project, the smallholder agriculture competitiveness project (SACP) jointly implemented by Bangladesh government and IFAD.

Aside from the impact on crop diversification, we extend our study to look for the impact of BAVC on the promotion of informal financing (input credit) source. This is important as smallholder farmers in Bangladesh face an imperfect credit market (Khandker & Koolwal, 2015; Hossain et al., 2018), despite the long history of female-centric micro-credit interventions (Pitt et al., 2006). While Bangladesh Bank regulates the banks to disburse agricultural credit to smallholder farmers for diversify their productions, smallholder farmers struggled to obtain bank credit due to transportation costs (distance), lack of collateral, and lack of information and required knowledge (Shahidur R., 2021). Given such credit market failures in the formal system, access to informal credit is important because it could improve smallholder farmers' productivity, income, and food security (Foltz, 2004; Adjognon et al., 2017; Khandker, 2020), whereas credit constraints limit the decision to adopt new technologies and input use (Ali et al., 2014; Adjognon et al., 2017; Balana et al., 2022). We thus investigate whether treated farmers will get more informal credit, especially input credit (excluding borrowing from moneylenders) from local vendors compared to control farmers because of the input sellers' reciprocity and trust building, and if so improved access to informal input credit results in the adoption of modern technologies, represented by the use of fertilizer[8].

We analyze the impacts of BAVC on crop diversification and informal input credit based on very short-term (1 year after interventions) and relatively longer-term (2 years after the interventions) periods. Overall, we fail to find a statistically significant consistent estimate of crop diversification in the very short-term. However, our models show a significant positive impact of BAVC on the

[8] Informal credit is important for current developing countries, although its importance will be eroded over the course of development.

informal input credit (input purchased on credit from local vendors). On the other hand, the relatively long-term results show significant impacts on both the crop diversification and informal input credit. Our extended analysis indicates significantly positive impacts of BAVC on fertilizer use of crops other than jute.

The rest of the paper is structured as follows: - section 2 describes the study design, randomization, interventions, data used for the study, and outcome variables; Section 3 describes the estimation strategy and baseline statistics, section 4 describes the estimation results, and section 5 provides discussions and concludes the paper.

2.2 Designing the BAVC and Data Collection

2.2.1 Overview of BAVC

The Bangladesh Agricultural Value Chains (BAVC) project, funded by USAID and implemented by International Food Policy Research Institute (IFFRI) with the technical assistance of Development Alternatives International (DAI), is targeted at increasing food security and nutrition by developing agricultural value chains in southern Bangladesh. BAVC especially targets a non-food crop of jute and aims to nudge stakeholders to change their behaviors. It also involves the variety of value chain participants, such as input suppliers, output buyers, and service providers, to jointly improve the entire market system.

More specifically, the BAVC tries to address the following three bottlenecks. The first is a lack of understanding among farmers about appropriate farming and post-harvest procedures. The second is a lack of trust in input quality between farmers and the input sellers. In situations like Bangladesh, where contracts are frequently unenforceable, reciprocity between concerned people

is crucial to raising the demand for and securing the quality of inputs. The third is high transaction costs in dealing with smallholder farmers because their scale of the production is generally small. Hence, BAVC focused on actively engaging the local input suppliers and traders in the value chain to facilitate farmers in collecting inputs and selling conveniently. Moreover, BAVC arranged linkage meetings between farmers and government and NGO officials aiming to provide information of existing government facilities (subsidy, extension programs etc.), available credit sources, and profitability of modern technology adoption for smallholder farmers.

Based on the focus and objectives, the BAVC has provided training to farmers through local NGOs. The farmer training class was conducted in February 2016, consisting of several sessions in two full days. Training included a wide range of jute-related best practices, such as the use of enhanced and certified seed varieties, the best mix and volume of inorganic fertilizer, pest identification, and control strategy, contemporary retting methods for fiber separation, and grading of jute fiber quality. The training intended to equip farmers with knowledge that would enable them to produce jute of a higher caliber and fetch a higher price. Selected farmers form a training group of 30 members who live geographically near to each other. This is expected to increase collaboration between farmers and facilitate the dissemination of agricultural and marketing knowledge among peers.

The BAVC project also contains (1) linkage meeting arranged after training among Government (local agriculture/administrative officers), local NGO officers and farmers; and (2) agricultural fairs arranged by the input sellers with the help of BAVC implementation team as well as crop clinics conducted by input sellers in the fairs for providing agricultural advice to the farmers. The linkage meeting is an interactive meeting comprised of predesigned lecture by the guest speakers

from local government and NGO officials who are experts in agricultural issues. After the talk of the guest speakers, famers can ask open questions and obtain their answers. The purpose of the linking meetings was to extend information exchange amongst various value chain participants who might not normally speak with one another directly. Meanwhile, agricultural fairs and crop clinics are implemented by BAVC's private sector partner, NAAFCO group - a leading agricultural input suppliers in Bangladesh. Crop clinics were set up at the fairs with the expert from suppliers to provide additional extension advice to the farmers, such as the upgraded jute seeds, NPKS fertilizer and discounts on the inputs managed by NAAFCO. Input sellers arrange raffle draw at the fairs which provide discounts on jute inputs. The fairs and clinics aim to strengthen the farmers' motivation of jute cultivation through expert connection and practical knowledge of inputs. The IFFRI team also conducted a trust game between input sellers and farmers aiming to build trust among them. Because one of the motivation of the BAVC project is to address the problematic trust issue between input sellers and farmers. A lack of trust is common in contexts such as Bangladesh, where contracts are often not enforceable. As long as contracts remain unenforceable, relational contracts will play an important role in improving the quality of and demand for inputs. Relational contracts are informal agreements sustained by the value of future relationships (depending on the circumstances, sometimes the value of relationship may be usurious). In a relational contract, a farmer and input seller may have the agreement that the input seller provides high quality along with additional services such as credit or agricultural extension, as long as the farmer buys from the input seller. The ultimate goals of the BAVC are to improve transactions, trust-building among different stakeholders, network-building, and market system to strength and facilitate investment, which could create favorable environments for jute farmers.

2.2.2 Randomization and Sampling Procedure

In order to evaluate the impact of BAVC's interventions, a clustered randomized controlled design was employed. The target districts were set to four southern districts of Bangladesh (Faridpur, Jhenaidah, Madripur, and Narail). These districts were chosen purposively to develop jute value chain due to the prevalence of jute cultivation among farmers of those districts. Later, the enumeration team sorted out 59 potential jute-producing villages in four districts for program implementation. Subsequently, out of 59, they selected 50 villages for implementation, excluding villages extremely close to one another that may cause spillover effects and to prevent upzillas (sub-districts: geographic unit above villages) with only one or two villages that could affect the ability to draw inferences of treatment effects.

Based on the focus and objectives, the BAVC has the following treatment arms (figure-2.1) and randomly allocated villages to one of the arms:

1. Farmers who receive both training and linkage meetings and attend fairs and crop clinics (13 villages), hereafter we call it T1
2. Farmers who receive training and linkage meetings only (12 villages), hereafter we call it T2
3. Farmers who attend fairs and crop clinics only (12 villages), hereafter we call it T3
4. Control group-who received neither treatment (13 villages), hereafter we call it C

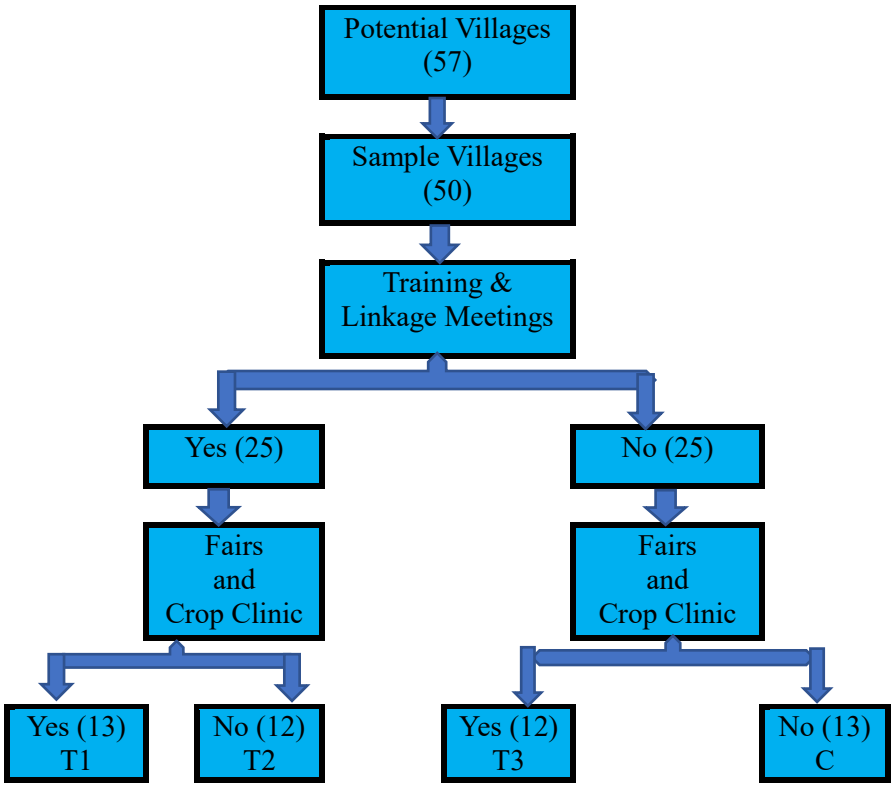

Fig-2.1: Randomization flow chart.

To obtain sample households in each village, the enumeration team conducted a household listing for all the sample villages at the beginning of 2016. The team used these data to apply two eligibility requirements for sample inclusion. Firstly, households had to have planted jute in the next season or have grown it in the previous one. Secondly, to guarantee that the sample consisted of smallholders rather than larger commercial farmers, it eliminates households possessing more than 5 acres of land. From the eligible households, 20 households are randomly selected from each village, consisting 1000 households in total. Then, a baseline survey was conducted between February and April 2016. The baseline data contain detailed rural household level data about individual household members' information such as age, education, ownership of cellphone, employment status, and physical conditions; detailed information of agricultural production such

as, main crop, others crops, land holdings, modern technology used for jute cultivation, cost of production of jute, availability and participation of local agricultural producer group; detailed information of marketing such as selling place, distance to market, mode of transportation to market etc.; housing information such as conditions of the house, materials used for floor, roof, and wall, sources of power and water, and garbage disposal etc.; household expenditure other than foods; and food security status. Midline and endline surveys were then implemented in February-March 2017 and April-May 2018, respectively. Unfortunately, however, those follow-up surveys did not collect detailed information on crop production other than jute, such as area harvested and sales price of each product. This limits the scope of our analysis.

The BAVC project for jute started with 1000 households and enumerators interviewed 978 households at the midline and 974 households at the endline among 1000 households as shown in Table 2.1 below.

Table 2.1: Data Collection by Survey Rounds and used by Treatment Arms

Survey Round	**Survey Period**	**Data Collection**			**Data used for Analysis based on Treatment Arms**			
		Targeted Sample	**Actual Collection**	**(%)**	**T1**	**T2**	**T3**	**C**
Baseline	February - April 2016	1000	1000	100	263	235	242	260
Midline	February - March 2017	1000	978	97.80	257	233	235	253
Endline	April - May 2018	1000	974	97.40	254	233	234	253

Although non-random attrition, such as that linked to treatment status or household characteristics, can be problematic, the incredibly low levels of attrition in this sample make it highly unlikely that observed attrition will significantly alter impact estimates. It shows only 2.20% attrition at midline

and 2.60% attrition at the endline. We run linear probability model to check the attrition is random across treatment arms following Ahmed et al., (2023). We construct attrition variable using endline attrition where the outcome is equal to 1 if the households stay at the endline and 0 otherwise. Our results in Appendix table-A1 shows that there is no statistically significant correlation between attrition and treatment arms.

2.2.3 Conceptual Framework:

Existing literature finds several root causes of limited crop diversification among smallholder farmers including insufficient market access due to the competitive disadvantage with large farmers, limited knowledge of modern agricultural management techniques, constraints in accessing input markets and input credit. Multifaceted interventions provided to the farmers under BAVC project to develop jute value chains in rural Bangladesh have the potential to mitigate the constraints of smallholder farmers in crop diversification. According the figure-2.1 BAVC's interventions mainly divided into two groups 1) Training and Linkage meetings – it includes training provided by a local NGO expertise in agricultural extension training, formation of peer groups, linkage meetings, and trust game. Training covers a wide variety of topics (land preparation, fertilizer use, seed quality, pest management, retting of jute fiber, storage procedure, source of finance, and market information) and 2) Agricultural fairs and crop clinic – where farmers got information about modern seeds, fertilizer, and other inputs of jute and provided discount offers to the farmers as well as the opportunities to discuss with expert from input sellers if required. By considering the constraints of adopting crop diversification and input credit among smallholder farmers, the BAVC's treatment arms may affect crop diversification and informal

input credit differently. The following figure shows how treatment contribute to mitigating the famers' constraints.

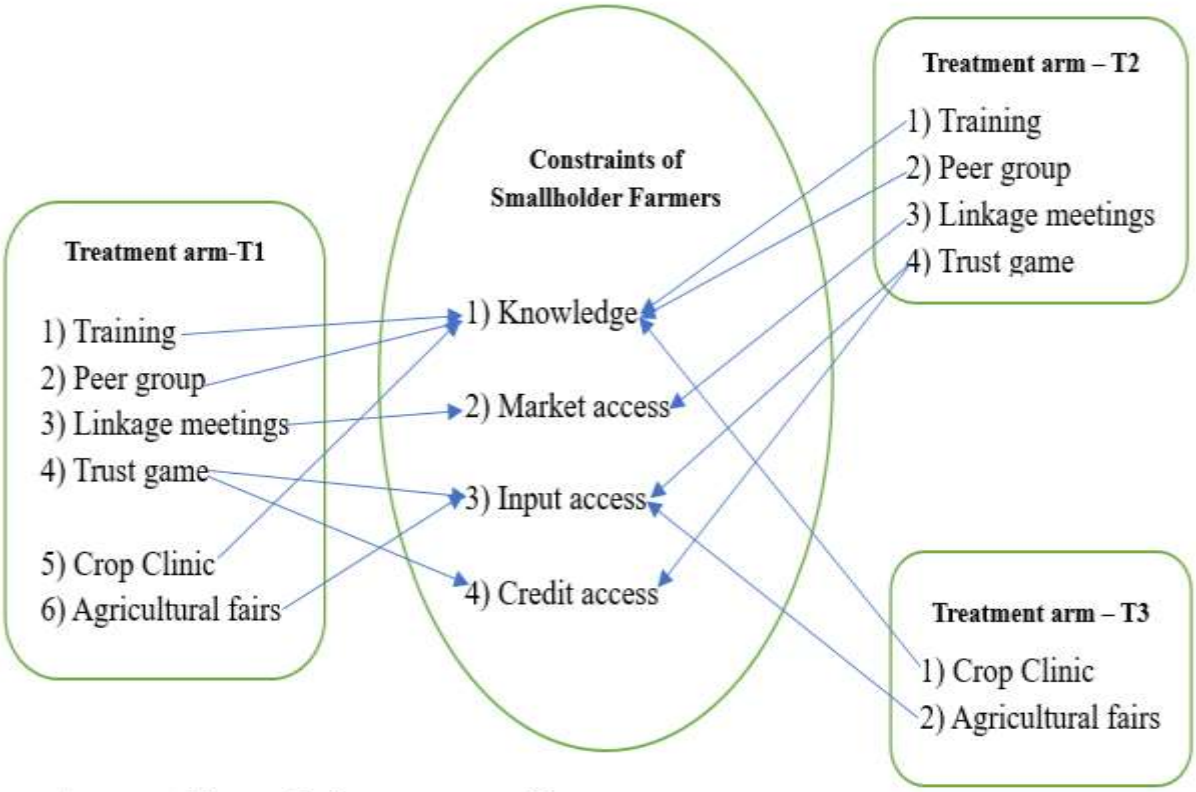

Fig – 2.2| conceptual framework of treatment arms and farmers constraints mitigation.

The figure-2.2 shows that T1 group received knowledge from two sources such as comprehensive modern agricultural management training conducted by local NGOs (same as T2 group) and expert opinion about jute inputs and cultivation procedure from the crop clinic. They also get peer group connection, linkage meetings, agricultural fairs participation, and trust game interventions. While those interventions were not originally intended to crop diversification, it indicates that, T1 group gets sufficient interventions that can successfully mitigate the constraints of crop diversification of smallholder farmers. Besides, farmers belong to T2 group gets less treatments (NGO training,

peer group connection, linkage meetings, and trust game) compared to T1 group but they can also address the constrained faced by smallholder farmers in crop diversification. On the other hand, farmers belong to T3 group only got information about jute cultivation process, jute inputs and discount on jute inputs but no formal modern agricultural management training, peer group connection, linkage meetings, and trust game. It indicates that farmers belong to T3 group still constraints from knowledge of modern agricultural management and market information that needed for diversified production. Hence, we hypothesize that T1 group may produce more diversified crops compared to T2 and T3 group. Accordingly T2 group may have higher crop diversification compared to T3 group. In case of informal input credit, T1 & T3 group may have discount at the midline at the fair, which may be extended to the later period due to the better relation with input sellers. Generally discounted products sale on cash, which reduces necessity of input purchase on credit. As a result, there is a possibility of having less input credit of the farmers belong T1 & T3 groups.

2.3 Estimation Strategy:

2.3.1 Outcomes of Interest:

Our primary outcome variable is crop diversity among smallholder farmers in rural Bangladesh. To capture crop diversity, we will use several different measurements. First, we use the crop richness of farmers, a widely used diversity indicator (Jones et al., 2014; Islam et al., 2018; Sibhatu & Qaim, 2018; Ahmed et al., 2023) constructed by counting crops produced by the households in the last 12 months of the survey date. We focus on 12 crop species (rice – cultivated in aus, aman, boro[9] seasons; wheat; pulses; vegetables – potato, tomato, others; spices – coriander, garlic, onion; and oilseeds). Hence, the crop richness score takes the values from 0 to 12 for each household.

Second, to better understand the nutrition availability from own sources of the rural farm household, we use the nutritional functional diversity (NFD) constructed by counting the food groups produced by each household. The idea behind NFD is that when farmers cultivate different groups of crops, their nutritional diversity is often secured as suggested by Hirvonen & Hoddinott, (2016); Koppmair et al., (2016); Romeo et al., (2016); and Sibhatu & Qaim, (2018). We particularly use six food groups (rice, wheat, pulses, vegetables, spices, and oilseeds) to construct NFD. Hence, the NFD score takes the values from 0 to 6 for each household.

We further constructed an outcome variable only for high value crops excluding rice from the 12 crop species to see the supply of dietary diversity of the households. This is the crop richness for high-value crops only which contains 9 crop spices (wheat; pulses; vegetables – potato, tomato,

[9] These are the three rice cultivation sessions in Bangladesh. Farmers usually cultivate aus rice during March-April, aman rice during June-July, and boro rice during December-January of every year.

others; spices – coriander, garlic, onion; and oilseeds). Hence, the high-value crop richness score takes the values from 0 to 9 for each household.

Often, the crop count or group count approaches lack to extract actual diversity in the production line. To overcome this limitation, we lastly use Simpson's diversity index (SDI) following Jones et al., (2014) & Ahmed et al., (2023) which is widely used in the study of diversification (Rahman, S. 2009). The SDI considers both the number of different crops grown by a household and the intensity of crops in the production line devoted to different crops. We use following equation to construct crop diversity index (CDI) following SDI: -

$$CDI = 1 - [(\frac{\sum g1}{N})\text{^}2 + (\frac{\sum g2}{N})\text{^}2 + \cdots + (\frac{\sum gn}{N})\text{^}2] \text{ ---------- (1)}$$

In the above equation, N represents the total number of crops produced by a household and g1, g2, gn represent total numbers of crop produced by the same household in each group. Hence, CDI is the 1 minus the squared sum of proportionate crops produced per group by the households. This approach of diversity is also known as Herfindahl–Hirschman index mainly used for calculating industrial diversity. A zero value of CDI indicates that the household produces no crop diversity and higher values closer to 1 indicate better crop diversity.

Our extended outcome variable is input purchase on credit from local vendors. As discussed in the introduction, informal credit market development (especially credit purchase from local vendors) in the rural areas can be beneficial for smallholder farmers in adopting modern technology such as seeds, fertilizer, and insecticides. To check the impact of BAVC on informal credit, we use input credit as an outcome variable that takes 1 if a household had purchased input on credit and 0 otherwise. We do not include informal credit from other sources, such as money lenders. Despite

there is chance that some input sellers may behave like moneylenders, which may adversely affect smallholder farmers' welfare, we hypothesized that the average impact of informal input credit is beneficial to smallholder farmers. While continuous outcome, such as amount of informal credit is also of great interest, our dataset contains information only on binary variable regarding input purchase on credit, which limits the scope of this study. Crop diversity and input credit variables were analyzed using midline and endline data.

2.3.2 Econometric Model:

We take advantage of the RCT design of the interventions to analyze our research questions. We use an intent-to-treat (ITT) estimate for our analysis. The main advantage of employing an ITT strategy is that it captures the average treatment effect of random assignment, accounting for the possibility that some participants may not be interested in participating in the interventions. To minimize the uncertain changes of variances of our outcome variables, we include lag (baseline) values of our outcome variables in the regressions (Ahmed et al., 2023). This approach is known as ANCOVA specification. We estimate the following equation: -

$$Y_{ht} = \beta_0 + Y_{ht-1} + \beta_1 TP_h + \beta_2 T_h + \beta_3 P_h + \beta_4 X_{ht-1} + \varepsilon_{ht} \text{ ---------- (2)}$$

Where Y_{ht} is the outcomes of interest for household *h* at the time *t* discussed above and Y_{ht-1} is the lagged (baseline) values of outcome variables. We estimate this equation separately for midline and endline to examine the differential impacts over time; TP, T, and P are the dummy variables that take the value of 1 if the household belongs to T1, T2, and T3 treatment arms respectively, and 0 otherwise. Control group (C) is the reference; X_{ht-1} is a vector of baseline covariates, and ε_{ht} represents error term.

For both continuous and dichotomous outcome variables, our main specification uses the ordinary least square (OLS) method. Given the censored nature of our main diversification outcome variables such as 0 to certain level for crop counting outcome variables and 0 to 1 for Simpson's index, the partial effects on E(y/x) produced by simple OLS cannot provide consistent results over wide range of X (Wooldridge, 2010). To overcome this issue, Wooldridge, (2010) suggested a corner solution such as Tobit estimates as a better alternative. In this paper, we also use Tobit regression for our diversity variables to cross check the validity of our OLS estimates. On the other hand, since our informal credit variable is a binary outcome variable, we also use Probit regression to verify our OLS estimates.

To determine whether the differences in impacts estimated from different treatment arms are statistically significant, we conduct Wald tests for each outcome. Particularly, we evaluate whether T1=T2, T1=T3, and T2=T3. Through these comparisons, we can assess how combined interventions differ from single interventions in case of crop diversification and informal input credit.

2.3.3 Controlling Variables:

We also include the following baseline controlling variables.

Household Head Characteristics: it includes the household head's age, and a dummy variable of the household head's literacy that takes 1 if he/she can read and write and 0 otherwise.

Household Characteristics: it includes a set of dummy variables for the highest education level achieved by any household member, comprising no school, completion of primary, pre-secondary, secondary school, and college, where no school is the base variable. We also include household size, total agricultural land in acres, number of cattle owned by the household, and a dummy variable of whether a household has the access to modern agricultural machinery or no. Besides, we include the household's yearly non-food expenditure as a proxy of household per capita expenditure, total yearly expenditure on durable goods (electronics appliances, jewelry, and housing) as a proxy to household fixed assets due to unavailability of per capita expenditure and fixed assets in the datasets, and the log of the number of food items consumed during the last seven days as a proxy of the household's socio-economic status.

Community Characteristics: it includes distance to the nearest market in minutes and a dummy variable of agricultural producer group in the community that takes 1 if available and 0 otherwise. Finally, following Abadie et al., (2022) and Ahmed et al., (2023) we include a set of upazila dummy (geographic unit above the unit of randomization) to capture the time-invariant spatial heterogeneity. The standard errors are clustered at the village level, at which the randomization was implemented.

2.3.4 Baseline Statistics:

Characteristics of Covariates and Outcome Variables based on Treatment Arms:

Table 2.2: Baseline Covariates Statistics by Treatment Arms (mean)

Variables	C	T1	T2	T3
Household Size (numbers)	4.69	4.93	4.60	4.64
	(3.49)	(3.45)	(2.33)	(2.01)
Household head gender (female=1, male=0)	0.06	0.04	0.02	0.03
	(0.06)	(0.04)	(0.02)	(0.03)
Household head Literacy (yes=1, no=0)	0.51	0.51	0.48	0.48
	(0.25)	(0.25)	(0.25)	(0.25)
Household head Age (years)	46.89	47.88	47.37	47.41
	(13.49)	(13.30)	(12.29)	(11.54)
Highest education achieved by any household members (years)	10.63	10.81	10.37	10.99
	(9.17)	(8.30)	(11.72)	(7.69)
Agricultural land own by household (acres)	1.76	1.96	1.81	1.61
	(1.94)	(1.94)	(1.72)	(1.25)
Access to modern agricultural machinery (yes=1, no=0)	0.40	0.47	0.50	0.48
	(0.24)	(0.25)	(0.25)	(0.25)
Numbers of cattle own by household	1.13	1.38	1.31	1.15
	(1.71)	(1.92)	(1.56)	(1.50)
Total yearly household expenditure other than food in Tk.	55244.14	64287.03	62423.62	76899.51
	(5.72e+09)	(6.76e+09)	(6.94e+09)	(8.97e+09)
Total yearly household expenditure for fixed assets in Tk.	3796.40	3715.28	4870.96	3507.79
	(2.23e+08)	(1.62e+08)	(5.27e+08)	(1.43e+08)
Household members consumed foods in last 7 days (numbers)	21.61	20.44	20.08	20.14
	(28.57)	(30.94)	(28.23)	(32.22)
Distance to nearest market (in minutes)	14.51	14.26	15.63	9.06
	(51.03)	(53.47)	(47.04)	(79.54)
Availability of active agriculture/livestock producer group in the community (yes=1, no=0)	0.15	0.17	0.18	0.17
	(0.13)	(0.14)	(0.15)	(0.14)
Total crop count (crop richness)	3.06	3.40	3.09	2.82
	(2.13)	(2.82)	(2.39)	(2.08)
Total crop group count (crop evenness)	2.72	2.99	2.67	2.46
	(1.68)	(2.56)	(1.99)	(1.73)
Simpson's diversity index (both crop richness and evenness)	0.50	0.49	0.48	0.45
	(0.06)	(0.06)	(0.06)	(0.07)
Informal input credit	0.14	0.09	0.09	0.07
	(0.12)	(0.08)	(0.08)	(0.07)
N	260	260	240	240

** Standard errors is in parenthesis*

Table 2.2 presents the mean and standard for the baseline control variables included in our models. The mean values of baseline control variables under the different treatment arms almost similar to each other with small differences except household head's gender and total yearly household expenditure other than food. The table shows that control (C) group have almost double female household head compared to treatment arms and treatment groups spend substantially higher amount during the year compared to control group. Besides, informal input credit – one of our outcome variable shows households belongs to group C enjoy higher access to informal input credit compared to treatment groups, more specifically the difference is almost double between C and T3. However, our balance t-test across treatment arms (Appendix table-A2) shows that two variables (access to modern agricultural machinery and number of foods consumed in last 7 days) under all treatment arms are statistically different from C. Besides, two variables (total agricultural land ownership and numbers of cattle owned) under T1, two variables (yearly household expenditure other than food and distance to nearest market) under T3, and household head gender under T2 & T3 are statistically different from control group while rest of the variables are balanced at baseline. On the other hand, our outcome variables at baseline show that total crop count and crop group count variables under T1 and T3, Simpson's index under T3, and informal input credit under all treatment arms are statistically different from C. While the underlying reasons are not clear, we control all the above baseline characteristics including land holding and baseline outcome variables in our model to limit the biases from baseline differences. Thus, we believe that our estimation results are internally valid given the data constraints.

2.4 Evaluation of the Impacts:

2.4.1 Results

The table 2.3 shows the OLS results of the impacts of BAVC interventions on crop diversification among smallholder farmers. Panel-A of the table 2.3 shows the results of crop diversification outcomes under different treatment arms at shortly (1 year) after the BAVC interventions and Panel-B shows relatively longer-term impacts (2 years after BAVC interventions).

Panel-A shows that all of our indicators of crop diversification (crops count, crops group count, high-value crop count, and Simpson's index) have a negative association for households that belongs to T1 & T2 groups and positive association for households under T3 group compared to control group. None of the above impacts are, however, statistically significant.

On the other hand, Panel-B shows all of our indicators of crop diversification (crops count, crop group count, high-value crop count, and Simpson's index) have a positive association for households assigned to different treatment groups compared to control group, although it is statistically insignificant for T3. Specifically, T1 groups produce 0.25 more crops and 0.18 more crop groups compared to control group and they are statistically significant at 10% level; similarly T2 group produces 0.36 more crops, 0.24 more crop groups, 0.28 more high-value crops, and 0.72 standard deviation (0.04 index) higher crop diversity compared to control group. The impacts of the rest of the diversity outcomes are also positive but not statistically significant. The results of Wald test show that we fail to reject the null hypothesis that the impacts across three treatment arms are equal for all outcome variables especially between significant results of T1 and T2 under panel-B. It implies that although the magnitude of T2 group show higher impact compared to other

two groups, they are not statistically different from each other at the relatively longer-term. However, in terms of statistical significance, the results show that all the diversity indicators under T2 group are statistically significant but only two indicators are statistically significant under T1 group and T3 group shows no statistical significance. It indicates that treatments provided to T2 group would have the potential to increase crop diversification among smallholder farmers. This result contradict to the hypothesis at our conceptual framework. The underlying reason may be that farmers belonging to the T1 group got motivated to invest most of their land in jute cultivation rather than diversified production due to getting a higher knowledge of jute cultivation from two sources (training & crop clinic) and have better relations with jute input experts from the crop clinic. As a supporting evidence of our argument, we compare the land used for jute cultivation during midline and endline across treatment groups (Appendix: table – A3). The data show that average jute cultivation at the midline for T1 group is 96.64 decimal and T2 group is 93.85 decimal whereas at the endline it is 105.30 decimals for T1 group and 93.44 decimals for T2 group. It indicates that farmers belong to T1 group use more land in jute cultivation compared to T2 group.

Table - 2.3: OLS Estimation- Crop Diversification

VARIABLES	Panel-A: Very Short-term (midline)				Panel – B: Relatively Longer-term (endline)			
	(1) Croup Count	(2) Group Count	(3) HVC Count	(4) Simpson's Index	(5) Crop Count	(6) Group Count	(7) HVC Count	(8) Simpson's Index
Treatment = T1	-0.09	-0.11	-0.06	-0.03	0.25*	0.18*	0.14	0.02
	(0.26)	(0.20)	(0.22)	(0.03)	(0.15)	(0.10)	(0.12)	(0.02)
Treatment = T2	-0.26	-0.23	-0.19	-0.02	0.36**	0.24*	0.28*	0.04*
	(0.24)	(0.19)	(0.23)	(0.02)	(0.16)	(0.13)	(0.15)	(0.02)
Treatment = T3	0.05	0.12	0.10	0.03	0.20	0.10	0.09	0.03
	(0.23)	(0.19)	(0.21)	(0.02)	(0.16)	(0.11)	(0.14)	(0.02)
Control Variables	yes	yes	yes	yes	yes	yes	yes	yes
Constant	5.14***	4.89***	4.11***	0.74***	3.74***	3.55***	2.68***	0.62***
	(0.63)	(0.52)	(0.57)	(0.06)	(0.47)	(0.35)	(0.45)	(0.06)
p-values of treatment equality								
T1 – T2	0.52	0.51	0.61	0.70	0.47	0.62	0.36	0.38
T1 – T3	0.54	0.21	0.43	0.02	0.78	0.49	0.70	0.86
T2 – T3	0.11	0.02	0.14	0.01	0.31	0.23	0.18	0.47
Observations	978	978	978	977	974	974	974	960
R-squared	0.09	0.15	0.13	0.11	0.13	0.14	0.16	0.10

##the control variables includes- lag (baseline) values of outcome variables; numbers of household member; household head's age, gender, literacy rate; highest level of education status of any household member; household's possession of agricultural land, numbers of cattle, and access to modern agricultural machinery; household's yearly fixed assets purchase, and total yearly expenditure other than food; numbers of food group consumed in last seven days; distance to the market, availability of community agricultural producer group, and upazila fixed effects.
##village level clustered standard errors is in parentheses; *** p<0.01, ** p<0.05, * p<0.1

Table – 2.4: Tobit Estimation- Crop Diversification

VARIABLES	Panel-A: Very Short-term (midline)				Panel – B: Relatively Longer-term (endline)			
	(1) Croup Count	(2) Group Count	(3) HVC Count	(4) Simpson's Index	(5) Crop Count	(6) Group Count	(7) HVC Count	(8) Simpson's Index
Treatment = T1	-0.09	-0.10	-0.54	-0.04*	0.26**	0.18*	0.16	0.03
	(0.16)	(0.13)	(0.59)	(0.02)	(0.13)	(0.10)	(0.12)	(0.02)
Treatment = T2	-0.25	-0.23*	-1.20	-0.03	0.38***	0.25**	0.31**	0.05**
	(0.16)	(0.13)	(0.23)	(0.02)	(0.13)	(0.10)	(0.12)	(0.02)
Treatment = T3	0.06	0.12	0.69	0.03	0.22*	0.11	0.11	0.03
	(0.16)	(0.14)	(0.49)	(0.02)	(0.13)	(0.10)	(0.12)	(0.02)
Control variables	yes	yes	yes	yes	yes	yes	yes	yes
Constant	5.13***	4.88***	4.15***	0.75***	3.72***	3.53***	2.63***	0.61***
	(0.53)	(0.44)	(0.51)	(0.07)	(0.42)	(0.34)	(0.39)	(0.07)
p-values of treatment equality								
T1 – T2	0.30	0.43	0.51	0.57	0.34	0.51	0.21	0.31
T1 – T3	0.36	0.07	0.22	0.00	0.76	0.49	0.69	0.79
T2 – T3	0.06	0.02	0.07	0.01	0.23	0.19	0.15	0.48
Observations	978	978	978	977	974	974	974	960

##the control variables includes- lag (baseline) values of outcome variables; numbers of household member; household head's age, gender, literacy rate; highest level of education status of any household member; household's possession of agricultural land, numbers of cattle, and access to modern agricultural machinery; household's yearly fixed assets purchase, and total yearly expenditure other than food; numbers of food group consumed in last seven days; distance to the market, availability of community agricultural producer group, and upazila fixed effects.
##standard errors is in parentheses; *** p<0.01, ** p<0.05, * p<0.1

Table 2.4 shows BAVC's interventions on crop diversification under Tobit regression. The results are mostly similar with the Table 2.3 except for several coefficients. For example, under the Tobit regression analysis, the impacts of group count under T2 group and T1 group under Simpson's index turn to be significantly negative in the short run. The results of the pane-B under Tobit estimation are consistent with the results from OLS estimates. However, the statistical significance is higher in Tobit results compared to OLS estimates for crop count under T1 and for all the

diversity indicators for T2. The largely consistent results in the relatively longer-term under two estimation methods would give a sense of confidence to the results produced by our study.

Now, we turn to the results on the informal credit. As stated above, one of the BAVC's goal is to increase intimacy among stakeholders to decrease barriers of input purchase and output sale by organizing linkage meetings and agricultural fairs. Table 2.5 shows that our very short-term results (panel-A) under OLS regression in Table 2.5 shows that the T1 and T2 groups have a positive association with input purchase on credit from local vendors while T3 group shows negative association. Among them, the impact is significant only for the T2 group. Our Probit regression under Panel-B (where the estimated marginal impacts are shown) confirms the OLS analysis, although the magnitude seems higher for the Probit regression: it shows that the T2 group purchases 8% more input on credit via OLS and the average marginal effect is 37% more via Probit compared with the control group. On the other hand, panel-B shows the same impact at relatively longer-term. According to OLS result in Column 3, T2 group purchases 7% more inputs on credit at longer-term which is almost similar to the very short-term (8%). Besides, Probit regression shows T2 group purchases 26% more inputs on credit than control group.

The results of Wald test show that we fail to reject the null hypothesis that the impacts across three treatment arms are equal for both Panel-A and Panel-B. It implies that although the magnitude of T2 group show higher impact compared to other two groups, they are not statistically different from each other. However, only the impact of T2 treatment arm on informal input credit is statistically significant under both Panel-A and Panel-B while T1 and T3 groups are not statistically significant. It indicates that treatments provided to T2 group would have the potential to increase

informal input credit among smallholder farmers. This results are consistent with our hypothesis made in the conceptual framework that farmers belong to T1 and T3 groups may get discounted inputs which require them purchase inputs in cash rather than credit. It might also be due to T2 farmers requires more inputs because of their higher diversity from other groups which require them to purchase on credit more.

Table- 2.5: Impact on Informal Credit (purchase input on credit from local vendors)

VARIABLES	Panel-A: midline outcomes		Panel-B: endline outcomes	
	(1) OLS	(2) Probit	(3) OLS	(4) Probit
Treatment = T1	0.01	0.01	0.01	0.05
	(0.06)	(0.24)	(0.04)	(0.12)
Treatment = T2	0.08*	0.37*	0.07*	0.26*
	(0.04)	(0.21)	(0.04)	(0.14)
Treatment = T3	-0.04	-0.19	0.02	0.06
	(0.06)	(0.23)	(0.04)	(0.13)
Control variables	yes	yes	yes	yes
Constant	0.96***	1.53***	0.95***	1.40***
	(0.11)	(0.59)	(0.11)	(0.40)
p-values of treatment equality				
T1 – T2	0.17	0.11	0.12	0.12
T1 – T3	0.37	0.39	0.90	0.96
T2 – T3	0.12	0.13	0.15	0.13
Observations	978	978	974	974
R-squared	0.11	--	0.06	--

##the control variables includes- lag (baseline) values of outcome variables; numbers of household member; household head's age, gender, literacy rate; highest level of education status of any household member; household's possession of agricultural land, numbers of cattle, and access to modern agricultural machinery; household's yearly fixed assets purchase, and total yearly expenditure other than food; numbers of food group consumed in last seven days; distance to the market, availability of community agricultural producer group, and upazila fixed effects.
##village level cluster standard errors is in parentheses; *** p<0.01, ** p<0.05, * p<0.1

The statistically significant impacts of T2 treatment arm of BAVC on promoting crop diversification and informal input credit among smallholder farmers is remarkable because the interventions provided under T2 treatment arm successfully address the constraints faced by the smallholder farmers in crop diversification and provide expected results. Besides, the interventions of T2 arm are cost effective compared to the treatment arm T1 which require additional cost, time, and managerial complexity to arrange agricultural fairs and crop clinic which are not required for promoting our expected outcome variables. Hence, we can say that comprehensive training, linkage meeting, peer group, and trust game jointly have the potential to increase the crop diversification and availability of informal financing in the rural areas of low and lower-middle-income countries.

2.4.2 Extended Analysis

The results of increased crop diversification and informal input credit in the relatively longer-term may not persist if it is not backed by improved technology adoption and provide better productivity of diversified crops. Modern technology adoption is a pre-requisite for better agricultural gain for the smallholder farmers (Takahashi et al., 2019). To see the sustainability of increased impacts of BAVC, we would ideally want to examine the impacts on productivity. However, because comparison of diversified crop productivity does not make sense, we instead check the status of adoptability of fertilizer used for diversified crops other than jute. BAVC's interventions may impacts fertilizer use because one of the BAVC's objectives was to increase modern technology adoption among treatment groups. In their midline report, the BAVC's researchers found a

significant increase in the knowledge and use of fertilizer in the jute production among treatment groups (IFFRI, 2019). There is a possibility of transferring the knowledge gain in fertilizer use to the other crops by the treatment farmers. We use endline data to check whether the multifaceted interventions of BAVC induce farmers to adopt higher modern technology compared to control group. Due to the unavailability of baseline fertilizer data we could not control the lag variable of fertilizer, hence, we use following equation for our analysis of modern technology adoption at relatively longer-term:

$$Y_{ht} = \beta_0 + \beta_1 TP_h + \beta_2 T_h + \beta_3 P_h + \beta_4 X_{ht-1} + \varepsilon_{ht} \text{ ---------- (3)}$$

Where Y is our outcome variables represented by total amount fertilizer (KGs) used for production in the last 12 months and fertilizer (KGs) used per acres of land for production. We constructed fertilizer used per acres by dividing total amount of fertilizer used for production in the last 12 months to total amount of land used for production in the last 12 months. Due to the extensive variation in the use of fertilizer from 0 to a magnitude of large amount among farm households, we transform the fertilizer variables into inverse hyperbolic sine (IHS) for our analysis.

Table 2.6 shows the results of fertilizer use in the diversified products at relatively longer-term. Our outcome variables indicates that fertilizer adoption among farmers of all treatment arms is positive and statistically significant. These results indicate that multifaceted interventions to develop AVC not only contribute in the crop diversification but also disseminate the knowledge gain from the interventions to the other crops too. This knowledge gain can also be a cause to have higher crop diversification among treatment households. However, according to the BAVC endline report, fertilizer adoption in jute cultivation did not show significant impact at the relatively longer-term. It might be due to given up in jute cultivation, or apply less fertilizer in jute due to the unexpected outcome of jute at the very short-term.

Table-2.6: Panel-B: Technology Adoption for Crops other than Jute

VARIABLES	(1) Total Fertilizer Use (KGs)	(2) Fertilizer Per Acres (KGs)
Treatment = T1	0.67***	0.42***
	(0.17)	(0.11)
Treatment = T2	0.52***	0.32**
	(0.18)	(0.13)
Treatment = T3	0.55***	0.35***
	(0.17)	(0.12)
Control variables	yes	yes
Constant	5.10***	4.78***
	(0.40)	(0.33)
Observations	974	974
R-squared	0.16	0.21

##the control variables includes- numbers of household member; household head's age, gender, literacy rate; highest level of education status of any household member; household's possession of agricultural land, numbers of cattle, and access to modern agricultural machinery; household's yearly fixed assets purchase, and total yearly expenditure other than food; numbers of food group consumed in last seven days; distance to the market, availability of community agricultural producer group, and upazila fixed effects.

##village level cluster standard errors is in parentheses; *** p<0.01, ** p<0.05, * p<0.1

5. Discussion and Conclusions

The Bangladesh agricultural value chain (BAVC) project designed to promote jute value employing multifaceted interventions (training, fairs, peer group, linkage meetings, trust game, crop clinic, and agricultural fairs). Taking the advantage of randomized design of the intervention, we study the impacts of BAVC on the crop diversification among smallholder farmers in rural Bangladesh because a group of researchers suggests crop diversification as a welfare enhancing strategy for smallholder farmers due to its contribution to eradicate persistent poverty and achieve food security (Asfaw et al., 2018; Makate et al., 2022). We further analyze the impacts of BAVC on informal input credit (purchase input on credit from local vendors) and fertilizer use due to the BAVC's interventions of improving intimacy between stakeholders.

We test the diversity using four outcome variables, i.e., crop count, crop group count, high-value crop count, and Simpson's diversity index separately for very short-term (1 year after interventions) and relatively longer-term (2 years after the interventions) period of BAVC interventions.

Overall, we fail to find a statistically significant and consistent estimate of crop diversification in the very short-term. As discuss above, it can be plausible because after the interventions, farmers get a little time to decide line and there is a high possibility of concentration to the jute cultivation due to the influence of interventions.

On the other hand, the relatively longer-term results show a positive impacts of BAVC on all the outcome indicators under all the treatment arm, including T1, T2 and T3, although the impacts are significant only for T1 and T2 groups. This result is mostly consistent with Ahmed et al. (2023)

who found smallholder farmers belongs to treatment arms including training produce more vegetables, fruits, eggs, and dairy compared to treatment arms without training and control group. The reason for better crop diversification in relatively longer-term may be because the BAVC interventions did not show a significant gain in production, productivity, and profitability in jute cultivation in very short-term (IFFRI, 2019). The findings of Blanc and Kledal (2012) also justify our claim that smallholder farmers in Brazil moved to diversified production due to the lower income from commercialized farming. Besides, in terms of statistical significance, our analysis reveal that interventions provided to T2 group (training by NGO, peer group connection, linkage meetings, and trust game) can plausibly address the constraints of the rural smallholder farmers works better for crop diversification.

Our extended analysis also shows a statistically significant positive impact of BAVC on the input purchased on credit from local vendors among T2 group, regardless of specifications even in the very short-term. Further, it shows significant positive impacts of BAVC on fertilizer adoption, which indicates that expertise gain from multifaceted interventions helps participants to apply it to other areas too. These results indicates that the interventions to increase intimacy among stakeholders may be an effective tool to modernize agricultural production even for the outside of the targeted crop.

Our study provides the statistically significant positive impact BAVC's interventions of T2 treatment arms on crop diversification and informal input credit. It indicates there is a need for critical thinking in taking development projects targeting smallholder farmers' welfare improvement in developing world especially in low and lower-middle-come countries where per

capita land share is decreasing due to the population growth. Given the land scarcity, food and nutritional deficiency, natural shocks, and climate change frequently happening in rural Bangladesh, and considering the BAVC's relatively longer-term impacts on crop diversification and informal input credit, we suggest policy makers to take projects consisting interventions such as comprehensive modern agricultural management training, peer group for knowledge sharing, linkage meeting to exchange information related to agriculture and market, and trust building among stakeholders, like T2 treatment arm of BAVC to spread crop diversification and informal input credit among smallholder farmers in developing countries to achieve SDG1, SDG2, SDG12, and SDG13. Our recommendation is consistent with the existing literature that argue for promoting the crop diversification among smallholder farmers to improve their welfare (Rahman, 2009; Owusu and İşcan, 2021; Ahmed et al., 2023).

Our study is based on the data generated from a cluster randomized control trial designed for the development of jute value chain in rural Bangladesh. The results have consistency in the two different models for our main outcome variables. Due to the data limitations we were unable to see the other indicators of smallholder farmers' welfare such as changes in income and consumption diversity. A multifaceted interventions project targeting crop diversification among smallholder farmers may give more freedom in designing the study in a broader range. Hence, the association between comprehensive interventions to crop diversification, informal credit, income, and consumptions may better demonstrate by the follow-up study with more variety of data under the context specific multifaceted interventions projects.

Chapter 3

Does the Authority of Women's Employment Decision Influence Child Nutrition? Evidence from Bangladesh.

3.1 Introduction

Despite striking decreases in average child malnutrition throughout the world, ending all forms of malnutrition (SDG-2) is far from complete due to the prevalence of child undernourishment and stunting among the poor in low and lower-middle income countries, especially in Africa and Asia. According to joint malnutrition estimates report 2021, average child (under 5 years) stunting in 2020 is 22% in the world but it is 30.7% in South Asia and 36.8%, 32.6%, & 30.9% in the Middle, Eastern, and Western Africa respectively (JME, 2021). Ironically, those poor households mostly live in rural areas and suffer persistent poverty, even though their primary economic activity is to produce food in agriculture. It is thus crucial to concentrate more to tackle persistent poverty and malnutrition in rural areas of the developing world.

Generally, it is considered mothers' responsibility to take care of children in the rural households of the many developing world (Dildar, 2015; Klasen & Pieters, 2015), and thus how mothers spent their time crucially affects child health. While female participation in income generating activities can be a tool to eradicate persistent poverty (Khanna et al., 2015; Getahun & Villanger, 2017; Klasen et al., 2020), achieving food security (Quisumbing et al., 1996; Pan et al., 2018; Dzanku, 2019) and women empowerment (Doss, 2013; Majlesi, 2016; Sangwan & Kumar, 2021), it may have two confounding effects on child growth through: (1) income effects-an increased income that ensures the availability of nutritious food and improves child health; and (2) time effects- a

decreased time in childcare that adversely affects the timely intake of sufficient food, letting children suffer frequent virus or bacterial infections (Abbi et al., 1991; Komatsu et al., 2018). Indeed, exiting literature is skeptical in drawing a clear causal relationship between female work and child nutrition, which resulted in some positive effects (Ngenzebuke & Akachi, 2017), some negative effects (Mahtab et al., 2000; Sethuraman et al., 2006; Rashad & Sharaf, 2018; Nankinga et al., 2019), and no effects (LESLIE, 1988; Debela et al., 2020). Hence, there is room to explore the new dimensions of maternal employment that affect child nutrition.

Given that institutional childcare facility, such as kindergarten, is not readily available in many rural areas of the developing world (Taylor, 2021), the associations of maternal workforce participation (WFP) on child nutrition can be heterogeneous depending on the WFP decision authority. It may associate the mothers' and other family members' (husband, in-laws, etc.) motivation for childcare. For example, when a mother makes her WFP decision (maternal autonomy), she may get motivated to care for her children well due to her self-confidence. Also, she may be able to have more control over her own earnings to make decisions that affect the child's nutrition (budget, food, etc.). Existing studies found that maternal autonomy in household decision-making and child nutrition are related (Carlson et al. 2014). However, if women make her WFP decision only by herself, husband and other family members may feel disengaged in WFP decision that may lead to lose their motivation to help in the mother’s task (childcare). Existing literature indicates that higher female autonomy in domestic affairs, as measured by her self-decisions, was linked to a notably decreased probability of her husband's participation in antenatal care (Mullany et al., 2005). Conversely, if she asks to work and others family members agree it beforehand, they may be obliged to provide extra childcare to mitigate the inverse time-effects of

maternal WFP. Indeed, Heaton and Forste, (2007) found that joint decision-making on household affairs gains more cooperation from a husband and has a link to lower rates of child mortality. Thus, aside from the mothers' actual time spent on different activities (i.e., child care and WFP), it is potentially significant to study who is the main decision maker of maternal WFP and its consequence on child health.

In this study, we examine the causal relationship between the authority of women's WFP decision and child nutrition in rural Bangladesh. Bangladesh is a densely populated country with concerning prevalence of malnutrition. According to data from the 2022 Bangladesh Demographic and Health Survey report, 24% of children under 5 years in Bangladesh are stunted, 11% are wasted, and 22% are underweight (NIPORT & ICF, 2023). On the other hand, despite comparative female WFP to male is low in Bangladesh, the female WFP rate grows remarkably from 14% in 1990-1991 to 36% in 2010 (Rahman & Islam, 2013). Recent Bangladeshi data reveal that women WFP transform from on-farm work to off-farm work (Raihan & Bidisha, 2018) and several studies showed that women's off-farm WFP has negative impacts on child nutrition (Popkin, 1980; Debela et al., 2020). On the other hand, according to Zahidi et al. (2021), Bangladesh becomes top in gender equality in South Asia, scoring 0.72 out of 1.00. Existing literature indicated that compared Bangladesh to other low-income nations, the country has greater women WFP due to the long history of female-centric micro-credit interventions (Pitt et al. 2006) and the impressive strides made in addressing the gender gap in education (Hahn et al., 2018). Moreover, Akter and Francis-Tan (2020) have shown that women's autonomy in households' productive decisions significantly increased in rural Bangladesh in 2015 compared to 2011.Thus, it is of great interest to investigate the consequences

of recent surge in women WFP and women's autonomy in decision making on child nutrition in rural Bangladesh.

We use Bangladesh integrated household survey (BIHS) pooled cross-sectional data spanning from 2015 to 2019 which is a nationally representative rural household survey data jointly collected by the IFPRI-PRSSP to track the socio-economic performance of rural farm households in Bangladesh. Since our focus is mainly on the mothers' WFP decision among rural households, we divide households' decision into two groups (autonomic and otherwise), and following different studies used in the review article by Carlson et al., (2014), we restrict our sample to working women in the main analysis[10]. In our study, if mothers make their own WFP decision sorely, we call it an autonomic decision, and for the rest of the cases (joint, husband only, and others), the decision is considered as otherwise.

As outcomes of interest, we use children's height-for-age z-score (HAZ), weight-for-height z-score (WHZ), and weight-for-age z-score (WAZ), which represent long-term, short-term, and mixed-term child nutrition status, respectively. According to O'Donnell et al., (2008) HAZ, WHZ, and WAZ are comparatively more reliable indicators of child nutrition than other indicators such as Body Mass Index because z-score accounts for the genetic variations among infants and children during the measurement of nutrition status. To overcome the identification issues in maternal autonomy to child nutrition, we use an instrumental variable (IV) estimation strategy to control potential endogeneity for the authority of decision-making. Since the validity of IV can be

[10] Potentially, the data on the authority of WFP decision should be observable for those who do not work in the labor market. However, BIHS has this variable only for those who actually work.

somehow questioned, we also run the reduced form regressions to confirm the robustness of the findings.

To the best of our knowledge no studies concentrate on the associations of authority of women's WFP decision on the child nutrition. A group of existing literatures focus on the impacts of women employment itself on child nutrition asking questions about whether a female participate in a job or not, segregate job into on-farm & off-farm, and time allocation between the job and childcare (LESLIE, 1988; Mahtab et al., 2000; Ngenzebuke & Akachi, 2017; Rashad & Sharaf, 2018; Debela et al., 2020). Another group of literature focuses on the impacts of women's bargaining power in household decision making on child nutrition using multiple correspondence analysis of different categorical variables. More specifically, women's bargaining power is defined by asking categorical questions about job status (Lépine & Strobl, 2013), decision regarding freedom of movement, visiting doctors, control over income (Lépine & Strobl, 2013; Imai et al., 2014; Debnath & Bhattacharjee, 2016), and food purchase and cooking (Patel et al., 2007; Rajaram et al., 2016; Dasgupta, 2016). The final group of literature studies the association between maternal autonomy in household decision-making and child nutrition (Brunson et al., 2009; Begum & Sen, 2009; Ross .S, 2010; Shroff et al., 2011; McKenna et al., 2019; Agu et al., 2019; Chilinda et al., 2021 Paul & Saha, 2022). Our study setting is close to the last group of literature. However, due to the inconsistency in study design, measurement of autonomy variables, and data availability, their findings constraint to showing a clear path of causality between maternal autonomy and child nutrition (Carlson et al., 2014), whereas this study attempts to overcome such limitations using rigorous study setting with pooled cross sectional data spanning from 2015 to 2019 under a new dimension of maternal autonomy (authority of maternal work participation decision).

Among others, this study is closest to Holland and Rammohan (2019), who studied the impacts of women empowerment in agricultural index (WEAI) on child nutrition in rural Bangladesh. However, their explanatory variables WEAI and 5 binary women empowerment indicators (contribution to agricultural input use, autonomy in agricultural production, control over use of income, speaking in public, and group membership) are different from our main explanatory variable, which is mothers' autonomy in WFP (a new dimension in the literature). Since the data on mothers' autonomy in WFP is available only to working mothers, we also use women's other decision-making, such as on food purchase and a composite score of maternal autonomy in household decision-making constructed from several indices as independent variables. This serves as a robustness check and generalizability test, whose approach is more similar to Holland and Rammohan (2019)' study. However, our intention to use such alternative measurements are to disentangle whether our main conclusion is derived from women's intra-household decision-making power (in which case, we may see the same results even when we use different measurements) or from restricted sample to working mothers whose characteristics are different from non-working mothers (in which case, we may see different results when we include non-working mothers in estimation). We believe that these extended analyses may help obtain insight into a mechanism underlying the estimation results.

Our results show that conditional on being mother in the labor market, there is a statistically significant positive association between maternal autonomy in her WFP decision and child nutrition: for child stunting (HAZ) and underweight (WAZ) at the 1% level and wasting (WHZ) at the 10% level. As a robustness check, we use different empowerment measures. We first estimate

these regressions only for working mothers and then for both working and non-working mothers in our sample as an additional generalizability test. The results of this analysis are almost identical to our initial estimation, indicating that our results are robust regardless of the choice of decision autonomy variables and are not driven by sample-selection into labor force participation. To check heterogeneous associations, we further extend our study by separating the initial model into (1) mothers who work at home and (2) mothers who work otherwise (outside/both home and outside) to check heterogeneity between those mothers who work at home and mothers who work outside the home. The result shows positive and statistically significant for mothers who work at home but statistically insignificant for otherwise. The results may indicate that mothers' childcare time at home is necessary for better child nutrition outcomes along with additional income provided the scarcity of institutional childcare facilities.

The rest of the paper is structured as follows: - section 3.2 describes the literature review of female autonomy and child nutrition, section 3.3 describes the data used for analysis, section 3.4 describes the estimation strategy, section 3.5 describes the results, and section 3.6 concludes the paper.

3.2 Female Autonomy and Child Nutrition in Existing Literature

Females' decision-making autonomy in the household has been studied in various contexts with various measures. For example, Caldwell, (1986) used the right to receive education and the ability to work outside the home as proxies for autonomy, while Mason, (1986) used control over the household and societal resources as female autonomy. Later, several studies concentrated on how maternal autonomy in household decision-making affected children's nutrition, but no studies

addressed how maternal autonomy in work participation decisions affects children's health. Existing studies found an improvement in children's nutritional status has a link to maternal decision-making power regarding household purchases, chores, and productions, but the pattern of causality is indecisive (Carlson et al. 2014). Several existing literature come up with positive (Rahman et al., 2015; Arulampalam et al., 2016), mixed (BRUNSON et al., 2009; Shroff et al., 2011; Agu et al., 2019; Chilinda et al., 2021), and others found a no (Begum & Sen, 2009; Ross .S, 2010; McKenna et al., 2019; Paul & Saha, 2022) association between females' autonomy in decision-making and their child nutrition.

Indeed, using a composite autonomy score of decision-making status, financial control, and prevention of domestic violence, Chilinda et al., (2021) revealed that maternal autonomy and child height-for-age z-score (HAZ) has a negative association. However, after controlling for the covariates such as family wealth and maternal education, the result no longer becomes statistically significant. In their test, Shroff et al., (2011) observed that the maternal ability to make household decisions was positively associated with child WAZ and WLZ/WHZ but not LAZ/HAZ using the composite autonomy score. Examining data from the Bangladesh Demographic and Health Survey, Begum and Sen, (2009) did not find statistical significance between a composite decision-making autonomy score of mothers and their children's stunting, wasting, or underweight.

The inconsistency in the result is perhaps mainly due to study design, variability in data and estimation techniques, and lack of a universal measure of autonomy in decision-making (Carlson et al. 2014). Carlson et al., (2014) thus suggested more rigorous research on each autonomy dimension separately using longitudinal data, separating maternal authority between joint decision

and self-decision, and robust statistical method to determine whether various factors affect child nutrition outcomes differently.

In this paper, we examine a new dimension of maternal autonomy (authority of employment decision) using pooled cross-sectional data and segregating maternal decision authority into self and otherwise. In our datasets, the source of the information of decision authority is the female household member. There is a concern among researchers about the authenticity of the authority of bargaining power reported by a sole household member. Several studies showed a significant difference between males' and females' perceptions of decision authority but it varies across regions and culture (Ghuman et al. 2006; Anderson et al., 2017; Seymour & Peterman, 2018). In contrast, Anderson et al. (2017) found that compared to men's reports on women's decision-making authority, there is little evidence that women considerably underreport themselves. Seymour and Peterman (2018) also found same evidence in rural Bangladesh. Yet, due to the heterogeneity in reporting of decision-making authority our test outcome might be potentially biased. We use IV estimates to control the unobserved heterogeneity in decision authority among women and possible measurement errors. We also check the robustness of our main result employing alternative explanatory variables (maternal autonomy in household food decision) and apply reduced forms. Finally, we will examine the generalizability of our main estimation and heterogeneous associations based on maternal work place.

3.3 Data Used for Analysis

3.3.1 Populations & Data Collection Strategy

This study uses a nationally representative two round pooled cross-sectional datasets of Bangladesh, called Bangladesh Integrated Household Survey (BIHS), consisting of the 2015-16 and 2018-19 years. It contains detailed rural household level data about individual household members' information such as age, education, gender, employment status, and physical conditions; farm & off-farm income and expenditure of the households; socio-economic conditions of the village and district level; and food security status. It also contains gender differentiated data such as women's role in household decision making, their employment, assets, and education of surveyed households. The women's status module also provides information about the women's employment decision authority. The datasets further provide detailed information (height, weight, age, etc.) about the children who are under 5 years. The BIHS data are supplemented with a community survey that provides data on context-specific local characteristics. In 2015, the datasets comprise information of 7540 households. In the first stage, researchers divided entire rural villages into eight strata. Later, they randomly chose 377 primary sampling units (PSUs) or villages using the number of households identified in the population census data from 2001. In the final stage, 20 households were chosen at random from each PSU. Hence, we have rural households' data from entire Bangladesh.

3.3.2 Sample Selection

We focus on the households which have children under five years old. We restrict our data to children from 6 months to 59 months, provided that our dependent variables are the child's nutrition indicators (Meskerem Jisso1 et al., 2022). We exclude children under 6 months because of difficulties in physical status (height, weight, age, etc.) measurements of infants (Lopriore et al., 2007) and accommodating chronic malnutrition and child's food security (Holland & Rammohan, 2019). Then we check for females who have children aged 6 months to 59 months and are currently married and living with husband[11]. Our final sample comes in two waves with 5441 observations for all mothers, 4192 observations for working mothers (main target of our study), out of which 3372 observations are mothers who work at home, and 820 observations are mothers who work otherwise. While panel data is useful for controlling maternal innate health, our dataset suffer from classical sample selection problems and also cause low statistical power issue if we construct panel data restricting children from age 6-59 months. Thus, we use pooled cross-sectional data in this study.

[11] In our dataset female household head is only 3% and among those who are married and live with husband, all household heads are male reflecting that Bangladesh is a patriarchic society. Thus, there should be no duplication of head's characteristics and mothers' characteristics.

3.3.4 Descriptive Statistics

Table 3.1: Households and Mothers' Characteristics

Households Characteristics						
	Full Sample			Working Mothers Sample		
Variable	Obs.	Mean	Std. Dev.	Obs.	Mean	Std. Dev.
Household head education:	.	.	.	.	.	.
No school (yes=1, no=0)	5441	0.38	0.48	4192	0.39	0.49
Primary (yes=1, no=0)	5441	0.31	0.46	4192	0.30	0.46
Secondary (yes=1, no=0)	5441	0.15	0.36	4192	0.15	0.35
Higher secondary (yes=1, no=0)	5441	0.15	0.35	4192	0.15	0.35
College (yes=1, no=0)	5441	0.02	0.13	4192	0.02	0.13
Household members (numbers)	5441	6.19	2.54	4192	6.11	2.45
Household head age (years)	5441	41.46	13.37	4192	41.64	13.19
Total household assets (amount in BDT)	5441	96409.90	129832.88	4192	97851.10	132129.59
Monthly household income (amount in BDT)	5441	10297.00	10764.30	4192	10450.60	10547.20
Households religion (Islam=1, others=0)	5441	0.90	0.31	4192	0.90	0.30
Sanitary latrine use (yes=1, no=0)	5441	0.76	0.43	4192	0.76	0.43
Hand washing facilities (yes=1, no=0)	5441	0.63	0.48	4192	0.63	0.48
Safe drinking water (yes=1, no=0)	5441	0.40	0.49	4192	0.40	0.49
Safe garbage disposal (yes=1, no=0)	5441	0.33	0.47	4192	0.34	0.47
Mothers' education:	-	-	-	-	-	-
No school (yes=1, no=0)	5441	0.15	0.36	4192	0.15	0.35
Primary (yes=1, no=0)	5441	0.32	0.47	4192	0.32	0.47
Secondary (yes=1, no=0)	5441	0.27	0.44	4192	0.28	0.45
Higher secondary (yes=1, no=0)	5441	0.24	0.43	4192	0.24	0.42
College (yes=1, no=0)	5441	0.02	0.13	4192	0.02	0.14
Mothers' TV watching status (often=1, otherwise=0)	5441	0.34	0.47	4192	0.32	0.47
Asset brought to marriage (amount in BDT)	5441	31922.78	62866.89	4192	29130.13	56758.2
Asset brought to marriage (yes=1, no=0)	5441	0.84	0.36	4192	0.84	0.37
Mothers' work place (outside=1, home=0)	-	-	-	4192	0.2	0.4
Mother's age (years)	5441	27.62	5.86	4192	27.7	5.88
Earned money spending decision (mother=1, otherwise=0)	-	-	-	4192	0.43	0.5

Table 3.1 shows that the households head's education level is generally not high: 38% has no education and 31% completed primary education under full sample, whereas 39% receive no education and 30% completed only primary education under working mothers' sample. The mean household members are around 6 and the average household head's age is around 41 years old. Average household assets are less than BDT 100000 (USD 1.00 = BDT 110.00), while the monthly average household income is approximately BDT 10000. Muslim households are 90% under both the samples.

Table 3.1 also shows that the average mothers' education level, such as having no school, completion of primary school, completion of secondary school, completion of higher secondary school, and college degree, are identical in both samples, namely 15%, 32%, 27%, 24%, & 2%. However, working mothers samples have a 1% advantage compared to others in the case of higher secondary school completion. The mothers' TV watching status shows that 2% more mothers frequently watch TV under whole samples than others. The mothers in the full sample brought an average of BDT 31922.78, while the other mothers brought an average of BDT 29130.13. However, the percentage of mothers who brought assets throughout their marriage remained the same (84%). An average of 80% of mothers work at home, and 43% of mothers have autonomy in the spending decisions of their earnings. The mothers' mean age is 0.08 (27.70 – 27.62) years higher under the working mothers' sample than others.

Table 3.2: Children's Characteristics

Child Characteristics						
	Full Sample			Working Mothers Sample		
Variable	Obs.	Mean	Std. Dev.	Obs.	Mean	Std. Dev.
Child height for age z-score (HAZ)	5441	-1.56	1.28	4192	-1.56	1.26
Child weight for age z-score (WAZ)	5441	-1.41	1.06	4192	-1.41	1.04
Child weight for height z-score (WHZ)	5441	-0.79	1.18	4192	-0.78	1.16
Child age (months)	5441	32.29	15.07	4192	32.33	15.04
Child's birth order (numbers)	5441	2.33	1.49	4192	2.35	1.38
Child breast feeding (yes=1, no=0)	5441	0.47	0.50	4192	0.48	0.50
Child gender (female=1, male=0)	5441	0.47	0.50	4192	0.47	0.50

The Table 3.2 shows almost same features of child's anthropometric variables under the full and restricted samples. The average child's height for age z-score (HAZ), weight for age z-score (WAZ), weight for height z-score (WHZ), age, birth order, breast feeding status, and gender are (1.56), (1-41), (0.79), 32.30 months, 2.33, 47% breast feeder, 47% female under full sample which are comparable to working mothers' sample.

3.4 Estimation Strategy

3.4.1 Econometric Models

To examine the associations of mothers' WFP decision authority on children's nutrition of rural farmers we consider the following pooled OLS equation: -

$$Y_{ict} = \beta_0 + \beta_1 E_{it} + \beta_2 X_{ht} + \beta_3 X_{ct} + \beta_4 X_{mt} + \beta_5 X_{st} + \beta_6 year + \varepsilon_{ict} \text{ ---------- (1)}$$

The subscript *i* stands for individual observation, *c* stands for child, *t* stands for time period, *h* stands for household, *m* stands for mother, s stands for community characteristics.

Where Y_{ict} is outcome variables (HAZ, WAZ, & WHZ) and the variable of interest is E (a dummy for the maternal autonomic WFP decision equal to 1 if a mother takes decision by herself, and 0 otherwise). We also includes X_{ht} to represent household characteristics, X_{ct} to indicate the children's characteristics, X_{mt} to be the vector of mothers' observable characteristics, X_{st} to be the social support indicators (described in controlling variables section), year to be the year dummy variable, and ε_{ihtt} to indicate unobserved disturbance terms. The more detailed explanation on each variable is as follows.

3.4.2 Dependent Variables

Our focus is on the status of child nutrition. There are different indicators of child nutrition measurement such as HAZ, WAZ, and WHZ (Sanità, 2006). Among those indicators WHZ uses to measure wasting reflecting the consequences of acute illness (particularly diarrhea) or malnutrition, HAZ uses to measure stunting covering chronic malnutrition from gestation period to early childhood, and WAZ uses to measure underweight reflecting the changes in the malnutrition magnitude over time (O'Donnell et al., 2008). As briefly explained in Introduction, HAZ indicates the long-term child nutrition, WHZ is the short-term child nutrition and WAZ

confounds the short-term and long-term child nutrition status (O'Donnell et al., 2008). We thus use HAZ for inferring the long-term associations and WHZ for the short-term associations, and WAZ to show the confounding between short-term and long-term child nutrition associations as the dependent variables for our analysis. The pooled cross-sectional data show that child nutrition indicators improve among rural farm households of Bangladesh in 2018 compared to 2015 (Appendix: table – A11).

3.4.3 Independent Variables

Authority of mother's WFP decision is the main independent variable in our study. Measuring autonomy in decision-making is a long issue of debate among researchers. A group of researchers measures maternal autonomy using a composite score, while the others use dummy variables of the individual claim of authority over a specific issue. Due to the study settings, we use a dummy variable of maternal workforce participation decision as the autonomy. More specifically, it is a dummy variable containing '1' if it is a mothers' autonomic decision and '0' otherwise. We also test our results using different measures as the robustness check: mothers' autonomy in household food purchase decision (maternal decision=1, otherwise=0) and composite score of maternal autonomy under principal component analysis (PCA). We compute composite maternal autonomy score using maternal autonomic decision of 5 variables (food decision, housing decision, healthcare decision, child education decision, and clothing decision). The descriptive statistics show that 50% mother take their autonomic work decisions, 15% mothers take autonomic food decisions, and composite autonomy score is 0.13 (Appendix: table – A4). The pooled cross-sectional data show that maternal autonomy in workforce participation decisions increase over time (Appendix: table – A12).

3.4.4 Controlling Variables

The controlling variables are discussed according to their category as follows:

Household factors: it includes the number of household's members, a set of dummy variables of the household's religion containing Muslims, Hindus, Christians, and others, where Muslims is used as the base variable. Besides, we include a set of dummy variables for household head's education, comprising no school, completion of primary, secondary, higher secondary school, and college, where no school is the base variable. Also included are household head's age, log of sale value of total household assets, and hygiene index constructed using principal component analysis (PCA). The household hygiene indicators used to construct the hygiene index are the use of sanitary latrines, flushing of toilets, hand-washing facilities, source of drinking water, source of cooking water, and garbage disposal facilities. It is expected that the hygiene index play a significant role in child health.

Child's factors: it includes the child's gender (female=1 and male=0), child breast feeding status (yes=1, no=0), and a set of dummy variables of child's birth order including child rank from 1st to 2nd child, 3rd to 4th child, and 5th and above, where the rank of 1st to 2nd child is the base variable.

Mothers' factors: it includes a set of dummy variables of the mother's education comprising no school, completion of primary, secondary, higher secondary school, and college, where no school is the base variable. We further include the mother's workplace (home=0 and otherwise=1), the mother watching TV (often=1 and otherwise=0)[12], and the mother's age at the first child as a set

[12] It is a proxy for mothers' awareness of childcare and feeding. Following Tidwell et al. (2019), we expect mothers who frequently watch TV to be more informed about the procedure and importance of child feeding and childcare through awareness-building advertisements, dramas, movies, and serials.

of dummy variables, including the mother's age less than 18 years, 18 to 20 years, 21 to 24 years, 25 to 30 years, and greater than 30 years, where mother's age less than 18 years is the base variable. Social factors: it includes the community health workers visit in the last six months (yes=1, no=0,). The health worker are from the government, BRAC, and others institutions. The numbers of females' alive brothers. We included the number female's brothers provided that her brothers can be a helping hand in conducting her income generating activities smoothly.

3.4.5 Potential Endogeneity Issues

There are several observable mothers' characteristics such as education, age, job status, asset ownership, and time-variant observed household-level heterogeneity (such as religion, education of household head, and asset holdings) that will affect both decision authority and childcare. Those observable characteristics are controllable in estimation. However, unobserved heterogeneity (management ability, willingness to child development, sacrificing mentality etc.) might also influence decision authority and childcare practices. For instance, mothers who make the autonomic decision may have husbands or in-laws who prefer wives with higher levels of education. These households' unobserved preference for education might also encourage them to spend more on their kids' human capital, which could impact the child's nutrition outcomes. Besides, mothers who enjoy autonomy in household decision-making may come from households where the wife makes all of the decisions because the husband is less involved. The measurement error is also unavoidable in survey data, which may affect the estimation. Given that maternal decision-making is complicated by her husband and other family members' lack of effort, the association of maternal autonomy in WFP decision on children's nutrition may thus be biased. We

apply instrumental variable (IV) estimation method to control the potential endogeneity in decision authority.

It is often difficult to find an ideal IV that fully comply both the exclusion restriction and relevance condition. Different studies use various IVs to mitigate the endogeneity issues in identification of the impacts of bargaining power of mother on child nutrition (Lépine & Strobl, 2013) and women empowerment on food security (Sraboni et al., 2013)[13].

In this study, we use asset brought to marriage as a proxy of socio-economic status of wife's parents[14]. First, we expect that amount of asset brought to marriage by females depends on the socio-economic status of their families. We argue that the socio-economic status of the families can influence maternal autonomy in her workforce participation decision because socio-economic status in rural areas of developing countries highly affects people's life-style. According to Conger et al., (2010) socioeconomic status has been linked to many developmental outcomes for both adults and children, as well as to the durability and satisfaction of family relationships in the last decade. On the other hand, as this is an ex-ante issue determined during the marriage, this may have a little direct impact on current child nutrition outcomes, although such a wealth variable may be dynamically correlated over time, and thus potentially affects current wealth and a resultant

[13] In their study, Lépine & Strobl, (2013) use relative ethnicity as an IV to control for endogeneity in female bargaining power in the household. They argue that the women from the Fula tribe who live in the Wolof territory enjoy more bargaining power in household decision-making than those who live in the Fula territory. On the other hand, Sraboni et al., (2013) use a bunch of IVs, namely the age difference between husband and wife, arguing it can reflect the difference between human resources between spouses and influence the relative bargaining power. They use informal credit sources in the community as an IV due to the influence of the availability of fool of funds on decision-making. The other IVs are the gender parity gap and community group membership because the active members enjoy more power in decision-making, and homestead land ownership argues it affects bargaining power & satisfies externality conditions.

[14] Following Sraboni et al. (2013) we consider age-difference of husband and wife as an alternative instrument but it is insignificant at first-stage in our models.

childcare capacity as well. Thus, we also run reduced from regressions to obtain insight into the direction of bias, if any.

The first-stage results (appendix: table – A5) show that the instrument is significantly correlated with the main and alternative explanatory variables. The value of F-statistic at first-stage comprising of mothers' autonomic work decision (14.40), food decision (10.81), and composite decision (18.43). The value of F-statistic under all the models complies the typical role of thumb (F>10), although the recent studies require much stronger correlation. Alternatively, the critical values of Stock-Yogo [16.38=10%; 8.96=15%] indicate that our models limit the bias of the standard errors to 15% (close to 10%) for main estimates, 15% for estimates of food decisions, and 10% for composite decisions (score). These together seem to imply the relevance of our IV. Holland and Rammohan (2019) attempted to use this IV but they fail to get the relevance of IV in their settings.

Besides, our first-stage results (appendix: table-A5) unexpectedly showed that asset brought to marriage negatively affect maternal autonomy in workforce participation decision. It may be because higher asset control by wife induces a couple to take more egalitarian (joint) decisions rather than autonomic decisions by female only. Indeed, Deere and Twyman (2012) found that the likelihood of harmonized agreement in joint decision-making on female work participation and spending of income is positively and significantly associated with the share of assets possessed by women in the family. Our data also support that mothers who brought more assets during marriage take more otherwise (joint) decisions in spending their own earnings compared to others (Appendix: table – A8).

3.5 Results

3.5.1 Main Estimation Outcomes

The main estimation results with the restricted samples (table-3.3) show the mothers' autonomy in work participation decisions positively affects child nutrition indicators. The associations are statistically significant at a 1% level of both HAZ and WAZ, while it is statistically significant at a 10% level for WHZ. The results indicate that the children whose mothers take autonomic work decision have higher HAZ of 2.67 standard deviation (SD), 2.22 SD WAZ, and 1.14 SD WHZ compared to the rest. Our results are similar to the findings of Rahman et al., (2015), who showed that the children of mothers who make autonomic household decisions have lower odds of stunting, wasting, and underweight compared to the rest of the mothers in Bangladesh[15]. Besides, Smith et al. (2003) discovered that in South Asia, a rise in female status significantly affects their children's long-term and short-term nutritional indicators, reducing stunting and wasting (see also Arulampalam et al. 2016; Shroff et al. 2011).

Since the IV data is on nominal term, it may be affected by time. To address this issue, we converted the nominal data into real term using consumer price index and rerun the models. The results are consistent with our main estimates (Appendix: table – A13). Since other caregiver such as in-laws and sisters affect child nutrition, one may be interested in looking into the differential impacts of autonomic and joint (couple) decisions. Considering the data distribution between self and self & husband (Appendix: table – A14) , we further construct an explanatory variable which takes 1 if mothers take autonomic workforce participation decisions and 0 if mother and father jointly take the decisions. We construct this variable to see the differential associations of maternal

[15] Unexpectedly, our model show negative value of R square. This could be due to high variation in dependent variables (HAZ, WAZ, and WHZ) compared to binary nature of explanatory variable. It seems our models over fitted.

autonomy and joint decisions. Because, it may helpful to explain the associations of other family members (in laws, sisters) who reside at the same house or nearby. The results are consistent with the main estimation (Appendix: table – A15).

One of the potential reasons to see such positive associations is the control over own earnings. In our sample, mothers who make autonomic work decisions are substantially more at controlling their income (68.30%) than mothers who make work decisions otherwise (18.19%). As mothers who make autonomic work decisions extensively enjoy more control over their income than others, it could be a considerable reason in having a significant positive results. Alternatively, maternal control over the money spent on household chores can also be a potential reason to the positive results of this study. In our dataset mothers who make autonomic work decisions are substantially more at controlling money needed to buy goods (81.99% food from the market, 83.90% clothes for herself) than mothers who make work decisions otherwise (69.64% food from the market, 75.70% clothes for herself). Thus, we use the autonomy of decision-making on food expenditure as a robustness check.

Table-3.3: Child's nutrition to mother's WP decision with working mothers' sample

VARIABLES	(1) HAZ	(2) WAZ	(3) WHZ
Mothers' work decision (autonomic=1, otherwise=0)	2.67***	2.22***	1.14*
	(0.95)	(0.76)	(0.67)
Control variables	yes	yes	yes
Constant	-5.40***	-4.31***	-1.88***
	(0.73)	(0.58)	(0.51)
F-statistics (first-stage)	14.40	14.40	14.40
Observations	4,192	4,192	4,192
R-squared	-1.00	-0.90	-0.14

The control variables includes- child breast feeding, birth order, child gender, household hygiene index, log of household assets, household head's education, numbers of household members, household head's age, religion, mother's education, mothers TV watching status, mother's work place, mother's age at first child, health worker visit, females (mothers) brothers, and year. Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

3.5.2 Reduced Form and Pooled OLS Estimation:

Since our IV poses a concern of exclusion restriction, we conduct reduced form and pooled OLS estimates to see the direction of associations of IV to the child nutrition indicators. In the reduced form, we analyze the association of assets brought to marriage on child nutrition and pooled OLS analyze the association of maternal autonomy in workforce participation decision on child nutrition. We apply OLS estimates to conduct the reduced form analyses. The results of the reduced form (table – 3.4) show that log of asset brought to marriage has a negative association with child nutrition indicators, whereas the pooled OLS (table 3.5) show that the results are consistent with our main estimation. Since the asset brought to marriage may be highly likely to have positive correlation with current asset, and current asset may have positive correlation with child nutrition, if this first reduced form result is positive, some of our IV estimation results should come from the

dynamic wealth effects. However, the negative estimation results in the reduced form may indicate that the IV result may be mostly driven by women's decision-making effect. This reduced form and pooled OLS results give some extend of confidence that the association between maternal autonomy in workforce participation decision come from the bargaining power of the mother.

Table-3.4: Reduced form regression of Child health to Asset brought to marriage

VARIABLES	(1) HAZ	(2) WAZ	(3) WHZ
Log of Asset Brought to marriage	-0.02*** (0.00)	-0.01*** (0.00)	-0.001 (0.00)
Control variables	yes	yes	yes
Constant	-3.39*** (0.18)	-2.77*** (0.15)	-1.21*** (0.17)
Observations	5,441	5,441	5,441
R-squared	0.06	0.09	0.04

The control variables includes- child breast feeding, birth order, child gender, household hygiene index, log of household assets, household head's education, numbers of household members, household head's age, religion, mother's education, mothers TV watching status, mother's work place, mother's age at first child, health worker visit, females (mothers) brothers, and year. Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

Table-3.5: Polled OLS of Child health to maternal autonomic work decisions

VARIABLES	(1) HAZ	(2) WAZ	(3) WHZ
Mothers' work decision	0.03** (0.04)	0.13*** (0.03)	0.15** (0.04)
Control variables	yes	yes	yes
Constant	-3.56*** (0.20)	-2.85*** (0.16)	-1.19*** (0.19)
Observations	4,192	4,192	4,192
R-squared	0.06	0.08	0.04

The control variables includes- child breast feeding, birth order, child gender, household hygiene index, log of household assets, household head's education, numbers of household members, household head's age, religion, mother's education, mothers TV watching status, mother's work place, mother's age at first child, health worker visit, females (mothers) brothers, and year. Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

3.5.3 Robustness Tests

Thus far, we have used a new dimension of maternal autonomy variable (maternal autonomy in workforce participation decisions) to test its association on child nutrition. However, one may curious whether similar results can be obtained if explanatory variable replaced with other maternal autonomic decision variables. Thus, for checking the robustness of our result, we run models with different explanatory variables. Our explanatory variables for this exercise are maternal autonomy in household food purchase and maternal autonomy (score) in composite decision of five households activities such as food purchase, housing, healthcare, child education, and clothing for which the data are available for all households. We first do these exercise with restricted samples to working mothers and then extend them to all mothers, including non-working mothers.

Table-3.6: Child's nutrition to mother's alternative decision under working mothers' sample

VARIABLES	(1) HAZ	(2) WAZ	(3) WHZ
Mothers' food decision (autonomic=1, otherwise=0)	4.76**	3.63***	1.87*
	(1.68)	(1.37)	(1.13)
Control variables	yes	yes	yes
Constant	-4.55***	-3.61***	-1.52***
	(0.50)	(0.41)	(0.34)
F-statistics (first-stage)	10.81	10.81	10.81
Observations	4,192	4,192	4,192
R-squared	-1.33	-1.27	-0.23

VARIABLES	(1) HAZ	(2) WAZ	(3) WHZ
Autonomy in mothers' composite decision (PCA)	3.92***	3.26***	1.68*
	(1.30)	(1.05)	(0.96)
Control variables	yes	yes	yes
Constant	-4.32***	-3.41***	-1.42***
	(0.38)	(0.30)	(0.28)
F-statistics (first-stage)	18.43	18.43	18.43
Observations	4,192	4,192	4,192
R-squared	-0.71	-0.65	-0.09

The control variables includes- child breast feeding, birth order, child gender, household hygiene index, log of household assets, household head's education, numbers of household members, household head's age, religion, mother's education, mothers TV watching status, mother's work place, mother's age at first child, health worker visit, females (mothers) brothers, and year. Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

The maternal autonomy in household food decision (table 3.4) with the restricted sample shows positive and statistically significant association on child nutrition outcome which is qualitatively similar to our main results. The intensity of the association of maternal autonomy in household food decision on child nutrition is stronger compared to maternal autonomy in WFP decision. The results indicate that the children whose mothers take autonomic food decision have higher HAZ of 4.16 SD, 3.65 SD WAZ, and 1.87 SD WHZ compared to HAZ of 2.56 SD, 2.25 SD WAZ, and 1.14 SD WHZ of the children whose mothers take autonomic work decision.

The maternal autonomy in composite household decision (table 3.4) also shows positive and statistically significant association on child nutrition outcome consistent with the results of the main models and food decision models. The results indicate that maternal autonomy in composite household decision increase children's 3.74 SD HAZ, 3.28 SD WAZ, and 1.68 SD WHZ compared to the otherwise. These robust results also support prior research that found maternal autonomy in household decision-making results in a lower rate of child malnutrition (Shroff et al., 2011; Christian et al., 2023).

Overall, our results indicate that maternal autonomy in decisions on WFP as well as other dimensions positively associations children's nutrition.

3.5.4 Generalizability Tests

While the positive associations of mother's decision autonomy might be plausible, our results could not be generalizable to the entire population as we restricted the sample to only working mothers. Potential concerns are that child health preferences and knowledge may significantly vary between working mothers and non-working mothers. Hence, our estimation may suffer from a classic sample selection bias. Thus we re-estimate models with full sample (working mothers+ non-working mothers) using maternal autonomy in household food purchasing decision and composite maternal autonomy, which are available for all sample mothers. Although there is no new dimension of this generalizability test, it is important to identify the mechanism underlying the main result.

The estimation results of the generalizability test (table 3.5) under maternal autonomy in household food purchase decision generally reveal the positive association to child nutrition outcomes although it is insignificant only for WHZ. The results of the generalizability test are similar to Onah (2020) who found that maternal autonomy in household decision-making has a statistically significant association on child stunting and underweight, but it is moderate on wasting. According to WHO wasting is the consequence of short-term food insufficiency or frequent incidence of infectious diseases especially diarrhea. In the context of rural area of developing world where hygiene is a concern, children often suffer from diarrhea. This could be a reason of positive but insignificant association of maternal autonomy in food decision to children's wasting (WHZ). However, the results may be plausible given that the maternal preferences and enthusiasm for childcare may be different under different explanatory variables.

Table-3.7: Child's nutrition to mother's autonomy in alternative decisions under full sample

VARIABLES	(1) HAZ	(2) WAZ	(3) WHZ
Mothers' food decision (autonomic=1, otherwise=0)	2.65***	1.85**	0.64
	(0.98)	(0.75)	(0.75)
Control variables (same as main analysis)	yes	yes	yes
Constant	-3.96***	-3.17***	-1.35***
	(0.27)	(0.21)	(0.21)
F-statistics (first-stage)	19.65	19.65	19.65
Observations	5,441	5,441	5,441
R-squared	-0.44	-0.23	0.02

VARIABLES	(1) HAZ	(2) WAZ	(3) WHZ
Mothers' composite decision (PCA)	2.51***	1.75***	0.60
	(0.87)	(0.67)	(0.71)
Control variables (same as main analysis)	yes	yes	yes
Constant	-3.84***	-3.08***	-1.32***
	(0.23)	(0.18)	(0.19)
F-statistics (first-stage)	29.86	29.86	29.86
Observations	5,441	5,441	5,441
R-squared	-0.26	-0.10	0.03

The control variables includes- child breast feeding, birth order, child gender, household hygiene index, log of household assets, household head's education, numbers of household members, household head's age, religion, mother's education, mothers TV watching status, mother's work place, mother's age at first child, health worker visit, females (mothers) brothers, and year. Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

The generalizability results imply that our main estimation results hold even when we include non-working mothers in the sample.

3.5.4 Heterogeneous Association Analysis

Since females' workplace varies among households, there is a possibility of differential associations of maternal autonomy in WFP decisions on child nutrition based on the maternal workplace. For instance, mothers who work at home may have more time for childcare compared to mothers who work outside. Researchers found that maternal stress from work negatively affects children's cognitive and socio-emotional competence (Gershoff et al., 2007). Alternatively, mothers who work outside may higher managerial skills and capable in childcare compared to mothers who work at home. Thus, it is important to examine whether there is a significant differential association of maternal autonomy in WFP decision and child nutrition based on maternal work place. In our datasets, mothers divide into three categories, work at home, work outside, and work at both home & outside. Due to the data prevalence in mothers who work at home, we divided mothers' workplaces into two groups, such as mothers who work at home and otherwise (outside & both home & outside). Hence, we test our initial model separately for workplace at home and otherwise to check the heterogeneous associations of WFP decisions on child nutrition based on the maternal workplace. Our data show that 53% of mothers who work at home take autonomic decisions and 38% mothers who work outside or both take autonomic decisions (Appendix: table – A9).

3.5.4.1 Outcomes of mother who work at home

Table 3.6 shows that the autonomy of WFP and other decision-making variables has a positive and statistically significant effect on HAZ and WAZ when mothers work at home. Besides, WHZ is significant only with the composite indicate, largely replicating the results above.

Table-3.8: Child's nutrition to autonomic decision of mother's who work at home

VARIABLES	(1) HAZ	(2) WAZ	(3) WHZ
Mothers' work decision (autonomic=1, otherwise=0)	2.66**	2.36**	1.36
	(1.15)	(0.96)	(0.84)
Control variables (same as main analysis)	yes	yes	yes
Constant	-5.68***	-4.67***	-2.18***
	(0.92)	(0.77)	(0.67)
Observations	3,372	3,372	3,372
R-squared	-0.99	-1.05	-0.22

VARIABLES	(1) HAZ	(2) WAZ	(3) WHZ
Mothers' food decision (autonomic=1, otherwise=0)	4.69**	4.16**	2.40
	(2.16)	(1.91)	(1.57)
Control variables (same as main analysis)	yes	yes	yes
Constant	-4.80***	-3.89***	-1.73***
	(0.65)	(0.55)	(0.45)
Observations	3,372	3,372	3,372
R-squared	-1.45	-1.60	-0.37

VARIABLES	(1) HAZ	(2) WAZ	(3) WHZ
Mothers' composite decision (PCA)	4.13**	3.67***	2.11*
	(1.69)	(1.41)	(1.28)
Control variables (same as main analysis)	yes	yes	yes
Constant	-4.39***	-3.52***	-1.52***
	(0.42)	(0.35)	(0.32)
Observations	3,372	3,372	3,372
R-squared	-0.77	-0.82	-0.17

Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

3.5.4.2 Outcomes of mother who work outside or both

Meanwhile, table 3.7 shows the results for mothers who work outside or both. The results are generally not precisely estimated with null results. For instance, the p-value of children whose mothers take autonomic work decision are HAZ (0.175), WAZ (0.228), WHZ (0.815); whose mothers take autonomic food decision are HAZ (0.128), WAZ (0.197), and WHZ (0.816), and whose mothers take autonomic composite decision are WAZ (0.175), and WHZ (0.815).

The findings of our study of heterogeneity show that mothers who work from home are consistent with the outcomes of our primary analysis, in contrast to mothers who work outside/both. As Taylor (2021) claims, it would suggest that mothers' time availability for childcare is a strong factor in child nutrition. Mothers who work at home can intensively feed, bathe, and take extra care of their children compared to mothers who work outside/both. In rural Bangladesh, where there are few institutional childcare facilities, the husband or other family members may not make up for the mother's absence.

Table-3.9: Child's nutrition to autonomic decision of mother's who work outside/both

VARIABLES	(1) HAZ	(2) WAZ	(3) WHZ
Mothers' work decision (autonomic=1, otherwise=0)	2.88	1.75	0.30
	(2.12)	(1.46)	(1.29)
Control variables (same as main analysis)	yes	yes	yes
Constant	-4.44***	-3.10***	-0.88
	(1.25)	(0.86)	(0.76)
Observations	820	820	820
R-squared	-1.09	-0.45	0.05

VARIABLES	(1) HAZ	(2) WAZ	(3) WHZ
Mothers' food decision (autonomic=1, otherwise=0)	3.02	1.84	0.32
	(1.99)	(1.43)	(1.36)
Control variables (same as main analysis)	yes	yes	yes
Constant	-4.03***	-2.86***	-0.83
	(0.89)	(0.64)	(0.61)
Observations	820	820	820
R-squared	-0.66	-0.26	0.05

VARIABLES	(1) HAZ	(2) WAZ	(3) WHZ
Mothers' composite decision (PCA)	3.21	1.96	0.34
	(1.99)	(1.44)	(1.44)
Control variables (same as main analysis)	yes	yes	yes
Constant	-4.28***	-3.01***	-0.86
	(0.97)	(0.70)	(0.70)
Observations	820	820	820
R-squared	-0.48	-0.14	0.06

Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

3.6 Conclusion

Mother's role in the betterment of child health is indispensable in the rural areas of developing nations due to persistent poverty and lack of institutional childcare availability. Existing literature attempted to explore the relation between maternal employment and child nutrition hypothesizing compounding income effects and time effects, came with inconclusive result. To fill this gap, this study deploy a new dimension of maternal employment called mothers' autonomy in work decisions and analyzes its association to child nutrition indicators. We apply the instrumental variable (IV) to control potential endogeneity, reduced form estimation to test the direction of IV, and alternative explanatory variables to test the robustness and generalizability by using rural household data of Bangladesh. We further segregate our data according to maternal workplace into mothers who work at home and mothers who work outside to test the heterogeneous association.

The main contribution of this study is to examine the association between a new dimension of maternal autonomy (autonomy in workforce participation decisions) and child nutrition indicators. The outcomes are statistically significant and positively associated to maternal autonomic work participation decisions, where the height-for-age z-score (HAZ), the indicator of child stunting, weight-for-age z-score (WAZ), the indicator of underweight are statistically significant at 1% and weight-for-height z-score (WHZ), the indicator of wasting is significant at 10%. The other specifications using maternal autonomy in household food purchase decisions and composite autonomy (score) in household decisions validate our primary results.

The overall positive and statistically significant association of mothers' autonomic decisions on work participation on child nutrition indicators implies that the mothers who make her work

decisions feels enough self-confidence to take extra care of their children. However, the results of heterogeneity analysis show that mothers who work at home have children who are less stunted, wasted, and underweight. It indicates that besides self-confidence and preferences to take extra care of their children, maternal childcare time is also essential to child nutrition in the rural area of Bangladesh. It might be because other family members' childcare time does not compensate for mothers' childcare or they are not supportive in childcare in addition to limited institutional availability. In these circumstances, in line with Debela et al. (2020), we recommend concerned authorities to formulate regulations to increase job opportunities for women in rural areas of Bangladesh so that they can choose their desired job for additional income. Enhancing social awareness of the importance of females' workforce participation may also contribute to increased mothers' status in the household and facilitate cooperation among family members in childcare. In this regard, we further recommend policymakers to develop infrastructures to facilitate quality childcare services in rural areas of Bangladesh, which in turn may help to minimize trade-offs between female income and childcare time..

Our study concentrated on the rural households of Bangladesh. Even though the results were robust to applying several econometric tools, we admit that the estimation results for the empirical study may be specific to the context we study. The association between maternal autonomy in work decisions and child health may be better demonstrated by the follow-up study with more variety of data in various geographic and cultural contexts.

Chapter 4

4 Concluding Remarks

4.1 Conclusion

Improvement of welfare of smallholder farmers of low and lower-middle-income countries is a vital issue in achieving SDG1 and SDG2 by 2030. Government and international donors take several strategies to increase the welfare of smallholder farmers. Crop diversification is such a welfare enhancing strategy which is included in the national policy of several developing countries including Bangladesh. Several constraints such as knowledge gap, limited access to modern inputs, barriers to market access, and shortage of available finance limit the spread of crop diversification among smallholder farmers. In such a context, Antier et al. (2022) suggested to develop a new value chain to establishment and growth of agricultural diversification by improving coordination and providing targeted support to the numerous stakeholders of value chains.

We investigated the possibility of crop diversification using a cluster randomized control trial in rural Bangladesh. The program was designed to improve jute value chains providing the multifaceted interventions among smallholder farmers. Farmers were divided into four groups according to the treatment arms and provided interventions such as training, fairs, linkage meetings among stakeholders, crop clinics in the fairs, trust building game between input sellers and farmers, and formation of training group to have peer effects. We use two econometric models for crop diversification (OLS and Tobit) and two models for informal input credit (OLS, Probit) to test the research questions.

Our results from the intention-to treat (ITT) estimates showed that (1) in the very short-term (one year after interventions), multifaceted interventions have no impact on crop diversification; (2) in the relatively long-term (2 years after interventions) multifaceted interventions under treatment arm T2 increase crop diversifications among smallholder farmers and the result is consistent under OLS and Tobit; and (3) informal input credit and treatment arm T2 have a statistically significant positive association in both the short-term and long-term. Our study indicates that a package of interventions like T2 treatment arms of BAVC can significantly increase crop diversification and informal input credit among smallholder farmers in rural areas of Bangladesh.

We next explore the possible pathways to improve the child nutrition among the small farm households in rural areas of Bangladesh. Existing literature attempted to explore the relation between maternal employment and child nutrition hypothesizing compounding income effects and time effects, came with inconclusive result. We investigated a new dimension of maternal employment called mothers' autonomy in work decisions and analyzes its association to child nutrition indicators. We apply the instrumental variable (IV) to control potential endogeneity, reduced form and pooled OLS analysis to test the IV directions, and alternative explanatory variables to test the robustness and generalizability by using rural household data of Bangladesh. We further segregate our data according to maternal workplace into mothers who work at home and mothers who work outside to test the heterogeneous association.

We find that the child nutrition outcomes are positively associated to maternal autonomic work participation decisions, where the height-for-age z-score (HAZ), the indicator of child stunting, weight-for-age z-score (WAZ), the indicator of underweight are statistically significant at 1% and

weight-for-height z-score (WHZ), the indicator of wasting is significant at 10%. The results of our robustness estimates, using the different decision-making power variable, are consistent with the main results. The results of generalizability tests, using the different sample including non-working women, are also consistent with our main results which give a sign of confidence to our study outcomes. The overall positive association of maternal autonomic workforce participation decisions on child nutrition indicators implies that the mothers autonomic workforce participation decision matter for child nutrition in rural areas of Bangladesh. However, the results of heterogeneity analysis show that mothers who work at home have children who are less stunted, wasted, and underweight. It indicates that besides autonomic decisions, maternal childcare time is also essential to child nutrition in the rural area of developing world.

4.2 Policy Implications

In the broader perspective, this study address three strands of literature regarding the improvement of smallholder farmers' welfare of the low and lower-middle-income countries. The findings of this study have substantial policy implications as they point to the vital role multifaceted interventions can play in i) promoting crop diversification and ii) increasing informal input credit as well as the importance of maternal autonomy in workforce participation decisions in iii) improving child nutrition indicators among small farm households of rural areas of developing world. The findings show that governmental and donor commitment of improving smallholder farmers can significantly improve crop diversification and informal input credit in developing countries, where substantial constraints among smallholder farmers are prevalent. Moreover, the

findings also show the pathway of achieving SDG2 by substantially improving the child nutrition where maternal childcare time and preference play a vital role in abating child malnutrition.

The positive impact multifaceted interventions on crop diversification and informal input credit indicates there is a need for critical thinking in taking development projects targeting smallholder farmers' welfare improvement in low and lower-middle-come countries where population pressure shrinks per capita land gradually. Given that the multifaceted interventions have positive impacts on crop diversification and informal input credit, we suggest policy makers to take projects consisting interventions like treatment arm T2 in BAVC to spread crop diversification among smallholder farmers in developing countries to achieve SDGs by 2030. Our recommendation is consistent with the existing literature that argue for promoting the crop diversification among smallholder farmers to improve their welfare (Rahman, 2009; Owusu and İşcan, 2021; Ahmed et al., 2023). Besides, given the findings of maternal autonomy in workforce participation decisions on child nutrition indicators, we suggest policy makers to create opportunities of income generating activities in rural Bangladesh to facilitate women for taking their job participation decision for additional cash. Enhancing social awareness of the importance of females' workforce participation may also contribute to increased mothers' status in the household and facilitate cooperation among family members in childcare. In this regard, we further recommend policymakers to develop infrastructures to facilitate quality childcare services in rural areas of Bangladesh, which may help to minimize trade-offs between female income and childcare time. Our recommendation is consistent with the existing literature that argue for facilitating maternal employment to decrease child malnutrition (Debela et al. 2020).

4.3 Future Research

Our study concentrated on the rural households of Bangladesh. Our results show important policy implications for improving the welfare of smallholder farmers. We use two datasets such as Bangladesh integrated household survey (BIHS) and Bangladesh agricultural value chains (BAVC) data collected by IFPRI between 2015 and 2019. Data limitation is a concern for setting different outcome variables. Due to the data limitations we were unable to see the some desired indicators of smallholders farmers welfare such as changes in income, consumption diversity etc. A multifaceted interventions project targeting crop diversification among smallholder farmers may give more freedom in designing the study in a broader range. Hence, the association between comprehensive interventions to crop diversification, informal credit, income, and consumptions may better demonstrate by the follow-up study with more variety of data under the context specific multifaceted interventions projects. Moreover, we admit that the estimation results for the empirical study may be specific to the context we study. The association between maternal autonomy in work decisions and child health may better demonstrate by the follow-up study with more variety of data in various geographic and cultural contexts.

References

Abadie, A., Athey, S., Imbens, G. W., & Wooldridge, J. M. (2022). When Should You Adjust Standard Errors for Clustering? *The Quarterly Journal of Economics*. https://doi.org/10.1093/qje/qjac038

Abbi, R., Christian, P., Gujral, S., & Gopaldas, T. (1991). The Impact of Maternal Work Status on the Nutrition and Health Status of Children. *Food and Nutrition Bulletin*, *13*(1), 1–6. https://doi.org/10.1177/156482659101300128

Adjognon, S. G., Liverpool-Tasie, L. S. O., & Reardon, T. A. (2017). Agricultural input credit in Sub-Saharan Africa: Telling myth from facts. *Food Policy*, *67*, 93–105. https://doi.org/10.1016/j.foodpol.2016.09.014

Agu, N., Emechebe, N., Yusuf, K., Falope, O., & Kirby, R. S. (2019). Predictors of early childhood undernutrition in Nigeria: the role of maternal autonomy. *Public Health Nutrition*, *22*(12), 2279–2289. https://doi.org/10.1017/s1368980019000818

Ahmed, A. U., Coleman, F., Ghostlaw, J., Hoddinott, J., Menon, P., Parvin, A., Audrey Vidal Pereira, Quisumbing, A. R., Roy, S., & Younus, M. (2023). Increasing production diversity and diet quality: Evidence from Bangladesh. *American Journal of Agricultural Economics*. https://doi.org/10.1111/ajae.12427

Ahmed, A. U., Hoddinott, J. F., Menon, P., Quisumbing, A. R., Roy, S., & Younus, M. (2018). *Agriculture, Nutrition, and Gender Linkages (ANGeL) evaluation results*. https://doi.org/10.2499/p15738coll2.136540

Ahmed, Akhter and Ghostlaw, Julie. 2019. Diversifying rice-centric agriculture and diets: The Bangladesh experience. In Agriculture for improved nutrition: Seizing the momentum. Chapter 15. Fan, Shenggen; Yosef, Sivan; Pandya-Lorch, Rajul (Eds.). Wallingford, UK:

International Food Policy Research Institute (IFPRI) and CABI. http://ebrary.ifpri.org/cdm/ref/collection/p15738coll2/id/133088

Akter, S., & Francis-Tan, A. (2020). Partners or Rivals? Exploring the Relationship between Men's and Women's Empowerment in Bangladesh. *The Journal of Development Studies*, *57*(6), 906–929. https://doi.org/10.1080/00220388.2020.1826448

Alam, M. J., Begum, I. A., Mastura, T., Kishore, A., Woodhill, J., Chatterjee, K., & Jackson, T. (2023). Agricultural diversification and intra-household dietary diversity: Panel data analysis of farm households in Bangladesh. *PloS One*, *18*(6), e0287321. https://doi.org/10.1371/journal.pone.0287321

Alan, de B., Mike, M., Elena, M., & Berber, K. (2019). *Endline Report on Impacts Associated with the Bangladesh Agricultural Value Chains Project.* International Food Policy Research Institute (IFPRI) . url: PA00TRHM

Ali, D. A., Deininger, K., & Duponchel, M. (2014). Credit Constraints and Agricultural Productivity: Evidence from rural Rwanda. *The Journal of Development Studies*, *50*(5), 649–665. https://doi.org/10.1080/00220388.2014.887687

Anderson, C. L., Reynolds, T. W., & Gugerty, M. K. (2017). Husband and Wife Perspectives on Farm Household Decision-making Authority and Evidence on Intra-household Accord in Rural Tanzania. *World Development, 90,* 169–183. https://doi.org/10.1016/j.worlddev.2016.09.005

Angelini, P., Di Salvo, R., & Ferri, G. (1998). Availability and cost of credit for small businesses: Customer relationships and credit cooperatives. *Journal of Banking & Finance*, *22*(6-8), 925–954. https://doi.org/10.1016/s0378-4266(98)00008-9

Antier, C., Rossing, W., Villa, A., Fares, M., & Messéan, A. (2022, May 23). *How to support the*

development of crop diversification? The importance of an approach at the value chain level. Hal.inrae.fr. https://hal.inrae.fr/hal-04235574

Arslan, A., Cavatassi, R., Alfani, F., Mccarthy, N., Lipper, L., & Kokwe, M. (2017). Diversification Under Climate Variability as Part of a CSA Strategy in Rural Zambia. *The Journal of Development Studies*, *54*(3), 457–480. https://doi.org/10.1080/00220388.2017.1293813

Arulampalam, W., Bhaskar, A., & Srivastava, N. (2016). Does Greater Autonomy Among Women Provide the Key to Better Child Nutrition? *SSRN Electronic Journal*. https://doi.org/10.2139/ssrn.2742569

Asfaw, S., Pallante, G., & Palma, A. (2018). Diversification Strategies and Adaptation Deficit: Evidence from Rural Communities in Niger. *World Development*, *101*, 219–234. https://doi.org/10.1016/j.worlddev.2017.09.004

Asselt, J., & Useche, P. (2022). Agricultural commercialization and nutrition; evidence from smallholder coffee farmers. *World Development*, *159*, 106021. https://doi.org/10.1016/j.worlddev.2022.106021

Balana, B. B., Mekonnen, D., Haile, B., Hagos, F., Yimam, S., & Ringler, C. (2022). Demand and supply constraints of credit in smallholder farming: Evidence from Ethiopia and Tanzania. *World Development*, *159*, 106033. https://doi.org/10.1016/j.worlddev.2022.106033

Becker, G. S. (1974). A Theory of Social Interactions. *Journal of Political Economy*, *82*(6), 1063–1093.

Begum, S., & Sen, B. (2009). Maternal Health, Child Well-Being and Chronic Poverty: Does Women's Agency Matter? *The Bangladesh Development Studies, 32*(4), 69-93. https://doi.org/10.2307/40795736

Bellemare, M. F., & Wichman, C. J. (2019). Elasticities and the Inverse Hyperbolic Sine Transformation. *Oxford Bulletin of Economics and Statistics*, *82*(1), 50–61. https://doi.org/10.1111/obes.12325

Bergquist, L. F., & Dinerstein, M. (2020). Competition and Entry in Agricultural Markets: Experimental Evidence from Kenya. *American Economic Review*, *110*(12), 3705–3747. https://doi.org/10.1257/aer.20171397

Biancotti, C., D'Alessio, G., & Neri, A. (2008). MEASUREMENT ERROR IN THE BANK OF ITALY'S SURVEY OF HOUSEHOLD INCOME AND WEALTH. *Review of Income and Wealth, 54*(3), 466–493.

Birthal, P. S., Roy, D., & Negi, D. S. (2015). Assessing the Impact of Crop Diversification on Farm Poverty in India. *World Development*, *72*, 70–92. https://doi.org/10.1016/j.worlddev.2015.02.015

Blanc, J., & Kledal, P. R. (2012). The Brazilian organic food sector: Prospects and constraints of facilitating the inclusion of smallholders. *Journal of Rural Studies*, *28*(1), 142–154. https://doi.org/10.1016/j.jrurstud.2011.10.005

Brannan, T., Bickler, C., Hansson, H., Karley, A. J., Weih, M., & Gordana Manevska-Tasevska. (2023). Overcoming barriers to crop diversification uptake in Europe: A mini review. *Frontiers in Sustainable Food Systems*, *7*. https://doi.org/10.3389/fsufs.2023.1107700

BRUNSON, E. K., SHELL-DUNCAN, B., & STEELE, M. (2009). Women's Autonomy and its Relationship to Children's Nutrition Among the Rendille of Northern Kenya. *American*

journal of human biology : The official journal of the Human Biology Council, *21*(1), 55. https://doi.org/10.1002/ajhb.20815

Burchfield, E. K., & Poterie, A. T. de la. (2018). Determinants of crop diversification in rice-dominated Sri Lankan agricultural systems. *Journal of Rural Studies*, *61*, 206–215. https://doi.org/10.1016/j.jrurstud.2018.05.010

C Lopriore , M-C Dop , A Solal-Céligny , & G Lagnado. (2007). Excluding infants under 6 months of age from surveys: impact on prevalence of pre-school undernutrition. *Public Health Nutrition* , *Volume 10*(Issue 1), 79–87. Cambridge University Press. https://doi.org/10.1017/S1368980007219676

Caldwell, J. C. (1986). Routes to Low Mortality in Poor Countries. *Population and Development Review*, *12*(2), 171. https://doi.org/10.2307/1973108

Carletto, G., Ruel, M., Winters, P., & Zezza, A. (2015). Farm-Level Pathways to Improved Nutritional Status: Introduction to the Special Issue. *The Journal of Development Studies*, *51*(8), 945–957. https://doi.org/10.1080/00220388.2015.1018908

Carlson, G. J., Kordas, K., & Murray-Kolb, L. E. (2014). Associations between women's autonomy and child nutritional status: a review of the literature. *Maternal & Child Nutrition*, *11*(4), 452–482. https://doi.org/10.1111/mcn.12113

Chilinda, Z. B., Wahlqvist, M. L., Lee, M.-S., & Huang, Y.-C. (2021). Higher maternal autonomy is associated with reduced child stunting in Malawi. *Scientific Reports*, *11*(1). https://doi.org/10.1038/s41598-021-83346-2

Christian, A. K., D Yaw Atiglo, Okyere, M. A., Akua Obeng-Dwamena, Marquis, G. S., & Jones, A. D. (2023). *Women's empowerment, children's nutritional status, and the*

mediating role of household headship structure: Evidence from sub-Saharan Africa. *19*(3). https://doi.org/10.1111/mcn.13520

Conger, R. D., Conger, K. J., & Martin, M. J. (2010). Socioeconomic Status, Family Processes,and Individual Development. *Journal of Marriage and Family*, *72*(3), 685–704. https://doi.org/10.1111/j.1741-3737.2010.00725.x

Cunningham, K., Ruel, M., Ferguson, E., & Uauy, R. (2014). Women's empowerment and child nutritional status in South Asia: a synthesis of the literature. *Maternal & Child Nutrition*, *11*(1), 1–19. https://doi.org/10.1111/mcn.12125

Dasgupta, S. (2016). Son Preference and Gender Gaps in Child Nutrition: Does the Level of Female Autonomy Matter? *Review of Development Economics*, *20*(2), 375–386. https://doi.org/10.1111/rode.12231

Debela, B. L., Gehrke, E., & Qaim, M. (2020). Links between Maternal Employment and Child Nutrition in Rural Tanzania. *American Journal of Agricultural Economics*, *103*(3), 812–830. https://doi.org/10.1111/ajae.12113

Debnath, A., & Bhattacharjee, N. (2016). Understanding Malnutrition of Tribal Children in India: The Role of Women's Empowerment. *Ecology of Food and Nutrition*, *55*(6), 508–527. https://doi.org/10.1080/03670244.2016.1223652

Deere, C. D., & Twyman, J. (2012). Asset Ownership and Egalitarian Decision Making in Dual-headed Households in Ecuador. *Review of Radical Political Economics*, *44*(3), 313–320. https://doi.org/10.1177/0486613412446043

Degryse, H., & Van Cayseele, P. (2000). Relationship Lending within a Bank-Based System: Evidence from European Small Business Data. *Journal of Financial Intermediation*, *9*(1), 90–109. https://doi.org/10.1006/jfin.1999.0278

Del Boca, D., Flinn, C., & Wiswall, M. (2013). Household Choices and Child Development. *The Review of Economic Studies*, *81*(1), 137–185. https://doi.org/10.1093/restud/rdt026

Dildar, Y. (2015). Patriarchal Norms, Religion, and Female Labor Supply: Evidence from Turkey. *World Development*, *76*, 40–61. https://doi.org/10.1016/j.worlddev.2015.06.010

Dillon, A., Arsenault, J., & Olney, D. (2018). Nutrient Production and Micronutrient Gaps: Evidence from an Agriculture-Nutrition Randomized Control Trial. *American Journal of Agricultural Economics*, *101*(3), 732–752. https://doi.org/10.1093/ajae/aay067

Doan, R. M., & Bisharat, L. (1990). Female autonomy and child nutritional status: The extended-family residential unit in Amman, Jordan. *Social Science & Medicine*, *31*(7), 783-789. https://doi.org/10.1016/0277-9536(90)90173-P

Doss, C. (2013). Intrahousehold Bargaining and Resource Allocation in Developing Countries. *The World Bank Research Observer*, *28*(1), 52–78. https://doi.org/10.1093/wbro/lkt001

Dzanku, F. M. (2019). Food security in rural sub-Saharan Africa: Exploring the nexus between gender, geography and off-farm employment. *World Development*, *113*, 26–43. https://doi.org/10.1016/j.worlddev.2018.08.017

Emmanuel Inoni, O., Sule Gani, B., & Sabo, E. (2021). Drivers of Crop Diversification: Evidence from Smallholder Farmers in Delta State Nigeria. *Acta Universitatis Agriculturae et Silviculturae Mendelianae Brunensis*, *69*(1), 59–70. https://doi.org/10.11118/actaun.2021.006

Engle, P. L., Menon, P., & Haddad, L. (1999). Care and Nutrition: Concepts and Measurement. *World Development*, *27*(8), 1309–1337. https://doi.org/10.1016/s0305-750x(99)00059-5

Fan, S., Brzeska, J., Keyzer, M., & Halsema, A. (2013). *From subsistence to profit: Transforming smallholder farms*. https://doi.org/10.2499/9780896295582

Foltz, J. D. (2004). Credit market access and profitability in Tunisian agriculture. *Agricultural Economics*, *30*(3), 229–240. https://doi.org/10.1111/j.1574-0862.2004.tb00191.x

Gershoff, E. T., Aber, J. L., Raver, C. C., & Lennon, M. C. (2007). Income Is Not Enough: Incorporating Material Hardship Into Models of Income Associations With Parenting and Child Development. *Child Development*, *78*(1), 70–95. https://doi.org/10.1111/j.1467-8624.2007.00986.x

Getahun, T. D., & Villanger, E. (2017). Labour-Intensive Jobs for Women and Development: Intra-household Welfare Effects and Its Transmission Channels. *The Journal of Development Studies*, *54*(7), 1232–1252. https://doi.org/10.1080/00220388.2017.1327661

Ghosh, P. K., Kali Krishna Hazra, Venkatesh, M. S., Chaitanya Prasad Nath, Singh, J., & N. Nadarajan. (2017). Increasing Soil Organic Carbon Through Crop Diversification in Cereal–Cereal Rotations of Indo-Gangetic Plain. *Proceedings of the National Academy of Sciences, India Section B: Biological Sciences*, *89*(2), 429–440. https://doi.org/10.1007/s40011-017-0953-x

Ghuman, S. J., Lee, H. J., & Smith, H. L. (2006). Measurement of women's autonomy according to women and their husbands: Results from five Asian countries. *Social Science Research*, *35*(1), 1–28. https://doi.org/10.1016/j.ssresearch.2004.06.001

Global Multidimensional Poverty Index 2023: Unstacking global poverty – Data for high-impact action, United Nations Development Programme (UNDP), and Oxford Poverty and Human Development Initiative (OPHI), University of Oxford.

Hahn, Y., Islam, A., Nuzhat, K., Smyth, R., & Yang, H.-S. (2018). Education, Marriage, and Fertility: Long-Term Evidence from a Female Stipend Program in Bangladesh. *Economic Development and Cultural Change*, *66*(2), 383–415. https://doi.org/10.1086/694930

Hazell, P., Poulton, C., Wiggins, S., & Dorward, A. (2010). The Future of Small Farms: Trajectories and Policy Priorities. *World Development*, *38*(10), 1349–1361. https://doi.org/10.1016/j.worlddev.2009.06.012

Heaton, T. B., & Forste, R. (2007). Domestic Violence, Couple Interaction and Children's Health in Latin America. *Journal of Family Violence*, *23*(3), 183–193. https://doi.org/10.1007/s10896-007-9142-7

Hirvonen, K., & Hoddinott, J. (2016). Agricultural production and children's diets: evidence from rural Ethiopia. *Agricultural Economics*, *48*(4), 469–480. https://doi.org/10.1111/agec.12348

Holland, C., & Rammohan, A. (2019). Rural women's empowerment and children's food and nutrition security in Bangladesh. *World Development*, *124*, 104648. https://doi.org/10.1016/j.worlddev.2019.104648

Hossain, M., Malek, M. A., Hossain, Md. A., Reza, Md. H., & Ahmed, Md. S. (2018). Agricultural Microcredit for Tenant Farmers: Evidence from a Field Experiment in Bangladesh. *American Journal of Agricultural Economics*, *101*(3), 692–709. https://doi.org/10.1093/ajae/aay070

Hussain, A., & Thapa, G. B. (2012). Smallholders' access to agricultural credit in Pakistan. *Food Security*, *4*(1), 73–85. https://doi.org/10.1007/s12571-012-0167-2

Imai, K. S., Annim, S. K., Kulkarni, V. S., & Gaiha, R. (2014). Women's Empowerment and Prevalence of Stunted and Underweight Children in Rural India. *World Development, 62*, 88–105. https://doi.org/10.1016/j.worlddev.2014.05.001

International Food Policy Research Institute (IFPRI), 2019, "Bangladesh Agricultural Value Chain (AVC) Impact Evaluation: Midline Survey", https://doi.org/10.7910/DVN/E3WDFQ, Harvard Dataverse, V2, UNF:6:kkLcKJvXXiwiMcId4/KiSQ== [fileUNF]

Islam, A. H. Md. S., von Braun, J., Thorne-Lyman, A. L., & Ahmed, A. U. (2018). Farm diversification and food and nutrition security in Bangladesh: empirical evidence from nationally representative household panel data. *Food Security*, *10*(3), 701–720. https://doi.org/10.1007/s12571-018-0806-3

JME. (2021). *Levels and trends in child malnutrition: key findings of the 2021 edition of the joint child malnutrition estimates.* UNICEF / WHO / World Bank Group.

Jones, A. D., Shrinivas, A., & Bezner-Kerr, R. (2014). Farm production diversity is associated with greater household dietary diversity in Malawi: Findings from nationally representative data. *Food Policy*, *46*, 1–12. https://doi.org/10.1016/j.foodpol.2014.02.001

Kenney, C. T. (2008). Father Doesn't Know Best? Parents' Control of Money and Children's Food Insecurity. *Journal of Marriage and Family*, *70*(3), 654–669. https://www.jstor.org/stable/40056358

Khandker, S. R. (2020). Credit for agricultural development. *RePEc: Research Papers in Economics*. https://doi.org/10.2499/9780896293830_16

Khandker, S. R., & Koolwal, G. B. (2015). How has microcredit supported agriculture? Evidence

using panel data from Bangladesh. *Agricultural Economics*, *47*(2), 157–168. https://doi.org/10.1111/agec.12185

Khanna, M., Kochhar, N., & Palaniswamy, N. (2015). A Retrospective Impact Evaluation of the Tamil Nadu Empowerment and Poverty Alleviation (Pudhu Vaazhvu) Project. *The Journal of Development Studies*, *51*(9), 1210–1223. https://doi.org/10.1080/00220388.2015.1028538

Khonje, M. G., Ricker-Gilbert, J., Muyanga, M., & Qaim, M. (2022). Farm-level production diversity and child and adolescent nutrition in rural sub-Saharan Africa: a multicountry, longitudinal study. *The Lancet Planetary Health*, *6*(5), e391–e399. https://doi.org/10.1016/s2542-5196(22)00071-7

Klasen, S., & Pieters, J. (2015). What Explains the Stagnation of Female Labor Force Participation in Urban India? *The World Bank Economic Review*, *29*(3), 449–478. https://doi.org/10.1093/wber/lhv003

Klasen, S., Le, T. T. N., Pieters, J., & Santos Silva, M. (2020). What Drives Female Labour Force Participation? Comparable Micro-level Evidence from Eight Developing and Emerging Economies. *The Journal of Development Studies*, *57*(3), 417–442. https://doi.org/10.1080/00220388.2020.1790533

Komatsu, H., Malapit, H. J. L., & Theis, S. (2018). Does women's time in domestic work and agriculture affect women's and children's dietary diversity? Evidence from Bangladesh, Nepal, Cambodia, Ghana, and Mozambique. *Food Policy*, *79*, 256–270. https://doi.org/10.1016/j.foodpol.2018.07.002

Koppmair, S., Kassie, M., & Qaim, M. (2016). Farm production, market access and dietary diversity in Malawi. *Public Health Nutrition*, *20*(2), 325–335.

https://doi.org/10.1017/s1368980016002135

Kumar, N., Harris, J., & Rawat, R. (2015). If They Grow It, Will They Eat and Grow? Evidence from Zambia on Agricultural Diversity and Child Undernutrition. *The Journal of Development Studies*, *51*(8), 1060–1077. https://doi.org/10.1080/00220388.2015.1018901

Lépine, A., & Strobl, E. (2013). The Effect of Women's Bargaining Power on Child Nutrition in Rural Senegal. *World Development*, *45*, 17–30. https://doi.org/10.1016/j.worlddev.2012.12.018

LESLIE, J. (1988). *Women's Work and Child Nutrition in the Third World*. World Development,; Volume 16, Issue 11, November 1988, Pages 1341-1362, elsevier. https://doi.org/10.1016/0305-750X(88)90209-4

Lundberg, S., & Pollak, R. A. (1993). Separate Spheres Bargaining and the Marriage Market. *Journal of Political Economy*, *101*(6), 988–1010. https://doi.org/10.1086/261912

Ma, M., & Sexton, R. J. (2021). Modern agricultural value chains and the future of smallholder farming systems. *Agricultural Economics*, *52*(4), 591–606. https://doi.org/10.1111/agec.12637

Ma, M., Lin, J., & Sexton, R. J. (2021). The Transition from Small to Large Farms in Developing Economies: A Welfare Analysis. *American Journal of Agricultural Economics*, *104*(1), 111–133. https://doi.org/10.1111/ajae.12195

Mahtab S. Bamji & B.V.S. Thimayamma (2000) Impact of women's work on maternal and child nutrition, Ecology of Food and Nutrition, 39:1, 13-31, DOI: 10.1080/03670244.2000.9991602

Makate, C., Angelsen, A., Holden, S. T., & Westengen, O. T. (2022). Crops in crises: Shocks

shape smallholders' diversification in rural Ethiopia. *World Development*, *159*, 106054. https://doi.org/10.1016/j.worlddev.2022.106054

Makate, C., Wang, R., Makate, M., & Mango, N. (2016). Crop diversification and livelihoods of smallholder farmers in Zimbabwe: adaptive management for environmental change. *SpringerPlus*, *5*(1). https://doi.org/10.1186/s40064-016-2802-4

Mango, N., Makate, C., Mapemba, L., & Sopo, M. (2018). The role of crop diversification in improving household food security in central Malawi. *Agriculture & Food Security*, *7*(1). https://doi.org/10.1186/s40066-018-0160-x

Mason, K. O. (1986). The status of women: Conceptual and methodological issues in demographic studies. *Sociological Forum*, *1*(2), 284–300. https://doi.org/10.1007/bf01115740

McCord, P. F., Cox, M., Schmitt-Harsh, M., & Evans, T. (2015). Crop diversification as a smallholder livelihood strategy within semi-arid agricultural systems near Mount Kenya. *Land Use Policy*, *42*, 738–750. https://doi.org/10.1016/j.landusepol.2014.10.012

McElroy, M. B., & Horney, M. J. (1981). Nash-Bargained Household Decisions: Toward a Generalization of the Theory of Demand. *International Economic Review*, *22*(2), 333. https://doi.org/10.2307/2526280

McKenna, C. G., Bartels, S. A., Pablo, L. A., & Walker, M. (2019). Women's decision-making power and undernutrition in their children under age five in the Democratic Republic of the Congo: A cross-sectional study. *PLOS ONE*, *14*(12), e0226041. https://doi.org/10.1371/journal.pone.0226041

Meskerem Jisso1 , Tizalegn Tesfaye2 , Sibhatu Biadgilign3 , Amare Abera Tareke4 , & Tadesse Alemu Zerfu. (2022). The role of multi-dimensional women's empowerment in

agriculture to improve the nutritional status of under-five children in rural cash crop producing, resource-limited settings of Ethiopia. *Journal of Nutritional Science* , *Volume 11*(e92). Cambridge University Press . https://doi.org/10.1017/jns.2022.86

Michler, J. D., & Josephson, A. L. (2017). To Specialize or Diversify: Agricultural Diversity and Poverty Dynamics in Ethiopia. *World Development*, *89*, 214–226. https://doi.org/10.1016/j.worlddev.2016.08.011

Mizushima, A., & Futagami, K. (2014). Non-cooperative versus cooperative family. *Journal of Economics, 114*(1), 43–62. https://doi.org/10.1007/s00712-014-0391-7

Mullany, B. C., Hindin, M. J., & Becker, S. (2005). Can women's autonomy impede male involvement in pregnancy health in Katmandu, Nepal? *Social Science & Medicine, 61*(9), 1993–2006. https://doi.org/10.1016/j.socscimed.2005.04.006

Mulwa, C. K., & Visser, M. (2020). Farm diversification as an adaptation strategy to climatic shocks and implications for food security in northern Namibia. *World Development*, *129*, 104906. https://doi.org/10.1016/j.worlddev.2020.104906

Munro, A. (2017). INTRA-HOUSEHOLD EXPERIMENTS: A SURVEY. *Journal of Economic Surveys, 32*(1), 134–175. https://doi.org/10.1111/joes.12196

Nankinga, O., Kwagala, B., & Walakira, E. J. (2019). Maternal employment and child nutritional status in Uganda. *PLOS ONE, 14*(12), e0226720. https://doi.org/10.1371/journal.pone.0226720

Neme, A. A., & Tefera, T. L. (2021). A REVIEW ON COMMERCIALIZATION OF SMALLHOLDER AGRICULTURAL PRODUCERS AND ITS IMPACTS ON HOUSEHOLD LIVELIHOODS. EVIDENCE FROM ETHIOPIA CONTEXT. *Journal of Agribusiness and Rural Development*, *59*(1).

https://doi.org/10.17306/j.jard.2021.01393

Neme, A. A., & Tefera, T. L. (2021). A REVIEW ON COMMERCIALIZATION OF SMALLHOLDER AGRICULTURAL PRODUCERS AND ITS IMPACTS ON HOUSEHOLD LIVELIHOODS. EVIDENCE FROM ETHIOPIA CONTEXT. *Journal of Agribusiness and Rural Development*, *59*(1). https://doi.org/10.17306/j.jard.2021.01393

Njeru, E. (2013). Crop Diversification: A Potential Strategy To Mitigate Food Insecurity by Smallholders in sub-Saharan Africa. *Journal of Agriculture, Food Systems, and Community Development*, 1–7. https://doi.org/10.5304/jafscd.2013.034.006

O'Donnell, O., Eddy Van Doorsslaer, Wagstaff, A., & Magnus Lindelow. (2008). *Analyzing Health Equity Using Household Survey Data*. World Bank Publications.

Ogutu, S. O., & Qaim, M. (2019). Commercialization of the small farm sector and multidimensional poverty. *World Development*, *114*, 281–293. https://doi.org/10.1016/j.worlddev.2018.10.012

Onah, M. N. (2020). Women's empowerment and child nutrition in South-Central Asia: how important is socioeconomic status? *SSM - Population Health*, 100718. https://doi.org/10.1016/j.ssmph.2020.100718

Owusu, O., & İşcan, T. B. (2021). Drivers of farm commercialization in Nigeria and Tanzania. *Agricultural Economics*, *52*(2), 265–299. https://doi.org/10.1111/agec.12618

P. Shirisha, & Bansal, A. (2022). Is mother's financial autonomy associated with stunting among children aged 7–35 months: An empirical study from India. *PLOS Global Public Health*, *2*(1), e0000134–e0000134.

Pan, Y., Smith, S. C., & Sulaiman, M. (2018). Agricultural Extension and Technology Adoption for Food Security: Evidence from Uganda. *American Journal of Agricultural Economics, 100*(4), 1012–1031. https://doi.org/10.1093/ajae/aay012

Patel, A. M., Leonard, W. R., Reyes-García, V., McDade, T., Vadez, V., Huanca, T., & Tanner, S. (2007). *Parental preference, bargaining powe, and child nutritional status: Evidence from the Bolivian Amazon*. *TAPS Working paper* (31). Brandeis University, Waltham, MA.

Paul, P., & Saha, R. (2022). Is maternal autonomy associated with child nutritional status? Evidence from a cross-sectional study in India. *PLOS ONE, 17*(5), e0268126. https://doi.org/10.1371/journal.pone.0268126

Pingali, P. (2007). Agricultural growth and economic development: a view through the globalization lens. *Agricultural Economics*, *37*, 1–12. https://doi.org/10.1111/j.1574-0862.2007.00231.x

Pitt, Mark M., Khandker, Shahidur R., & Cartwright, J. (2006). Empowering Women with Micro Finance: Evidence from Bangladesh. *Economic Development and Cultural Change, 54*(4), 791–831. https://doi.org/10.1086/503580

Planning Commission. (2011). *SIXTH FIVE YEAR PLAN FY2011-FY2015 Accelerating Growth and Reducing Poverty Part-1 Strategic Directions and Policy Framework General Economics Division Planning Commission Ministry of Planning Government of the People's Republic of Bangladesh*. https://faolex.fao.org/docs/pdf/bgd150862.pdf

Popkin, B. M. (1980). Time allocation of the mother and child nutrition. *Ecology of Food and Nutrition*, *9*(1), 1–13.

Quisumbing, A. R., & Maluccio, J. A. (2003). Resources at Marriage and Intrahousehold Allocation: Evidence from Bangladesh, Ethiopia, Indonesia, and South Africa*. *Oxford Bulletin of Economics and Statistics*, *65*(3), 283–327. https://doi.org/10.1111/1468-0084.t01-1-00052

Quisumbing, A. R., Brown, L. R., Feldstein, H. S., Haddad, L., & Peña, C. (1996). Women: The Key to Food Security. *Food and Nutrition Bulletin*, *17*(1), 1–2. https://doi.org/10.1177/156482659601700116

Rahman, Md. M., Saima, U., & Goni, Md. A. (2015). Impact of Maternal Household Decision-Making Autonomy on Child Nutritional Status in Bangladesh. *Asia Pacific Journal of Public Health*, *27*(5), 509–520. https://doi.org/10.1177/1010539514568710

Rahman, R. I., & Islam, R. (2013). *Female labour force participation in Bangladesh: trends, drivers and barriers / Rushidan I. Rahman and Rizwanul Islam; International Labour Organization, ILO DWT for*. International Labor Organization-ILO.

Rahman, S. (2009). Whether crop diversification is a desired strategy for agricultural growth in Bangladesh? *Food Policy*, *34*(4), 340–349. https://doi.org/10.1016/j.foodpol.2009.02.004

Rahman, S. (2010). Six decades of agricultural land use change in Bangladesh: Effects on crop diversity, productivity, food availability and the environment, 1948-2006. *Singapore Journal of Tropical Geography*, *31*(2), 254–269. https://doi.org/10.1111/j.1467-9493.2010.00394.x

Raihan, S., & Bidisha, S. H. (2018). *Female employment stagnation in Bangladesh*. The Asia Foundation - UK-AID.

Rajaram, R., Perkins, J. M., Joe, W., & Subramanian, S. V. (2016). Individual and community levels of maternal autonomy and child undernutrition in India. *International Journal of Public Health, 62*(2), 327–335. https://doi.org/10.1007/s00038-016-0850-8

Rama Lionel Ngenzebuke & Yoko Akachi, 2017. "Female work status and child nutritional outcome in Nigeria," WIDER Working Paper Series wp-2017-196, World Institute for Development Economic Research (UNU-WIDER).

Rashad, A. S., & Sharaf, M. F. (2018). Does maternal employment affect child nutrition status? New evidence from Egypt. *Oxford Development Studies, 47*(1), 48–62. https://doi.org/10.1080/13600818.2018.1497589

Reardon, T., Barrett, C. B., Berdegué, J. A., & Swinnen, J. F. M. (2009). Agrifood Industry Transformation and Small Farmers in Developing Countries. *World Development*, *37*(11), 1717–1727. https://doi.org/10.1016/j.worlddev.2008.08.023

Reckling, M., Watson, C. A., Whitbread, A., & Helming, K. (2023). Diversification for sustainable and resilient agricultural landscape systems. *Agronomy for Sustainable Development*, *43*(4). https://doi.org/10.1007/s13593-023-00898-5

Rehan, S. F., Sumelius, J., & Bäckman, S. (2017). Determinants of on-farm diversification in Bangladesh. *International Journal of Agricultural Resources, Governance and Ecology*, *13*(3), 294. https://doi.org/10.1504/ijarge.2017.087001

Romeo, A., Meerman, J., Demeke, M., Scognamillo, A., & Asfaw, S. (2016). Linking farm diversification to household diet diversification: evidence from a sample of Kenyan ultra-poor farmers. *Food Security*, *8*(6), 1069–1085. https://doi.org/10.1007/s12571-016-0617-3

Rosenzweig, M. R., & Schultz, T. P. (1983). Estimating a Household Production Function: Heterogeneity, the Demand for Health Inputs, and Their Effects on Birth Weight. *Journal of Political Economy*, *91*(5), 723–746. https://doi.org/10.1086/261179

Ross-Suits, Hannah Murphy, "Maternal Autonomy as a Protective Factor in Child Nutritional Outcome in Tanzania." Thesis, Georgia State University, 2010. doi: https://doi.org/10.57709/1341035

Sangwan, N., & Kumar, S. (2021). Labor force participation of rural women and the household's nutrition: Panel data evidence from SAT India. *Food Policy*, *102*, 102117. https://doi.org/10.1016/j.foodpol.2021.102117

SanitàD. (2006). *WHO child growth standards: length/height-for-age, weight-for-age, weight-for-length, weight-for-height and body mass index-for-age: methods and development*. World Health Organization.

Sethuraman, K., Lansdown, R., & Sullivan, K. (2006). Women's Empowerment and Domestic Violence: The Role of Sociocultural Determinants in Maternal and Child Undernutrition in Tribal and Rural Communities in South India. *Food and Nutrition Bulletin*. https://doi.org/10.1177/156482650602700204

Seymour, G., & Peterman, A. (2018). Context and measurement: An analysis of the relationship between intrahousehold decision making and autonomy. *World Development*, *111*, 97–112. https://doi.org/10.1016/j.worlddev.2018.06.027

Shahidur R., K.(2021). Credit for agricultural development. In *AGRICULTURAL DEVELOPMENT:NEW PERSPECTIVES IN A CHANGING WORLD* (pp. 529–561). INTERNATIONAL FOODPOLICY RESEARCH INSTITUTE (IFPRI). https://www.ifpri.org/publication/credit-agricultural-development

Shroff, M. R., Griffiths, P. L., Suchindran, C., Nagalla, B., Vazir, S., & Bentley, M. E. (2011). Does maternal autonomy influence feeding practices and infant growth in rural India? *Social Science & Medicine*, *73*(3), 447–455. https://doi.org/10.1016/j.socscimed.2011.05.040

Sibhatu, K. T., & Qaim, M. (2018). Farm production diversity and dietary quality: linkages and measurement issues. *Food Security*, *10*(1), 47–59. https://doi.org/10.1007/s12571-017-0762-3

Smith, L., Ramakrishnan, U., Ndiaye, A., Haddad, L., & Martorell, R. (2003). *The Importance of Women's Status for Child Nutrition in Developing Countries INTERNATIONAL FOOD POLICY RESEARCH INSTITUTE sustainable solutions for ending hunger and poverty*. IFPRI. https://core.ac.uk/download/pdf/6289649.pdf

Sraboni, E., Malapit, H. J., Quisumbing, A. R., & Akhter, A. (2013). Women's Empowerment in Agriculture: What Role for Food Security in Bangladesh? *SSRN Electronic Journal*. https://doi.org/10.2139/ssrn.2373183

Swinnen, J., & Vos, R. (2021). COVID-19 impacts on global food systems and household welfare: Key insights from the Special Issue. *Agricultural Economics*. https://doi.org/10.1111/agec.12623

Takahashi, K., Muraoka, R., & Otsuka, K. (2019). Technology adoption, impact, and extension in developing countries' agriculture: A review of the recent literature. *Agricultural Economics, 51*(1). https://doi.org/10.1111/agec.12539

Taylor. (2021). *Women's Work and Child Welfare in the Third World*. Routledge.

Thapa, G., Kumar, A., Roy, D., & Joshi, P. K. (2017). Impact of Crop Diversification on Rural Poverty in Nepal. *Canadian Journal of Agricultural Economics/Revue Canadienne*

D'agroeconomie, *66*(3), 379–413. https://doi.org/10.1111/cjag.12160

Tidwell, J. B., Gopalakrishnan, A., Lovelady, S., Sheth, E., Unni, A., Wright, R., Ghosh, S., & Sidibe, M. (2019). Effect of Two Complementary Mass-Scale Media Interventions on Handwashing with Soap among Mothers. *Journal of Health Communication*, *24*(2), 203–215. https://doi.org/10.1080/10810730.2019.1593554

Timsina, J., Wolf, J., Guilpart, N., van Bussel, L. G. J., Grassini, P., van Wart, J., Hossain, A., Rashid, H., Islam, S., & van Ittersum, M. K. (2018). Can Bangladesh produce enough cereals to meet future demand? *Agricultural Systems*, *163*, 36–44. https://doi.org/10.1016/j.agsy.2016.11.003

U. Ahmed, A., Ahmad, K., Chou, V., Hernandez, R., Menon, P., Naeem, F., Yu, B., Naher, F., Quabili, W., & Sraboni, E. (2013). The Status of Food Security in the Feed the Future Zone and Other Regions of Bangladesh: Results from the 2011-2012 Bangladesh Integrated Household Survey. In *IFPRI.org*. International Food Policy Research Institute. https://www.ifpri.org/publication/status-food-security-feed-future-zone-and-other-regions-bangladesh-results-2011-2012

Waha, K., van Wijk, M. T., Fritz, S., See, L., Thornton, P. K., Wichern, J., & Herrero, M. (2018). Agricultural diversification as an important strategy for achieving food security in Africa. *Global Change Biology*, *24*(8), 3390–3400. https://doi.org/10.1111/gcb.14158

Wollburg, P., Tiberti, M., & Zezza, A. (2020). Recall length and measurement error in agricultural surveys. *Food Policy*, 102003.

Yan, Z., Zhou, J., Liu, C., Jia, R., Mganga, K. Z., Yang, L., Yang, Y., Peixoto, L., Zang, H., & Zeng, Z. (2023). Legume-based crop diversification reinforces soil health and carbon storage driven by microbial biomass and aggregates. *Soil and Tillage Research*, *234*,

105848. https://doi.org/10.1016/j.still.2023.105848

Yount, K. M., DiGirolamo, A. M., & Ramakrishnan, U. (2011). Impacts of domestic violence on child growth and nutrition: A conceptual review of the pathways of influence. *Social Science & Medicine*, *72*(9), 1534–1554.

Zahidi, S., Kali Pal, K., Ratcheva, V., & Crotti, R. (2021). Global Gender Gap Report 2021. In *www.weforum.org* (p. 10). World Economic Forum. https://www3.weforum.org/docs/WEF_GGGR_2021.pdf

Ziaei, S., Naved, R. T., & Ekström, E.-C. (2012). Women's exposure to intimate partner violence and child malnutrition: findings from demographic and health surveys in Bangladesh. *Maternal & Child Nutrition*, *10*(3), 347–359.

Appendix

Table-A1: OLS - Baseline Results: Correlates of Attritions

VARIABLES	(1) LPM
Treatment = T1	-0.00
	(0.02)
Treatment = T2	0.02
	(0.02)
Treatment = T3	-0.00
	(0.01)
Control variables	yes
Constant	0.96***
	(0.03)
Observations	1,000
R-squared	0.05

##The control variables includes- numbers of household member; household head's age, gender, literacy rate; highest level of education status of any household member; household's possession of agricultural land, numbers of cattle, and access to modern agricultural machinery; household's yearly fixed assets purchase, and total yearly expenditure other than food; numbers of food group consumed in last seven days; distance to the market, availability of community agricultural producer group, and upazila fixed effects.
##village level cluster standard errors is in parentheses; *** p<0.01, ** p<0.05, * p<0.1

**Dependent variable is 1 one if household stays and 0 otherwise.

Table – A2: Baseline covariates balance t-test base on Treatment Arms (p-values)			
Variables	**T1 to C**	**T2 to C**	**T3 to C**
Household Size (numbers)	0.136	0.532	0.728
Household head gender (female=1, male=0)	0.158	**0.017****	**0.097***
Household head Literacy (yes=1, no=0)	0.968	0.558	0.531
Household head Age (years)	0.582	0.751	0.854
Highest education achieved by any household members (years)	0.498	0.377	0.170
Agricultural land own by household (acres)	**0.099***	0.655	0.196
Access to modern agricultural machinery	**0.100***	**0.017****	**0.060***
Numbers of cattle own by household	**0.035****	0.127	0.872
Total yearly household expenditure other than food in Tk.	0.191	0.315	**0.005*****
Total yearly household expenditure for fixed assets in Tk.	0.947	0.533	0.812
Household members consumed foods in last 7 days (numbers)	0.014**	0.002***	0.003***
Distance to nearest market (in minutes)	0.888	0.526	**0.000*****
Availability of active agriculture/livestock producer group in the community (yes=1, no=0)	0.441	0.389	0.553
Total crop count (crop richness)	0.014**	0.812	0.070*
Total crop group count (crop evenness)	0.033**	0.675	0.029**
Simpson's diversity index (both crop richness and evenness)	0.753	0.309	**0.019****
Informal input credit	0.069*	0.095*	0.009***
N	523	495	502

Table – A3:

Land use to cultivate jute (in decimal)

Treatment Arms	Midline					Endline				
	obs	mean	std.	min	max	obs	mean	std.	min	max
T1	256	96.64	67.11	7	464	251	105.30	69.02	15	473
T2	232	93.85	66.65	10	368	232	93.44	72.42	10	420
T3	235	92.76	64.84	13	416	227	95.47	64.81	8	528

Table – A4: Descriptive Statistics of explanatory variables

Variable	Obs	Mean	Std. Dev.	Min	Max
Autonomic work decision	4192	0.501	.5	0	1
Autonomic food decision	5441	0.152	.36	0	1
Composite autonomy score (PCA)	5441	0.001	.98	-.41	2.7

Table – A5: First-stage results of the IV-log of asset brought to marriage (working mothers)

VARIABLES	(1) Work decision main model	(2) Food decision robust model	(3) Composite decision robust model
Log of asset brought to marriage	-0.01***	-0.00***	-0.01***
	(0.00)	(0.00)	(0.00)
Controlling other variables used in main model	yes	yes	yes
Constant	0.77***	0.28***	0.25***
	(0.08)	(0.06)	(0.05)
Observations	4,194	4,194	4,194
R-squared	0.04	0.04	0.05

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table – A6: First-stage results of IV-log of asset brought to marriage (generalizability tests)

VARIABLES	(1) Food decision	(2) Composite decision
Log of asset brought to marriage	-0.01***	-0.01***
	(0.00)	(0.00)
Controlling other variables used in main model	yes	yes
Constant	0.21***	0.18***
	(0.05)	(0.04)
Observations	5,443	5,443
R-squared	0.05	0.05

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table – A7: First-stage results of IV- mothers work at home

VARIABLES	(1) Work decision	(2) Food decision	(3) Composite decision
Log of asset brought to marriage	-0.01***	-0.00***	-0.00***
	(0.00)	(0.00)	(0.00)
Controlling other variables used in main model	yes	yes	yes
Constant	0.82***	0.28***	0.21***
	(0.10)	(0.06)	(0.05)
Observations	3,372	3,372	3,372
R-squared	0.03	0.04	0.04

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table – A8: First-stage results of IV- mothers work outside/both

VARIABLES	(1) Work decision	(2) Food decision	(3) Composite decision
log of asset brought to marriage	-0.01**	-0.01**	-0.01**
	(0.00)	(0.00)	(0.00)
Controlling other variables used in main model	yes	yes	yes
Constant	0.56***	0.40***	0.45***
	(0.16)	(0.14)	(0.12)
Observations	820	820	820
R-squared	0.07	0.06	0.06

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table – A9: Explanation of Negative Coefficient of IV at the First-stage

VARIABLES	Mother spending Decision working mother
Log of asset brought to marriage	-0.01***
	(0.00)
Control variables	yes
Constant	0.33***
	(0.08)
Observations	4,192
R-squared	0.03

The control variables includes- child breast feeding, birth order, child gender, household hygiene index, log of household assets, household head's education, numbers of household members, household head's age, religion, mother's education, mothers TV watching status, mother's work place, mother's age at first child, health worker visit, females (mothers) brothers, and year. Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

Table – A10: data used for heterogeneous association analysis

Maternal Autonomy in work decision	Maternal Work place		Total
	At home	Outside/both	
Mother	1789 (53%)	310 (38%)	2093
Otherwise	1583 (47%)	510 (42%)	2099
Total	3372 (100%)	820 (100%)	4192

Table – A11: the changes of child nutrition over time.

Year	Nutrition Indicators			Observations
	HAZ	WAZ	WHZ	
2015	- 1.63 (1.30)	- 1.55 (1.00)	- 0.92 (1.17)	2090
2018	- 1.50 (1.21)	- 1.27 (1.04)	- 0.65 (1.15)	2102

Table – A12: the changes of maternal autonomy in workforce participation decisions over time.

Year	Maternal workforce participation decisions		Total
	herself	otherwise	
2015	972 (46.50%)	1118 (53.50%)	2090 (100%)
2018	1127 (53.62%)	975 (46.38%)	2102 (100%)

Table – A13: Child's nutrition under mother's WP decision using IV-log of real asset brought to marriage

VARIABLES	(1) HAZ	(2) WAZ	(3) WHZ
Mothers' work decision (autonomic=1, otherwise=0)	2.63*** (0.94)	2.23*** (0.76)	1.19* (0.67)
Controlling variables	yes	yes	yes
Constant	-5.37*** (0.72)	-4.32*** (0.58)	-1.91*** (0.51)
Observations	4,192	4,192	4,192
R-squared	-0.97	-0.91	-0.15

Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

Table – A14: Descriptive Statistics of Data on Workforce Participation Decisions.

Whose decision was to work to earn income	Freq.	percent	Cum.
Yourself	2099	50.07	50.07
Your husband	86	2.05	52.12
Self and husband	1971	47.02	99.14
Someone else	36	0.86	100
Total	4192	100	

Table – A15: Child's nutrition under mother's autonomy and joint decisions using IV-log of asset brought to marriage

VARIABLES	(1) HAZ	(2) WAZ	(3) WHZ
Mothers' work decision (self=1, self & husband=0)	2.47***	2.01***	0.98*
	(0.88)	(0.70)	(0.62)
Controlling variables	yes	yes	yes
Constant	-5.21***	-4.13***	-1.75***
	(0.67)	(0.53)	(0.48)
Observations	4,070	4,070	4,070
R-squared	-0.85	-0.72	-0.09

Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1