Eliciting Farmer Preferences for Rice Varietal Trait Improvements Using an Experimental Methodology Based on Investment Games

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Thesis Declaration

I certify that this work contains no material which has been accepted for the award of any other degree or diploma in my name, in any university or other tertiary institution and, to the best of my knowledge and belief, contains no material previously published or written by another person, except where due reference has been made in the text. In addition, I certify that no part of this work will, in the future, be used in a submission in my name, for any other degree or diploma in any university or other tertiary institution without the prior approval of the University of Adelaide and where applicable, any partner institution responsible for the joint-award of this degree.

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Abstract

Rice value chains are changing rapidly in Asia, partly due to changing consumption patterns, and also as a result of increasingly stringent quality standards imposed on producers. Rice farmers and other value chain actors must now consider rice varieties that are suitable for unique production environments and processing scenarios. Rice breeders face similar trade-offs, as demand for their products (genetics or new varieties of rice) is derived from farmers' and other value chain actors' (including consumers') demand for rice varieties and traits. Ultimately, breeders need to make informed decisions about where to invest and how to allocate increasingly scarce research and development resources. To facilitate successful adoption, it is important that farmers' preferences and needs are incorporated in the early phases of breeding research to make sure that rice varieties developed are suitable to local conditions and at the same time respond to market requirements.

This thesis utilises an innovative experimental Investment Game Application (IGA), which is a newly developed application for eliciting preferences for rice variety traits. The game is designed to simulate an investment market in which farmers can participate in investment decisions for public rice breeding programs. In the IGA, farmers are asked to identify a replacement variety and the traits of this variety that they want to see improved. Farmers are provided with an endowment fund, which they are asked to use to invest in trait improvements.

Therefore, using data from the investment games conducted in February 2016 in Nueva Ecija, Philippines, this thesis analyses farmer preferences for rice varietal trait improvements (VTIs). A total of 122 rice-farming households participated in the experiment, with both the husband and wife taking part in activities. The thesis consists of three core chapters, which specifically analyse the following: (i) farmers' investment preferences for VTIs and the factors that influence these preferences; (ii) farmers' heterogeneity in preferences for VTIs using a latent class cluster analysis; and (iii) gender and intrahousehold dynamics in the decision-making process regarding investment in VTIs.

The results from the analysis of farmers' investment preferences suggest that Filipino farmers prioritize investment in stress tolerance traits such as lodging tolerance, and disease and insect resistance. This is perhaps not surprising, because, on average, the replacement variety selected for improvement is already accepted in the market, i.e. it has the grain quality traits that Filipino consumers prefer (long and slender). On the other hand, the factors that influence farmers' decisions to invest in VTIs are related to the cropping season, variety type, and access to land.

Filipino rice farmers have significant heterogeneity in investment preferences; with a latent class cluster analysis identifying four distinct farmer segments each with unique preferences for the VTIs. When gender and intrahousehold dynamics in preferences are accounted for in the analysis, results suggest that the replacement variety selected individually and jointly by the couples is the same for most of the household-respondents. Moreover, the wife has more influence on the household's choice of VTIs when she works on-farm, and/or when she is considering the impact of VTI investment decisions on the household's future wellbeing.

The results of the study can guide breeders and donors to develop more resource efficient and client-oriented rice-breeding programs. Moreover, the novel approach of the methodology can transform the way farmer preferences for variety traits are elicited and can provide an opportunity for farmers to be truly involved in the agricultural research process through participation in resource allocation and priority-setting activities.

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Chapter 1: Introduction

1.1 Background and Motivation

Agriculture and the agri-food system are being transformed worldwide. At the same time, there are challenges that can affect their continual development and transformation. In Asia, for example, rice value chains are changing rapidly, partly due to changing consumption patterns, and increasingly stringent quality standards imposed on producers (Reardon et al. 2014). On the other hand, the food supply system is affected by increasing climate variability and natural resource scarcity (Briones and Felipe 2013, Timmer 2017). As such, rice farmers and other value chain actors must now consider rice varieties that are suitable for unique production environments and are tailored to meet unique market standards.

Investments in research and development will continue to play a significant role in agriculture and the global agri-food system as they evolve to meet both the supply-side and the demand-side challenges ahead. In the area of breeding research, rice breeders face trade-offs in variety development, as demand for their products (e.g. new varieties of rice) is derived from farmers' and other value chain actors' (including consumers') demand for rice varieties and traits. Thus, rice breeders need to make informed decisions about where to invest and how to allocate increasingly scarce research and development resources. To facilitate successful adoption, it is important that farmers' preferences and needs are incorporated in the early phase of breeding to make sure that rice varieties developed are suitable to evolving local production conditions, and at the same time, are responsive to changing market requirements.

Interest in incorporating farmers' preferences in the varietal development process has emerged over the last two decades. Through participatory techniques in plant breeding, breeders collaborate with farmers to gain a better understanding of their preferences and demands, leading to development of varieties more suitable to local needs and conditions (Almekinders and Elings 2001, Atlin 2004, Morris and Bellon 2004). In these participatory techniques, farmers can either participate at early or later stages of the breeding process. During the early stages (Participatory Plant Breeding (PPB)), farmers can participate in evaluating variety traits during the selection phase (Witcombe et al. 2006). On the other hand, farmers' participation during the later stages of the breeding process is often referred to as Participatory Varietal Selection (PVS) where farmers evaluate released and unreleased varieties through on-farm trials using their own crop management practices (Witcombe et al. 1996).

Although these participatory techniques are available and have been used in the past years, eliciting preferences for improvements in variety traits has not been given significant attention. In the existing participatory approaches, farmers' preferences for different variety traits have been elicited on the *traits* – per se – of released or unreleased varieties (Joshi and Witcombe 1996, Joshi et al. 2007, Joshi et al. 1997, Joshi and Witcombe 2002, Witcombe et al. 2001). Moreover, it has been recognized that limited research resources must be allocated more efficiently towards breeding programs (Morris and Bellon 2004). Previous research suggests that farmers are able to identify and suggest improvements or modifications in the technologies they use to make these more suitable to their needs (Pingali, Rozelle and Gerpacio 2001).

Therefore, we contend, that identifying the variety and trait improvements that farmers need, *prior to* the actual variety development, will be more efficient use of research funds as it can lead to increased adoption of new and /or improved varieties. Thus, this thesis examines farmers' preferences, both at the individual and household level, for varietal trait improvements (VTIs) in rice. Particular focus is placed on the Philippines, where rice is the most important staple food crop.

Additionally, due to the increasingly limited public funds available for crop research and development globally, we elicit farmers' preferences subject to financial constraints. We do this by allocating farmers with an endowment fund and asking them to participate in a novel investment game methodology, which is designed to reduce hypothetical bias, which is often a concern associated with preference elicitation methods. Specifically, preferences are elicited by means of a simulated investment market for rice breeding research, where farmers are asked to allocate research funding to variety traits that they perceive or prefer to be improved.

This hypothetical investment market is played using the Investment Game Application (IGA), an application developed at the International Rice Research Institute (IRRI) for eliciting preferences for VTIs (Demont et al. 2015). In the investment game, farmers were asked to consider their preferences and needs for rice VTIs and to allocate an endowed investment share for rice breeding research across several trait improvements.

Paris et al. (2001) was the first to include resource constraints in eliciting preferences for rice variety traits. Farmers in selected rain-fed areas in eastern India were asked to allocate a hypothetical amount of 100 *paisa* (100 *paisa* = 1

Indian Rupee) among different rice variety traits. Although the study was able to provide a ranking of the most important traits farmers consider in selecting varieties, this ranking did not inform breeders on how scarce research resources needed to be allocated among the various traits.

By asking farmers to allocate research funds to what they think should be prioritized in breeding research, they are given the opportunity to be involved early in the agricultural research process and have a voice in setting priorities for breeding research. Moreover, by making resource allocation and priority setting participatory, farmers' risk preferences (as investors) can be taken into account in resource allocation decisions. This makes the process even more participatory.

1.2 Rice in the Philippines

As mentioned, this thesis focused on the Philippines, where rice is the most important food crop. It is estimated that about 35% of the total area planted to crops in the Philippines is devoted to rice production (Philippine Statistics Authority 2016). As a staple food, rice contributed 46% of the total protein and 34% of the total calorie intake in the average diet of a Filipino in 2013 (International Rice Research Institute 2017). The average consumption per capita of rice in 2013 was about 120 kg. Moreover, expenditure on rice makes up 50% of the total food expenditures and 11% of annual income (Lantican, Quilloy and Sombilla 2011).

There have been significant changes in rice production in the Philippines over the last 50 years. The adoption of high-yielding rice varieties released in the late 1960s paved the way for the Green Revolution in the country (Umetsu, Lekprichakul and Chakravorty 2003). Rice production more than doubled from 3.9 million metric tons in 1961 to 9.8 million metric tons in 1990. Further, average yield per hectare increased from 1.23 tons in 1961 to 2.98 tons in 1990, (an increase of 142%). This significant increase in production took place with an increase in the area harvested of less than 5%. The increase in rice productivity in the Philippines can be attributed to the widespread adoption of high-yielding varieties, with almost 90% of the area planted to modern varieties in 1990.

From 1991 to 2015, production almost doubled from 9.7 million tons to 18 million tons. However, the growth in average yield per hectare from 1991 to 2015 slowed, increasing by only 38.3% (from 2.82 tons in 1991 to 3.90 tons in 2015). This may be due to the fact that most modern varieties planted were better in terms of grain quality, but were less superior in yield performance (Estudillo and Otsuka 2006).

Adoption of high yielding varieties resulted in increase in incomes, which in turn had a significant impact on the reduction of poverty in the rural areas (Estudillo, Sawada and Otsuka 2006, Takahashi and Otsuka 2009). With higher incomes, farming households were able to invest in schooling of their children, which enabled these children to join nonfarm labour markets (Estudillo, Sawada and Otsuka 2006). The increase in nonfarm employment provided the necessary capital to purchase machineries (tractors) and employ hired labour as a substitute for family labour (Takahashi and Otsuka 2009). Moreover, nonfarm income in the form of remittances relieved women family members from drudgery in farm production by using such income to hire field labourers (Paris et al. 2010). Remittances, particularly from international migration, also significantly increased the number of farms using mechanized production techniques (Gonzalez-Velosa 2011, INSTRAW 2008).

In the Philippines, women play a major role in rice production and marketing. Although they do not have equal opportunities compared to men in terms of acquiring land (Asian Development Bank 2013), women are still involved in the decision making regarding land utilization (Akter et al. 2017). And in most cases, they make joint decisions with their husbands on matters regarding rice farming and marketing. Most women are also responsible in handling and managing household income (e.g. crop sales), while also providing labour for transplanting, weeding, manual harvesting, and post-harvest activities (Akter et al. 2017).

On the consumption side, preferences for rice grain quality traits have changed over the years. In the 1980s, consumers placed importance on high head rice recovery, shorter and softer grains, and shorter cooking time (Abansi et al. 1992). In the 1990s, preferences for the size and shape of rice grain shifted to medium-size and medium shape (Juliano and Villareal 1993). Over the period 2000 to 2010, preferences for the size and shape further shifted towards the long-slender type, with additional preference for aroma (Calingacion et al. 2014). A recent consumer survey (2013–2014) found that aroma is now the number one trait that urban consumers demand in rice, with additional preferences for rice that is soft, white, with high volume expansion and chewy (Custodio et al. 2016).

As the most important staple crop in the Philippines, self-sufficiency has always been the goal of government programs in rice. However, despite the efforts in allocating scarce public resources towards rice self-sufficiency and availability of improved technologies, the Philippines remains an importing country. As Dawe, Moya and Casiwan (2006) point out, the Philippines' net importer status is mainly due to geography. The authors argue that traditional importers like the Philippines, as well as Indonesia, Sri Lanka, Japan, Korea, and Malaysia, are all island nations or narrow peninsulas with more varied landscape suitable for growing diversified crops. On the other hand, the major exporters of rice, like Thailand, Vietnam, Cambodia, and Myanmar, are endowed with major river deltas and extensive land suitable for rice production.

Domestic rice farmers in the Philippines must compete with major importers. This is increasingly challenging for Filipino farmers, particularly considering the country's full integration to the Association of Southeast Asian Nations (ASEAN) Economic Community and the related removal of the quantitative restrictions on imported rice as part of the country's commitment to the World Trade Organization (WTO) (Bordey et al. 2016). For example, a recent study found that the production cost of rice in irrigated areas in the Philippines is higher than in exporting countries such as Vietnam, Thailand, and India. The study found that differences in production costs could be attributed mainly to the difference in labour and machinery costs (Bordey et al. 2016). As such, imported rice from Vietnam is 21% cheaper than local Filipino rice at the wholesale market even with a tariff rate of 35%.

Bordey et al. (2016) outlined several policy recommendations across the rice value chain (from the farm to the wholesale market) to increase the competitiveness of Philippine rice production. Nevertheless, the importance of investment in research and development in addressing this issue cannot be overemphasized, especially in enhancing yields and grain quality traits.

Moreover, addressing local rice competitiveness is important to keep pace with the rapid transformation happening in global rice value chains and challenges resulting from increasing climate variability and natural resource scarcity. Fundamental to rice value chain upgrading is product upgrading through varietal improvement such that rice varieties are suitable to erratic and changing climatic conditions and tailored to evolving consumer preferences, urbanization and market trends. Better targeting of rice varieties to both the production environment and markets may lead to more efficient rice value chains and reduce the need to import rice that meets urban consumer demands.

1.3 Research Objectives and Contributions to the Literature

The main aim of this thesis is to assess farmers' preferences for rice VTIs through the use of an experimental methodology, which is based on investment games. The specific objectives of this study are to:

1) examine farmers' investment preferences for VTIs and the factors that affect their investment allocation decisions;
2) assess whether there are differences in investment preferences for rice VTIs using the individual investment decisions of husbands and wives and their joint investment decisions;
3) examine heterogeneity in preferences and identify clusters of farmers based on husbands' and wives' joint preferences for VTIs;

4) examine gender and intrahousehold dynamics in decision making in terms of investment in future rice varieties (both when selecting replacement varieties[1] and when deciding how to invest in research for VTIs).

The research presented in this thesis makes unique contributions to the extensive technology adoption literature, as well as to the growing body of literature on gender and intrahousehold decision making by doing the following:

- Examining *both* individual (male/husband and wife/female) and joint household decision making in the context of preferences and investments in improvements in rice variety traits (VTIs);
- Providing insights into the dynamics of intrahousehold decision making and the specific individual and household characteristics which are associated with and / or influence individual and joint decision with respect to investments in rice VTIs.
- Exploring the relative influence of husbands versus wives when making joint household investment decisions, as well as the determinants of individuals' relative influence in household decisions with respect to technology.
- Contributing methodologically through the use of a new and innovative experimental investment game to elicit both individual and joint preferences.

In addition to contributing to the literature, the research presented in this thesis has potential practical applications. For example, it can be used to guide

[1] The replacement variety is the basis to improve upon to obtain farmers' ideal variety. The replacement variety could be the farmers' most preferred variety, which they may or may not have previously grown.

the efficient allocation of scarce research and development resources, ultimately helping to make rice breeding more product-oriented and market-driven by providing feedback to rice breeders and donors on the relative share or importance of each of the traits.

1.4 Description of the Data and Methods

The primary data used to address the research objectives is based on framed field experiments using the IGA, which were led and conducted by the thesis author (Maligalig) in February 2016 in Nueva Ecija, Philippines. The protocol for the experiment is provided in Appendix 1 and is explained in more detail in subsequent analytical chapters.

The data generated from playing the IGA included information on the investment allocated to each of the ten VTIs considered and the corresponding level of improvement by type of respondent and level of decision making (husband, wife, and husband and wife jointly) and by season (wet and dry). It also includes data on the returns earned by husband, wife, and husband and wife jointly in investing in the VTIs.

In addition to the data generated from playing the IGA, several structured questionnaires were developed and used to gather other important information on individual, household and farm characteristics. Each of these instruments is provided in Appendices 2-5, and the following paragraphs provide more in-depth explanations of the instruments.

The Accompanying Sheet (see Appendices 2-3) provided data on the replacement varieties identified by season. It also provided information on whether the replacement variety is intended for consumption only, selling only, or both for consumption and selling. The Accompanying Sheet also recorded the specific disease, insect or abiotic stress that is targeted for improvement if the participant invested in these VTIs.

The Post-experiment Survey Questionnaire (see Appendix 4) was used to gather data on individuals' membership in organizations and attendance in training courses on rice farming in the past year. This questionnaire was also used to collect data on individuals' time preferences and investment preferences in rice farming. The time preference questions included a series of hypothetical scenarios relating to preferences for receiving a specific amount of cash now or a higher amount in a month's time. Investment preferences in rice farming were elicited through a Likert scale, with five representing "extremely likely to invest" and one meaning "extremely unlikely to invest". The questionnaire also allowed us to gain information on the factors that respondents considered in prioritizing the VTIs. Finally, the questionnaire included two review questions to check whether the respondents understood the investment game.

The Household Survey Questionnaire (Appendix 5) was used to collect information on general household characteristics, such as age, education levels, years of farming experience, household size, etc. The questionnaire also sought information on farm characteristics: area cultivated, rice varieties grown per season, total production and quantity sold, buyers, distance to market. Households were also asked if they had, in the last two years, experienced problems with: rice diseases and insects, abiotic stress, lodging, shattering of grains, late maturing, and lower prices due to lower head rice recovery. Households were also asked questions related to their relationships with buyers (e.g., buyers' standard requirement, millers adjusting prices according to head rice recovery), source of information (for rice farming and output price), and credit information (if they borrowed cash or other inputs, sources of credit). Lastly, the household questionnaire included a section on household decision making, asking respondents questions such as who in the household makes decisions related to a number of activities such as choice of crop and post-harvest operations.

1.5 Structure of the Thesis

The thesis has five chapters. Three chapters (Chapters 2-4) are analytical chapters addressing the main research objectives outlined in the previous section. Chapter 5 is a summary chapter providing an overview of the main findings as well as the practical and methodological implications of the research presented in the thesis. It is important to note that the three main chapters are designed to be "stand alone" papers, which will be submitted to different journals with the aim of future publication and individual contributions to the literature. Therefore, due to the unique or "hybrid" structure of this thesis, the primary data collection methods, as well as some summary statistics are to some extent repeated (albeit in paraphrased and not verbatim) throughout Chapters 2-4.

Chapter 2 explores farmers' investment preferences for the VTIs and the factors that influence these preferences. A fractional multinomial logit is used to analyse investment preference because of the multiple fractional nature of the dependent variables. Specifically because the proportion of the fund allocated to each VTI ranges between zero and one, and that the proportions add up to one for each observation. In this chapter, the analysis is both on the pooled data set and also on the disaggregated individual (husband, wife, and joint) data set to see whether there are differences in determinants of investment preferences of husbands, wives, and the husband and wife jointly.

Chapter 3 explores whether there is heterogeneity in preferences for VTIs among the farming households. In this chapter, a latent class (LC) cluster analysis is used to identify segments of farmers, each with distinct preferences for the VTIs. The resulting clusters are then further analysed using post-hoc characterisation to understand differences between farming households in each unique cluster.

Chapter 4 explores the gender and intrahousehold dynamics influencing the decision making process for the preferred replacement variety, as well as VTIs. Specific objectives were to examine and understand (i) how a couple's joint decision relates to their individual decisions with respect to the choice of a replacement variety and investment in VTIs, and (ii) which factors increase wives' intrahousehold decision-making power with respect to their choice of VTIs.

The last chapter, Chapter 5, provides conclusions and a summary of the main findings of Chapters 2 through 4. This chapter also discusses implications of the findings to (public) rice breeding research and to rice policies in the Philippines. Some areas which can be explored using the same experimental methodology used in this thesis are also discussed in this chapter.

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Overall percentage (%)	65%		
Certification:	This paper reports on original research I conducted during the period of my Higher Degree by Research candidature and is not subject to any obligations or contractual agreements with a third party that would constrain its inclusion in this thesis. I am the primary author of this paper.		
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Co-Author Contributions

By signing the Statement of Authorship, each author certifies that:

i. the candidate's stated contribution to the publication is accurate (as detailed above);
ii. permission is granted for the candidate to include the publication in the thesis; and
iii. the sum of all co-author contributions is equal to 100% less the candidate's stated contribution.

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Chapter 2: Farmers' Investment Preferences for Varietal Trait Improvements: The Case of Rice Farmers in Nueva Ecija, Philippines

Abstract

Farmers have individual preferences for agricultural technology attributes, which significantly influence their technology adoption decisions. Individual preferences are not always known, nor do they always match with the objectives of the researchers or investors leading technology research and development. To understand farmers' values for rice varietal trait improvements (VTIs), we conducted a framed field experiment. Farmers from 122 households in three municipalities in Nueva Ecija, a major rice-producing province in the Philippines, joined the experiment, with both the husband and wife participating. Farmers were given an endowment fund of 100 Philippine pesos and were asked to invest it among VTIs using an Investment Game Application (IGA). The IGA is a newly developed application for eliciting preferences in framed field experiments. Fractional multinomial logit models were used to examine the determinants of farmers' allocation of investment shares to alternative VTIs. Results indicate that market and climate change information, wet season cropping, hybrid varieties, and farm size are among the factors that affect farmers' investment decisions for VTIs. Moreover, results of the gender-specific analysis indicate that there are gender specific differences in farmers' values for VTIs. Overall, information from this study can assist breeders in their efforts to make rice breeding more market-driven and climate-resilient; thus, fostering the adoption of improved rice varieties.

Chapter 2: Farmers' Investment Preferences for Varietal Trait Improvements: The Case of Rice Farmers in Nueva Ecija, Philippines[2]

2.1 Introduction

2.1.1 Background

As end-users of agricultural technologies, it is likely that farmers have their own preferences for technology traits. They also have specific production and marketing requirements that they need to consider (Pingali, Rozelle and Gerpacio 2001). For example, farmers need to make trade-offs when choosing which crop varieties to grow to satisfy both the conditions of their production environment as well as the demands of buyers.

Previous research has found that farmer preferences for 'attributes' of technology are heterogeneous. Further, farmers' preferences, as well their socio-economic and demographic characteristics, help to explain adoption decisions (Adesina and Baidu-Forson 1995, Adesina and Zinnah 1993, Kshirsagar, Pandey and Bellon 2002, Pingali, Rozelle and Gerpacio 2001, Sall, Norman and Featherstone 2000). However, individual farmer preferences for technology attributes are not always known, nor do they always align with the objectives of the researchers (Hellin et al. 2008).

In most priority setting exercises related to investment of research and development funds, it is the scientific staff and senior management who are

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[2] An earlier version of this paper was presented at two local conferences and two international conferences: (1) XXIII Annual Conference of the Agri-food Research Network (AFRN), 7-10 December 2016, University of Adelaide, Australia; (2) The 61st Annual Conference of the Austrian Agricultural and Resource Economics Society (AARES), 7-10 February 2017, Brisbane, Australia; (3) The 9th Asian Society of Agricultural Economists (ASAE) International Conference, 11-13 January 2017, Bangkok, Thailand; (4) The 2017 Agricultural & Applied Economics Association (AAEA) Annual Meeting, 30 July – 1 August 2017, Chicago, Illinois, USA (poster presentation).

involved and consulted. Farmers, who are, ultimately, the end-users of research output or technologies, are usually not given the opportunity to participate in this exercise. As such, there are technologies for which adoption is limited because the technologies are not suited to the farmers' needs. To address the issue of limited adoptions, research leaders could conduct priority-setting exercises with relevant value chain stakeholders to determine which research areas or programs they should focus on. Farmer priorities can then guide researchers to more efficiently allocate limited or scarce research resources (Fox 1987, Gollin 2000).

In this study, we address limitations of previous research by using an experimental methodology based on investment games to elicit rice farmers' preferences for varietal trait improvements (VTIs). In most cases, farmers have general knowledge of the traits of the varieties they use, and they can suggest what should be improved to make the varieties more suitable to their production environments and better tailored to market demand.

Several studies have been conducted to better understand adoption decisions in the context of farmers' preferences for variety traits (Adesina and Baidu-Forson 1995, Adesina and Zinnah 1993, Fisher and Snapp 2014, Ghimire, Wen-chi and Shrestha 2015, Hintze, Renkow and Sain 2003, Joshi and Bauer 2006, Kshirsagar, Pandey and Bellon 2002, Lunduka, Fisher and Snapp 2012, Sall, Norman and Featherstone 2000, Smale, Bellon and Aguirre Gomez 2001). These trait-based studies conducted household surveys to elicit farmers' subjective assessments of variety traits. Both production and consumption traits were assessed since most farming households in developing countries both consume and sell their produce. These previous studies revealed that both production and consumption attributes significantly influence adoption decisions.

Stated preference techniques are often used to elicit farmers' preferences for variety traits. For example, Ward et al. (2014) used choice experiments to examine preferences for drought tolerance in rice with farmers from Bihar, India. They examined preferences for drought tolerant traits because drought is a major constraint in rice production throughout most of India. A similar study was done by Arora, Bansal and Ward (2015) in Odisha, India. Further, Dalton, Yesuf and Muhammad (2011) examined farmers' preferences for drought tolerance in maize varieties in Kenya using choice experiments.

Choice experiment methods are useful for assessing the relative value (e.g. willingness-to-pay) that farmers place on different crop variety traits. However, WTP estimates from choice experiments do not provide insights on farmers' preferences with respect to research investment decisions or specific values for improved varieties and/or seeds. Furthermore, it is likely difficult for farmers to fully assess their WTP for improved varieties or seeds. For example, in the Philippines, farmers' own-saved seeds accounted for more than 50% of the rice area harvested from 2009 to 2012 (Sombilla and Quilloy 2014).

2.1.2 **Investment game analysis**

Similar to a common investment game where there are two players – a sender and a receiver, the investment game in this study also involved a sender, which is the farmer, and a receiver, a public research institution (i.e. International Rice Research Institute (IRRI)). Farmers were given an endowment fund and were asked to decide how much they will send to the receiver, that is, how much they wanted to contribute to public breeding research. In this study, the amount farmer participants sent to the receiver can be considered as an indication of a trusting behaviour (Berg, Dickhaut and McCabe 1995, Kocher et al. 2015).

In the investment game, IRRI then returned an amount to the farmer depending on the estimated or expected performance of the portfolio of VTIs chosen. This can be seen as an indication that the receiver is ‘keeping the trust’ or reciprocating the sender’s trusting behaviour (Berg, Dickhaut and McCabe 1995).

By giving farmers an endowment fund and then rewarding farmers with a return on their investment, the experiment was non-hypothetical. Furthermore, the farmers faced real monetary incentives to contribute to breeding research, instead of keeping most or all of their endowment funds. Thus, the investment games allowed farmers to actively participate in the rice breeding investment allocation decisions by enabling them to “invest” in the VTIs that matter most to them.

Farmers’ preferred trait improvements translate into a corresponding investment portfolio for producing trait improvements. Through this investment portfolio, breeders can be guided on how to efficiently allocate limited research resources among different breeding development activities. This is important, especially since funding resources for international agricultural research declined in the 1990s and onwards (Morris, Edmeades and Pehu 2006). Efficient allocation of scarce R&D resources is of utmost importance, and this study hopes to provide guidance on this by eliciting farmers’ preferences for rice VTIs. Moreover, by informing farmers of the risks involved in improving variety traits, farmers not only take part in the resource allocation process, but the outcomes of the process will be consistent with their risk preferences instead of the risk preferences of resource portfolio managers. This will enable rice breeding to become truly client-driven.

Therefore, this study contributes to the existing literature in the following ways. Firstly, our approach is forward-looking such that we elicit preferences not for the variety traits per se, but for trait improvements relative to a benchmark variety. Preferences for trait improvements are not commonly elicited for crop varieties. However, as Pingali, Rozelle and Gerpacio (2001) point out, farmers are able to identify and suggest improvements in the agricultural technologies they use to make these more suitable to their needs. For example, Byrne et al. (2012) examined the preferences of experts and farmers from the Irish sheep industry for sheep trait improvements, and use this information to set breeding objectives. In another study, Martin-Collado et al. (2015) analysed dairy farmers' preferences for improvements in dairy cow traits in order to provide feedback to a review of national breeding objectives for the Australian dairy industry. Therefore, since one aim of this study is to provide feedback to breeders to help them set research priorities and allocate resources efficiently, the focus of this study is on trait improvements.

The second contribution of our study is that we confront farmers with similar resource constraints and risks to those that breeders face. This means that the farmer-participants are asked to express not only their preference for individual trait improvements, they are also compelled to prioritize individual trait improvements.

Thirdly, as with other economic experiments, our investment game approach involves real money and real returns. The returns are a function of farmers' choices and decisions made playing the investment games. Stated preference methods which ask participants to evaluate hypothetical products, which are not yet available are prone to hypothetical bias (Hensher 2010, List and Gallet 2001, Little and Berrens 2004, Murphy et al. 2005).

The overall objective of this study was to understand farmers' investment preferences for VTIs by identifying the varieties they want to replace and eliciting the VTIs they want public rice breeding programs to achieve to upgrade the replacement varieties to their "ideal" varieties. We also examined the factors that affect farmers' preferences for VTIs. We then explored whether there are gender differences in the preferences and the factors that influence these.

2.1.3 **Approach to application of investment game analysis**

To achieve our objectives, we conducted a framed field experiment with selected rice farming households in Nueva Ecija, Philippines. The experiment was carried out using the Investment Game Application (IGA), a newly developed application for eliciting preferences for rice VTIs (Demont et al. 2015). To examine if there are gender differences in preferences, we invited both husband and wife to participate in the experiment.

Male and female decision-makers may have different preferences for variety traits (Baidu-Forson 1997, Lope-Alzina 2007, Manzanilla et al. 2013, vom Brocke et al. 2010, vom Brocke et al. 2014), therefore we elicited individual preferences of both male and female decision-makers in the household, as well as their joint preferences. If male and female decision-makers in the same household have different preferences for trait improvements, then there may be implications for farming-related decisions, such as adoption of technologies. For example, men and women may have different preferences in terms of the end use of the crops either mainly for selling or home consumption, or both. The ultimate end-use or market can influence their preferences for variety traits (Doss 2001). Men and women may also have different risk, social, and competition preferences, which can affect many economic decisions, such as labour allocation and product markets (Croson and Gneezy 2009). Moreover, eliciting joint preferences is important as the dynamics between males and females (in most cases, husband and wife) would also influence the household's adoption decisions (Doss 2006).

The Philippines, specifically the province of Nueva Ecija, is an ideal setting for studying rice farmers' preferences for VTIs. Rice continues to be an important crop in the country, and Nueva Ecija remains a major rice-producing province. Adoption of innovations in agricultural technologies has played an important role in increasing production and improving the livelihoods of rice farming households (Mariano, Villano and Fleming 2012, Villano et al. 2015). A major contributor to gains in production is the adoption of modern varieties.

Several studies like that of Estudillo and Otsuka (2006), Herdt and Capule (1983), Launio et al. (2008) have documented the adoption of modern varieties in the Philippines since the beginning of the Green Revolution. A recent study by Laborte et al. (2015) analysed the variety traits important to rice farmers in Central Luzon, Philippines based on the traits of the adopted varieties. The study found that farmers consider high yield, good grain quality, and resistance to pests and diseases important when selecting for rice varieties to plant. However, it would also be interesting to get farmers' insights on the traits they want breeders to improve to better adapt the varieties to their environment and consumer needs. It would also be useful to understand the trade-offs in variety traits they are willing to make to have their most ideal variety.

The remainder of the paper is organized as follows. The next section describes the experimental approach, while Section 2.3 describes the data and methods. The empirical results are presented in Section 2.4. The last section provides discussion and conclusions.

2.2 Experimental Approach

2.2.1 Ethics approval

This research was approved by The University of Adelaide Human Research Ethics Committee with Approval Number H-2016-010 (Appendix 6). Informed written consent was obtained from all individual participants before the actual experiment started (Appendices 7-8).

2.2.2 Experimental design

The experiment was framed around a hypothetical context wherein a public breeding program received a grant from a donor. The grant was distributed in small shares among farmers. As shareholders in the breeding program, farmers were given the opportunity to allocate their share to several alternative breeding programs for improving varietal traits. This was done through the use of a unique IGA, a tablet-based application written in Microsoft Excel 2010 and designed to run on Windows 8 computer tablets.

In the IGA, farmers selected their preferred traits to be improved by pulling the VTI bars to the level they wanted a particular trait improved. This was done using the up and down spin buttons (Figure 2.1). Each level of improvement and combination of improvements had a corresponding cost, which was to be deducted from the farmer’s share. Each level of improvement is also subject to a relative investment risk, which is defined as one minus the “probability of success”, i.e. the probability that the level of improvement selected will be achieved by the public breeding program.

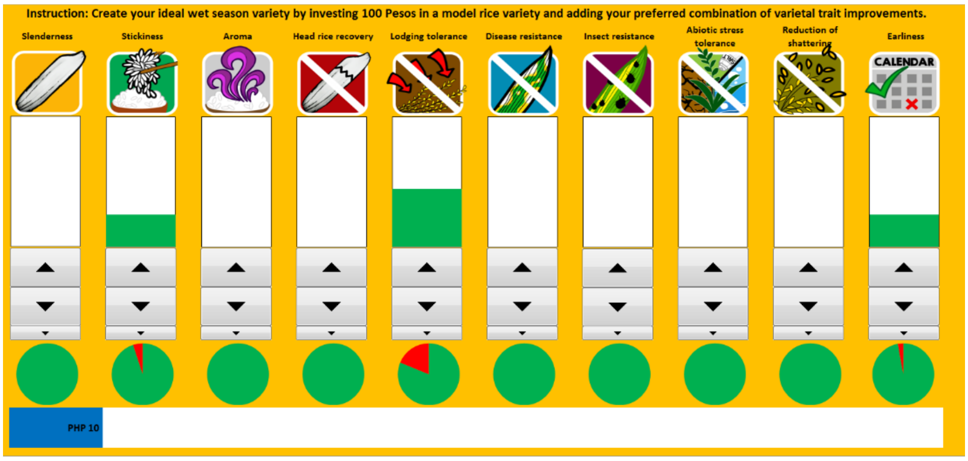

Figure 2.1 Investment Game Application (IGA) with example allocations in stickiness, lodging tolerance, and earliness. The blue horizontal bar at the bottom shows the status of the endowment fund, while the pie charts below the VTI bars indicate the riskiness of each investment – green segments represent the probability that the target VTI will be achieved; the red segments represent the odds of achieving a random VTI somewhere between zero and the target VTI

The initial improvement of a trait is more expensive compared to succeeding levels due to fixed start-up costs such as establishment of new laboratory or field experiments. The costs of improving the traits, either individually or the combination of several traits, were estimated through an expert elicitation workshop with a group of breeders from IRRI and National Agricultural Research Systems (NARS) partners (Demont et al. 2015).

As previously discussed, the investment game in this study involved a sender, which was the farmer and a receiver, which was IRRI. Farmers decided how much of their endowment fund to send to the receiver, that is, how much they wanted to invest in breeding research for each trait. IRRI then returned a pay-off (return to investment) to the farmer depending on the portfolio of VTIs chosen.

The amount that IRRI returned was the farmer's return to his/her investment portfolio composed of VTIs, subject to the risk incurred by breeding research programs in achieving the selected VTIs. Returns to investment in breeding research will normally be realized only after a new variety is released and adopted. This process will take about six years. However, in our study, breeding investment is framed as an investment with instantaneous return such that returns will be calculated and given right after playing the game.

Determining the replacement variety

At the start of the experiment, farmers were asked to identify a replacement variety. The experiment moderator first explained to the participants that the replacement variety could be their most preferred variety, and that could be a variety that they were already growing, or may have previously grown. The replacement variety provides the basis to improve upon to obtain a farmer's ideal variety.

Selecting VTIs

After choosing a replacement variety, farmers then selected from among the ten VTIs that they prefer to be improved. These VTIs were broadly categorized into: (i) grain quality traits – slenderness, aroma, stickiness, and head rice recovery; (ii) stress tolerance traits – lodging tolerance, disease resistance, insect resistance, abiotic stress tolerance, and reduction in shattering; and (iii) agronomic trait –

earliness. The specific baseline and target metrics on which the IGA was calibrated is shown in Table 2.1.

Table 2.1 Traits and trait-specific metrics on which the IGA is calibrated

Trait	Metric	Baseline	Target
Grain quality traits			
Slenderness	Length/width ratio	2.4	3.2
Stickiness	Amylose content (%)	27%	22%
Aroma	Price premium (%) (market benchmark=100%)	0%	100%
Head rice recovery	% head rice obtained from a sample of paddy	45%	60%
Stress tolerance traits			
Lodging tolerance	Crop losses eliminated (%)	20%	80%
Disease resistance	Crop losses eliminated (%)	50%	90%
Insect resistance	Crop losses eliminated (%)	80%	95%
Abiotic stress tolerance	Crop losses eliminated (%)	0%	90%
Reduction in shattering	Crop losses eliminated (%)	80%	95%
Agronomic trait			
Earliness	Number of days the duration is shortened	0	14

Source: Demont et al. (2015)

The experiment was comprised of four information treatments to test whether access to different pieces of forward-looking information affects farmers' investment preferences. The first information treatment was the control, where no information was provided. The second was the market information treatment which included information on the most preferred rice traits of urban (Metro Manila) consumers (Custodio et al. 2016)[3]. The third treatment was climate change information. The information provided in this treatment included increasing climate variability and the rise in frequency of extreme weather events, which can produce more frequent droughts, floods, and more uncertainty in

[3] Metro Manila is a major market for the rice produced in Nueva Ecija. Given the trends in consumption patterns and urbanization, this major market can provide farmers opportunities to increase their incomes if they are able to provide the grain quality traits demanded by the consumers.

rainy/wet season onset. The fourth information treatment combined both market information and climate change information.

Each participating household repeated the IGA over six rounds. The male and the female decision-makers or the husband (H) and wife (W) played the IGA for two seasons (wet (WS) and dry (DS)) independently and simultaneously. They then played the IGA jointly (J) for two seasons as well.

In each round, participants had an available endowment fund amounting to 100 Philippine pesos (PHP hereafter) (around AUD 2.95)[4] to invest in the VTIs. However, this amount was not given in cash. A final pay-off was instead given at the end of the experiment.

On top of the final pay-off participants received a fixed 'show-up fee' amounting to PHP 250 (around AUD 7) paid to each household. This was equivalent to approximately three hours of paid agricultural labour per participant.[5] This number of hours corresponded to the average time the farmers had to give up for participating in the experiment.[6]

2.2.3 **Sampling methods**

2.2.3.1 Study site

Nueva Ecija was purposively selected as the study site. Nueva Ecija is a major rice producing, predominantly irrigated province in the Philippines. This allowed us to capture farmers' preferences for VTIs in both wet and dry seasons. Our

[4] At the time of the experiment (February 2016), one Australian dollar (AUD) was equivalent to approximately PHP 34.
[5] At the time of the experiment, the minimum daily wage rate for agricultural labour in the province was PHP334 (Philippine Statistics Authority 2016).
[6] Pre-testing of the IGA experiment was conducted in Victoria, Laguna, Philippines in May 2015. The session took 2 hours to finish (Demont et al. 2015). The IGA experiment was then conducted in Eastern India in October 2015 and in Bangladesh in September–October 2016 (Ynion et al. 2015; 2016).

sample consisted of 122 rice-producing households, with both the male household decision-maker (husband) and the female household decision-maker (wife) participating.

2.2.3.2 Sampling approach

We used a multi-stage sampling approach to obtain our survey sample. In the first stage, we purposely selected three municipalities, i.e. Muñoz, Talavera, and Guimba. In the second stage, we randomly selected four villages in each municipality. In the final stage, we randomly selected ten households per village.

Several steps were carried out in the random selection of the villages and rice producing households. First, we approached the Municipal Agriculture Office (MAO) in each municipality to obtain a master list of rice farming households. The master lists included information on the names of the farmers and their respective rice areas, which were classified as either irrigated or rain-fed.

Second, we approached the local officials of the villages selected and asked them to check and verify the names included in the master list. This was done to determine who among the list met the screening criteria for participant selection. The screening criteria were as follows: (i) both husband and wife should be involved in rice production or in rice marketing activities; (ii) the household is planting rice in both wet and dry seasons; and (iii) the household is selling a portion of their rice production.

Once the list was verified and checked, a new list per village was generated to include only those households that satisfied the selection criteria. We used a spreadsheet program to randomly select ten households per village from these lists to be invited to participate in the experiment. We also randomly selected another set of ten households per village to serve as a back-up list in case of no-show at the onset of the experiment.

2.2.3.3 Recruitment of participants

The randomly selected households were invited through the designated local field coordinators in each of the selected villages. The local field coordinator was a village official in-charge of the Agriculture Committee in his or her village. The households were invited to participate via a letter, which explained the details of the research, and the schedule of the experiment. The invitation letters were sent two weeks before the scheduled experiment. Invited households were then reminded of the schedule two days before the actual experiment.

2.2.4 **Implementation and procedures**

The experimental sessions were held in local training halls or local village halls. There were a total of 12 experimental sessions – one in each village selected. The sessions were conducted using the local language, Filipino. The sessions were run over the course of six days, with one session in the morning and one in the afternoon.

The 12 sessions were divided into four groups of three sessions for each of the four treatments. The assignment of the information treatments was randomly drawn prior to the start of all experimental sessions.

Each session ran through the following stages: (i) registration, (ii) introduction of the research team, (iii) explanation of the experiment, (iv) presentation and explanation of the IGA and VTIs, (v) training on the IGA, (vi) six consecutive rounds of IGA, (vii) short post-experiment survey, and (viii) payment of returns and closure of the session.

A household survey questionnaire was also administered to gather data on socio-demographic variables, rice varieties grown, constraints in rice production and marketing, and marketing practices. For time management, this survey was also administered during the experimental sessions to households that were not being administered the IGA.

Prior to administering the IGA, farmers were trained first in the methodology of investing with budget constraints by using the “Training on Investment Game Application” (TIGA). In TIGA, farmers invested in their optimal dish by adding a vegetable or meat dish to a fixed amount of rice, using a budget amounting to PHP 50 (Figure 2.2). The purpose of TIGA was to familiarize farmers with the application, particularly in terms of the budget constraint involved and the use of spin buttons on the tablet. It was important that the participants be given the chance to use the tablet before the actual game as most of them were not familiar or had not used a tablet before.

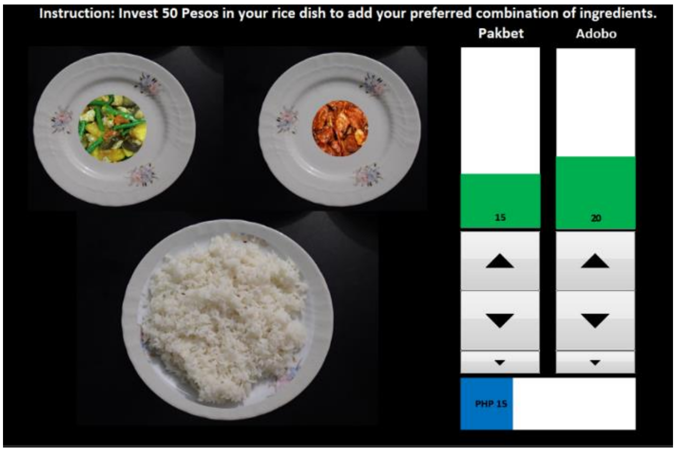

Figure 2.2 Training on Investment Game Application (TIGA) with example allocation of PHP15 to Pakbet (vegetable dish) and PHP20 to adobo (meat dish). The blue horizontal bar at the bottom shows the remaining budget

After the training and explanation of their tasks, each participant (both husband and wife) was assigned an agent who was the facilitator for the IGA. The husband and wife then played the IGA independently.

After playing the IGA independently, husband and wife were asked to play the IGA jointly. A different agent was assigned per couple for the consensus round. To provide equal opportunity in answering the IGA during the consensus round, husband and wife were given separate stylus pens and the tablet was placed at the middle of their table. However, no further instructions were given and households were free to decide on who should be dominating the discussions. This enabled us to measure the intrahousehold decision-making power of both household members in their investment decisions on future rice varieties (see Chapter 4).

In addition to the more extensive household survey, each participant (both the husband and wife) completed a brief post-IGA experiment survey. This short survey was administered immediately after they played the IGA, and husbands and wives completed it independently. The post-experiment survey included questions related to participants' motivations behind allocation decisions in IGA and a short quiz (two questions) to verify how well they understood the experiment.

The final pay-off was determined by the "binding" round, which was randomly selected among the six rounds by using a dice (1 – H/WS, 2 – H/DS, 3 – W/WS, 4 – W/DS, 5 – J/WS, 6 – J/DS), as is commonly done in experimental economics (e.g., Lusk and Shogren 2007). One volunteer was requested to roll the dice to draw the binding round after all households completed the six rounds of IGA. The IGA computed a stochastic return to investment. The return was a function of the VTI levels and the associated risk levels for each VTI that the participants chose for their investment portfolio (Demont et al. 2015).

The resulting cash returns were placed in an envelope and distributed to the couples one at a time. A single-blind payment protocol was used where the research team knows the participants' earnings but the participants did not know other participants' earnings. On average, each household earned PHP 1,210 (around AUD 36), which is roughly equivalent to four daily wages for agricultural labour,[7] with a maximum of PHP 2,300 (around AUD 68). This was on top of the PHP 250 'show-up' fee.

2.3 Data and Methods

2.3.1 **Econometric approach**

The objective was to understand the relationship of the investment shares (proportion of the endowment fund invested in the different trait improvements) to various factors that may affect farmers' allocation decisions. Estimation techniques such as ordinary least squares or general linear models are not applicable as these do not take into account the fractional nature of our dependent variables, that is, the investment allocations fall between zero and one and add up to one (Musumba, Mjelde and Adusumilli 2015, Wollni and Fischer 2015).

Papke and Wooldridge (1996) proposed a quasi-likelihood method to estimate the conditional mean of the dependent variable in a single fractional response model. Their approach does not require specifying a particular distribution, and hence no special adjustments or transformations are needed to

[7] At the time of the experiment, the minimum daily wage rate for agricultural labour in the province was PHP334.

the extreme values of zero and one. One possible distribution of the fractional observations is the dirichlet distribution, which is an extension of the beta distribution to multiple proportions. A limitation of the beta distribution, and consequently of the dirichlet distribution, is that it is difficult to justify if a considerable portion of the proportional or fractional observations has an extreme value of zero or one (Papke and Wooldridge 1996). In our case, 65% of the observations on investment preferences for the individual trait improvements are zeros.

Since we were interested in analysing the ten proportional investment shares corresponding to the ten VTIs, we used a fractional multinomial logit model, which is a multivariate generalization of the fractional logit model proposed by Papke and Wooldridge (1996). We let E be the total endowment fund and K be the investment allocation outcomes of the ten VTIs, with one outcome representing the uninvested portion.

We then let $y_{ik} = e_{ik}/E$, where y_{ik} is the proportional share for the kth investment allocation by the ith participant (husband, wife, or joint) and k = 1, …, K = 10. Moreover, we let $y_{ik} = e_{ik}/E$ be the marginal outcomes of interest such that $y_{ik} \in [0,1]$ and $\sum_{k=1}^{K} y_{ik} = 1$. From here, two restrictions are imposed on the estimation. First is that $E[y_{ik}|x_i] \in [0,1]$ for all i; and second is that $\sum_{k=1}^{K} E[y_{ik}|x_i] = 1$ for all i; x_i represents all relevant explanatory variables (Mullahy and Robert 2010).

The assumed model for investment shares is $E[y_{ik}|x_i] = G_t(x_i\beta)$, where β are the parameters to be estimated. Keeping the investment allocations within the unit interval of zero and one is done by using a multinomial logit functional form for $G_k(x_i\beta)$, such that the conditional distribution of investment shares among v trait improvements is

$$E[y_{ik}|x_i] = \frac{(x_i\beta_k)}{\sum_{v=1}^{K} exp\,(x_i\beta_v)}$$

We estimated the fractional multinomial logit model on the ten VTI investment shares and set the uninvested share as the base outcome using the command *fmlogit* (Buis 2008) in STATA 14. This implies that the coefficients need to be interpreted as changes relative to the uninvested share. Finally, we clustered standard errors at the decision-unit level (i.e. husband, wife and joint). Since each decision-unit completed the IGA exercise twice (i.e. for each season), we have a panel dataset of 3*122*2=732 observations.

2.3.2 **Dependent variables**

As previously mentioned, the dependent variables used in the analysis are the investment shares of the ten VTIs including the uninvested portion. Table 2.2 shows the overall average investment share for each of the VTIs by season across all treatments. The allocated investments in slenderness, stickiness, head rice recovery, lodging tolerance, and reduction in shattering differed significantly between wet season and dry season. Farmers invested significantly higher in stickiness and lodging tolerance during the wet season. In the dry season, they invested more in slenderness, head rice recovery, and reduction in shattering.

Table 2.2 Average investment shares per VTI and by season

VTI	Wet season (n=366)				Dry season (n=366)				Mean Diff.
	Mean	Std. Dev.	Min	Max	Mean	Std. Dev.	Min	Max	
Grain quality traits	*0.20*	*0.26*	*0.00*	*1.00*	*0.28*	*0.30*	*0.00*	*1.00*	
Slenderness	0.07	0.15	0.00	0.70	0.10	0.18	0.00	0.81	**-0.03****
Stickiness	0.04	0.11	0.00	0.55	0.03	0.10	0.00	0.55	**0.01***
Aroma	0.04	0.11	0.00	0.54	0.05	0.13	0.00	0.56	-0.01
Head rice recovery	0.05	0.13	0.00	0.65	0.10	0.18	0.00	1.00	**-0.05*****
Stress tolerance traits	*0.76*	*0.29*	*0.00*	*1.00*	*0.68*	*0.33*	*0.00*	*1.00*	
Lodging tolerance	0.22	0.22	0.00	1.00	0.09	0.17	0.00	1.00	**0.13*****
Disease resistance	0.17	0.21	0.00	0.70	0.16	0.21	0.00	1.00	0.01
Insect resistance	0.16	0.20	0.00	1.00	0.18	0.21	0.00	1.00	-0.02
Abiotic stress tolerance	0.12	0.19	0.00	0.80	0.12	0.21	0.00	1.00	0.00
Reduction in shattering	0.09	0.12	0.00	0.53	0.12	0.15	0.00	0.54	**-0.03****
Agronomic trait									
Earliness	0.04	0.09	0.00	0.48	0.03	0.09	0.00	0.50	0.002
Uninvested	0.01	0.02	0.00	0.24	0.01	0.03	0.00	0.39	0.00

Source: IGA Philippines Survey 2016
Notes: Mean difference is wet season investment share minus dry season investment share.
***, **, * denote statistical significance at the 1%, 5%, and 10% levels, respectively.

Farmers allocated, on average, 76% and 68% of their endowment fund to stress tolerance traits in the wet and dry seasons, respectively (Table 2.2). Interestingly, lodging tolerance had the highest average investment share (22%) in the wet season, but not the dry season. In the dry season, insect and disease resistance had the highest shares at 18% and 16%, respectively. The farmers also allocated a relatively large portion of their endowment fund to improvements in disease and insect resistance (17% and 16% in the wet season, respectively), and abiotic stress tolerance (12% in both seasons). In the dry season, we also observed increased allocation to grain quality traits (20% in the wet season versus 28% in the dry season); in particular, allocation to two grain quality traits increased substantially: head rice recovery and slenderness.

Tables 2.3 and 2.4 show the investment allocations made by husband and wife individually and jointly across the different VTIs. Table 2.3 shows that husband and wife individually prioritized stress tolerance traits, such as lodging tolerance, disease resistance, and insect resistance by investing more in these VTIs in the wet season. More than 70% were allocated to these stress tolerance traits. Jointly, husband and wife also invested more than 70% in stress tolerance traits during the wet season. The differences in the investments made by husband and wife in slenderness and aroma in the wet season were statistically significant. Women invested significantly more in the aroma VTI, while men invested significantly more in the slenderness VTI. No statistically significant differences in the investment shares were found among individual (husband, wife) and joint decisions.

Table 2.3 Investments allocated to the VTIs by husband and wife, individually and jointly, Wet season

VTI	Husband (n=122)		Wife (n=122)		Joint (n=122)	
	Mean	Std. Dev	Mean	Std. Dev.	Mean	Std. Dev.
Grain quality traits	*0.22*	*0.27*	*0.19*	*0.26*	*0.19*	*0.27*
Slenderness	**0.09***	0.17	**0.06***	0.13	0.07	0.14
Stickiness	0.05	0.13	0.03	0.09	0.04	0.11
Aroma	**0.03***	0.09	**0.06***	0.13	0.03	0.09
Head rice recovery	0.05	0.13	0.04	0.13	0.05	0.13
Stress tolerance traits	*0.73*	*0.29*	*0.77*	*0.27*	*0.77*	*0.29*
Lodging tolerance	0.24	0.23	0.22	0.21	0.21	0.21
Disease resistance	0.16	0.20	0.19	0.21	0.15	0.20
Insect resistance	0.14	0.21	0.15	0.19	0.19	0.20
Abiotic stress tolerance	0.11	0.18	0.13	0.19	0.11	0.20
Reduction in shattering	0.08	0.12	0.08	0.12	0.10	0.12
Agronomic trait						
Earliness	0.04	0.09	0.03	0.08	0.04	0.10
Uninvested	0.01	0.02	0.01	0.02	0.00	0.00

Source: IGA Philippines Survey 2016
Notes: * The mean differences between husband and wife allocations are statistically significant at the 10% level based on a T-test. No significant differences were found among husband, wife, and joint investment allocations.

Table 2.4 Investments allocated to the VTIs by husband and wife, individually and jointly, Dry season

VTI	Husband (n=122)		Wife (n=122)		Joint (n=122)	
	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
Grain quality traits	*0.23*	*0.27*	*0.30*	*0.32*	*0.29*	*0.30*
Slenderness	0.09	0.16	0.09	0.19	0.11	0.17
Stickiness	0.02	0.09	0.03	0.09	0.04	0.11
Aroma	0.04	0.11	0.06	0.15	0.05	0.12
Head rice recovery	0.08	0.16	0.12	0.2	0.1	0.18
Stress tolerance traits	*0.72*	*0.31*	*0.66*	*0.34*	*0.67*	*0.33*
Lodging tolerance	**0.13**^{a**}	0.20	0.10	0.18	**0.06**^{a**}	0.13
Disease resistance	0.15	0.19	0.17	0.22	0.17	0.21
Insect resistance	**0.17** ^{a*}	0.23	**0.15** ^{b***}	0.18	**0.23** $^{a*, b***}$	0.2
Abiotic stress tolerance	**0.16** ^{a***}	0.24	0.13	0.21	**0.08** ^{a***}	0.17
Reduction in shattering	0.12	0.15	0.12	0.15	0.12	0.14
Agronomic trait						
Earliness	0.03	0.10	0.03	0.08	0.04	0.10
Uninvested	0.01	0.04	0.01	0.02	0.00	0.00

Source: IGA Philippines Survey 2016
Notes: ***, **, * indicate statistical significance at the 1%, 5% and 10% levels, respectively.
^{a,b} Means within a row with same superscript letters are statistically different based on Bonferroni multiple comparison test.

In the dry season (Table 2.4), wives increased their investments in grain quality traits such as slenderness and head rice recovery. Husbands, on the other hand, also invested more in stress tolerance traits in the dry season. In the joint decision, there were also increased investments in grain quality traits. The differences in the investments in lodging tolerance and abiotic stress tolerance were statistically significant for husband and joint decision. There were also significant differences in the investments in insect resistance between husband and joint, and between wife and joint decision.

2.3.3 **Explanatory variables**

The explanatory variables used in the analysis are factors that we hypothesised may affect farmers' investment allocation decisions. Table 2.5 shows the descriptive statistics for each variable used in the pooled and gender-specific analyses. We include variables related to: (i) information treatment, (ii) characteristics of the replacement varieties, (iii) constraints in rice production experienced in the last two years, (iv) farm and farmer characteristics, (v) rice marketing, and (vi) respondent dummy variables.

The information treatment refers to the information provided to the participants during the experiment. We expected that respondents who were provided with market information would invest more in grain quality traits, while those who received climate change information would invest more in the stress tolerance traits that they expect to provide most resilience to climate change.

For the characteristics of the replacement varieties that the farmers identified as a basis for VTIs, we categorized them based on the season in which they are grown – wet or dry. We also characterized them based on the variety type – hybrid or inbred. We expected farmers to invest more in stress tolerance traits during the wet season when there is higher risk of pests and diseases and more uncertainties in weather conditions (David 2006). On the other hand, we expected farmers to invest more in grain quality traits if the replacement variety is a hybrid, as the grain quality of earlier hybrid varieties was found to be inferior compared to inbred varieties (Casiwan et al. 2003).

Table 2.5 Descriptive statistics for the explanatory variables used in the pooled data and gender-specific analysis

Variable	Definition	Mean	Std. Dev.
Information treatment			
Market information	1 – with market information, 0 – otherwise	0.49	0.50
Climate change information	1 – with climate change information, 0 – otherwise	0.52	0.50
Replacement variety characteristics			
Wet season	1 – replacement variety is for wet season, 0 – otherwise	0.50	0.50
Hybrid	1 – replacement variety is a hybrid, 0 – otherwise	0.37	0.48
Rice production constraints			
Experienced abiotic stress	1 – experienced abiotic stress, 0 – otherwise	0.34	0.48
Experienced lodging	1 – experienced lodging, 0 – otherwise	0.94	0.23
Experienced grain shattering	1 – experienced grain shattering, 0 – otherwise	0.43	0.49
Farm and farmer characteristics			
Education – husband	Years in school of husband	8.42	2.59
Education – wife	Years in school of wife	8.16	2.38
Education – joint	Average of husband & wife years in school	8.39	2.03
Farm experience – husband	Years of farming experience of husband	27.16*	11.96
Farm experience – wife	Years of farming experience of wife	18.57*	13.76
Farm experience – joint	Average of husband & wife years of farming experience	22.87	11.00
Occupation – husband	1 – primary occupation of husband is farming, 0 – otherwise	0.93*	0.26
Occupation – wife	1 – primary occupation of wife is farming, 0 – otherwise	0.09*	0.29
Occupation – joint	1 – primary occupation of both husband & wife is farming, 0 – otherwise	0.07	0.26
Time preference – husband	Discount factor – husband	1.63	4.65
Time preference – wife	Discount factor – wife	1.41	1.99
Time preference – joint	Average of husband & wife discount factor	1.52	2.62
Income	Annual family income in ‘000 PHP	73.91	52.60
Farm size	Total landholdings in hectares (own + lease)	1.30	1.04
Percent lease area	Proportion of leased area to total landholdings	0.45	0.49
Proportion of area planted	Proportion of area planted	0.98	0.11
Rice marketing			
Proportion sold	Proportion of total production sold	0.64	0.22
Output price	Price received from selling in PHP/kg	15.97	1.83
Distance to market	Distance of the farm to market in km	4.13	5.89
Buyers' standard requirement	1 – buyers require certain quality standards, 0 – otherwise	0.61	0.49
Respondent dummy variables			
Respondent – husband	1 – respondent is the husband, 0 – otherwise	0.33	0.47
Respondent – wife	1 – respondent is the wife, 0 – otherwise	0.33	0.47

Source: IGA Philippines Survey 2016
Note: * denotes that the difference between the means of husband and wife is statistically significant at the 5% level.

Variables related to the constraints in rice production experienced by the farmers were also included. We focused on constraints related to abiotic stress, lodging, and grain shattering. We expect that farmers who experienced these problems will invest more in improving the following traits: stress tolerance, resistance, and reduction in shattering.

We included variables representing farm and farmer characteristics. Previous research and studies were used to guide the choice of farm and farm characteristics included in the analysis. More experience in rice farming was expected to mean enhanced knowledge (Horna, Smale and Oppen 2007). Thus, farmers may be more likely to invest in certain VTIs associated with stress tolerance or agronomic issues, as opposed to keeping or saving their endowment fund. Similarly, we expected farmers to invest in VTIs if their primary occupation is farming.

We expected education to have a positive effect on overall investment levels in VTIs versus not investing. More educated farmers are expected to better process information (Mariano, Villano and Fleming 2012), which can help them to identify traits that need to be improved. Moreover, we expected that those with higher income would be less risk averse (Lucas and Pabuayon 2011), thus they might use more of their endowment fund to invest in VTIs.

We expected land access to have a positive effect on investment in VTIs versus non-investment. Farm size is one of the determinants of household income in rice growing villages in the Philippines (Estudillo, Sawada and Otsuka 2008, Takahashi and Otsuka 2009). Farm size is also positively correlated with adoption of innovations and technologies (Bravo-Monroy, Potts and Tzanopoulos 2016, Dixon et al. 2006, Mottaleb, Mohanty and Nelson 2015, Zhou et al. 2008). As such, we expected those farmers with a larger farm size and larger area planted to invest more in VTIs. However, it is unclear how farm size would affect trade-offs between agronomic, stress tolerance, and grain quality VTIs, as improved varieties could help increase both the quantity (e.g. agronomic and stress tolerance VTIs) and quality of the harvest (e.g. grain quality VTIs), which could lead to higher incomes.

We hypothesised that the proportion of leased area could have either a positive or a negative relationship with overall investment in VTIs. The effect might be positive if leaseholders invested in improvements in order to have higher production and /or receive a higher price. Investing in early maturing varieties, for example, can be a means to escape severe weather conditions (Laborte et al. 2015), thus ensuring leaseholders' share of the production. Although leaseholders are less likely to invest in productivity-enhancing activities (Abdulai, Owusu and Goetz 2011), early maturing varieties can provide them with an opportunity to plant high-value crops in between seasons or plant the next season rice earlier. But it could also have negative effect on overall investment since in the case of most leaseholders, it is the land owners who decide which varieties to grow, so leaseholders may rather save their endowment fund.

We measured farmers' time preferences through a discount factor, which we estimated from a standard series of hypothetical questions related to their preference of receiving a specific amount of cash now or a higher amount in a month's time (Coller and Williams 1999, Harrison, Lau and Williams 2002). Most of the participants have high discount factor in that they prefer to receive the cash amount immediately, instead of waiting for one month to receive a higher amount. This is consistent with Cardenas and Carpenter (2008) who argued that "people in less developed countries have high discount rates and are risk averse enough so that it is impossible for them to save and take risks necessary to begin to accumulate capital" (p. 325). They are also less likely to invest in technologies that have longer time gaps before benefits can be realized (Pannell, Llewellyn and Corbeels 2014). Thus, we hypothesized that those farmers with higher discount factor will be more likely to invest in the VTI "earliness" to obtain shorter-duration varieties.

We included variables related to rice marketing such as: the proportion of the production sold, output price, farm to market distance, and buyers' standard requirements. We hypothesized that these marketing-related variables will have a positive effect on farmers' investment overall in VTIs versus the share of their endowment fund that is not invested. This is because investment in VTIs could lead to improvements that would not only increase production levels, but also enhance the marketability of the harvested grains.

Lastly, for the pooled data analysis, we included dummy variables representing the husband as the respondent and the wife as the respondent. The joint decision is set as the reference dummy, which implies that the husband and wife dummies have to be interpreted as relative to the joint decision. A gender-disaggregated analysis was also carried out to further examine whether there are significant differences in the factors that influence the investment preferences of husband, wife and their joint decision.

These gender aspects were incorporated into the analyses because, as we discussed earlier, we found some significant differences in the investment allocations to VTIs between husbands, wives, and also differences between individual and joint decisions (Table 2.3 and Table 2.4). In addition to some gender differences in investment allocation to VTIs, there were some significant differences in characteristics between husbands and wives. For example, husbands had significantly more experience in rice farming than wives. There was also significant difference in farming as the primary occupation. Although only 9% of the wives said that their primary occupation is farming (Table 2.5), they are still involved in the household's farming decisions (Table 2.6).

Table 2.6 Participation in crop choice and post-harvest decision making

Variable	Mean	Std. Dev.	Min	Max
Crop choice				
What crop to grow in the field	1.96	0.67	1	4
What rice variety to plant	1.99	0.69	1	4
Post-harvest operations				
Amount of rice to store or sell	2.60	0.87	1	5
Where to sell rice or other crops	2.46	0.84	1	5
When to sell rice or other crops	2.43	0.82	1	5
Selecting crop types and seed for the next growing season	1.98	0.77	1	5
Who decides how to spend income from crop sale	4.16	0.79	2	5
Where to store seeds	1.95	0.72	1	4

Source: IGA Philippines Survey 2016
Note: Who decides: 1 – Husband only, 2 – Husband dominates, 3 – Both husband and wife, 4 – Wife dominates, 5 – Wife only.

2.4 Results

2.4.1 **Preferences for replacement varieties and VTIs**

Table 2.7 presents the replacement varieties selected by the farmers individually and jointly for each season. We did not find any significant differences in the replacement varieties identified by husband, wife, and joint husband and wife decision for either season. The table shows that one variety dominated in the wet season. NSIC Rc 222, an inbred variety, was identified as the replacement variety by 78% of the husbands and 79% of the wives. This choice further increased to

82% during the consensus rounds. NSIC Rc 222 was also one of the preferred replacement varieties in the dry season. This was the replacement variety for both 34% of husbands and wives in the individual responses and for 23% of the couples in the joint decision.

Table 2.7 Replacement varieties selected

Season	Variety	Husband (n=122)		Wife (n=122)		Joint (n=122)	
		Freq.	**Percent**	**Freq.**	**Percent**	**Freq.**	**Percent**
Wet season	NSIC Rc 222	95[a]	77.87	96[a]	78.69	100[a]	81.97
	NSIC Rc 216	17[a]	13.93	14[a]	11.48	16[a]	13.11
	Others	10[a]	8.20	12[a]	9.84	6[a]	4.92
Dry season	SL-8H	71[a]	58.20	67[a]	54.92	79[a]	64.75
	NSIC Rc 222	34[a]	27.87	34[a]	27.87	23[a]	18.85
	Others	17[a]	13.93	21[a]	17.21	20[a]	16.39

Source: IGA Philippines Survey 2016
Note: Using Chi-square test, different superscript letters in each row indicate statistically significant differences in values between columns at the 5% level.

NSIC Rc 222 was developed at IRRI and released in 2009. It is a high-yielding variety which can produce up to ten tons per hectare. It has moderate resistance to brown plant hoppers and green leafhoppers, but is susceptible to rice tungro virus. In terms of its grain quality traits, it is long and slender and has good milling and head rice recovery (National Seed Industry Council 2009). In general, consumers in the Philippines prefer rice grains that are long and slender (Calingacion et al. 2014, Custodio et al. 2016).

NSIC Rc 222 is a popular variety which occupied 11% and 13% of the area planted in the 2011 wet season and the 2012 dry season, respectively, based on a survey of 15 major rice producing provinces in the Philippines (Philippine Rice Research Institute 2012). NSIC Rc 222 was also a popular variety among our sample households, particularly for the 2015 wet season. Results of our survey showed that 70% and 24% of the area was planted to this variety in the 2015 wet and dry seasons, respectively.

Since the (dominant) replacement variety in the wet season has the grain quality traits that the consumers require, farmers prioritized stress tolerance traits to address the poor performance of the variety in terms of its resistance to pests and diseases as well as its tolerance to abiotic factors (Table 2.8). This illustrates that IGA results need to be interpreted relative to the replacement variety. Thus, low investment in grain quality does not necessarily mean that grain quality is unimportant, but rather that farmers tend to choose varieties with good grain quality as starting point to be improved in terms of stress tolerance and agronomic traits.

Table 2.8 Average investment shares per VTI for the dominant replacement varieties in the wet season

VTI	**NSIC Rc 222 (n=291)**	**NSIC Rc 216 (n = 47)**	**Others (n = 28)**
Grain quality traits			
Slenderness	0.07	0.09	0.06
Stickiness	0.05	0.01	0.04
Aroma	0.04	0.02	0.08
Head rice recovery	0.05	0.05	0.04
Stress tolerance traits			
Lodging tolerance	0.22	0.23	0.23
Disease resistance	0.16	0.20	0.16
Insect resistance	0.16	0.15	0.19
Abiotic stress tolerance	0.12	0.14	0.08
Reduction in shattering	0.09	0.07	0.06
Agronomic trait			
Earliness	0.03	0.03	0.05
Uninvested	0.01	0.00	0.01

Source: IGA Philippines Survey 2016

In the dry season, SL-8H, a hybrid variety, was the most preferred replacement variety. It was identified as the replacement variety by 58% of the husbands and 55% of the wives. This variety was also identified by 65% of the couples during the joint round. SL-8H was developed by SL Agritech Corporation, a private seed company, and was released in 2004. It has resistance to blast and intermediate resistance to bacterial leaf blight. However, it is moderately susceptible to brown plant hopper and susceptible to rice tungro virus. In terms of grain quality traits, it is long and has medium shape and has good head rice recovery (National Seed Industry Council 2004).

SL-8H occupied around 6% of the rice area planted during the 2012 dry season in the 15 major rice-producing provinces in the Philippines (Philippine Rice Research Institute 2012). Results of this study's own survey showed that 52% of the sample households' rice area was planted to SL-8H in the 2015 dry season.

As the (dominant) replacement variety in the dry season is inferior in terms of its resistance to some pests and diseases, farmers preferred to address this by investing more of their endowment fund into the improvement of these traits (Table 2.9). Farmers also accounted for consumer preferences by increasing investment in grain quality traits, specifically slenderness, a trait that was lacking in the replacement variety (Table 2.9).

Table 2.9 Average investment shares per VTI for the dominant replacement varieties in the dry season

VTI	SL-8H (n = 217)	NSIC Rc 222 (n = 91)	Others (n =58)
Grain quality traits			
Slenderness	0.10	0.12	0.06
Stickiness	0.02	0.06	0.02
Aroma	0.05	0.06	0.05
Head rice recovery	0.08	0.11	0.14
Stress tolerance traits			
Lodging tolerance	0.10	0.07	0.10
Disease resistance	0.17	0.13	0.17
Insect resistance	0.19	0.17	0.18
Abiotic stress tolerance	0.11	0.15	0.11
Reduction in shattering	0.13	0.09	0.14
Agronomic trait			
Earliness	0.04	0.02	0.02
Uninvested	0.01	0.01	0.01

Source: IGA Philippines Survey 2016

2.4.2 Determinants of investment preferences – Pooled data

Results of the marginal effects estimates for the pooled data are presented in Table 2.10. The explanatory variables were tested for multicollinearity through the estimation of variance inflation factors (VIFs) (Hair et al. 2013). We did not find any major problems as the maximum VIF is 1.44.

Our results suggest that farmers participating in the IGA responded to the information provided when making investment decisions. Access to market information was associated with significantly increased investments in two quality traits: stickiness and aroma. Relative to those who did not receive market information during the experiment, farmers who received such information invested 2.3% more in stickiness and 1.7% in aroma. These findings support our hypothesis that farmers who received market information would invest significantly more in grain quality traits.

Table 2.10 Average marginal effects on investment allocations to VTIs – Pooled data

Variable	Slenderness	Stickiness	Aroma	Head rice recovery	Lodging tolerance	Disease resistance	Insect resistance	Abiotic stress tolerance	Reduction in shattering	Earliness	Uninvested
Information treatment											
Market information	0.0202	0.0229**	0.0169*	-0.0004	-0.0115	-0.0127	-0.0133	-0.0115	0.0000	-0.0083	-0.0022
	(0.0140)	(0.0094)	(0.0096)	(0.0130)	(0.0168)	(0.0171)	(0.0169)	(0.0153)	(0.0113)	(0.0079)	(0.0016)
Climate change information	-0.0061	-0.0082	-0.0099	0.0032	0.0056	0.0062	0.0232	-0.0131	0.0139	-0.0158**	0.0010
	(0.0160)	(0.0090)	(0.0123)	(0.0134)	(0.0180)	(0.0190)	(0.0188)	(0.0163)	(0.0125)	(0.0080)	(0.0017)
Replacement variety characteristics											
Wet season	-0.0348**	-0.0212*	-0.0079	-0.0643***	0.1718***	0.0166	-0.0201	-0.0283	-0.0254*	0.0164**	-0.0030**
	(0.0144)	(0.0109)	(0.0113)	(0.0149)	(0.0231)	(0.0213)	(0.0216)	(0.0192)	(0.0141)	(0.0082)	(0.0015)
Hybrid	-0.0025	-0.0496***	0.0087	-0.0165	0.0549**	0.0045	-0.0072	-0.0204	0.0069	0.0223**	-0.0011
	(0.0157)	(0.0152)	(0.0124)	(0.0152)	(0.0245)	(0.0243)	(0.0245)	(0.0225)	(0.0153)	(0.0100)	(0.0018)
Rice production constraints											
Experienced abiotic stress	0.0007	-0.0237**	0.0064	-0.0222	0.0228	0.0007	-0.0518**	0.0700***	-0.0001	-0.0026	-0.0003
	(0.0143)	(0.0099)	(0.0097)	(0.0142)	(0.0186)	(0.0200)	(0.0204)	(0.0179)	(0.0129)	(0.0090)	(0.0016)
Experienced lodging	-0.0607**	0.0488	-0.0420*	-0.0300	0.0370	0.0055	0.0217	0.0421	0.0143	-0.0369***	0.0001
	(0.0307)	(0.0315)	(0.0232)	(0.0226)	(0.0321)	(0.0321)	(0.0354)	(0.0408)	(0.0221)	(0.0113)	(0.0011)
Experienced grain shattering	0.0438***	0.0039	-0.0022	0.0129	-0.0090	-0.0512**	0.0168	-0.0351**	-0.0025	0.0187**	0.0038**
	(0.0164)	(0.0093)	(0.0096)	(0.0144)	(0.0158)	(0.0204)	(0.0198)	(0.0155)	(0.0136)	(0.0080)	(0.0018)
Farm and farmer characteristics											
Education – husband	0.0002	-0.0013	0.0014	-0.0038	0.0064*	-0.0005	-0.0019	-0.0036	0.0029	0.0004	-0.0002
	(0.0034)	(0.0021)	(0.0028)	(0.0025)	(0.0036)	(0.0036)	(0.0038)	(0.0037)	(0.0023)	(0.0014)	(0.0002)
Education – wife	0.0009	-0.0045**	-0.0047*	0.0125***	-0.0049	0.0067*	-0.0029	-0.0038	0.0018	-0.0009	-0.0002
	(0.0035)	(0.0020)	(0.0025)	(0.0031)	(0.0035)	(0.0039)	(0.0036)	(0.0035)	(0.0024)	(0.0018)	(0.0004)
Farm experience – husband	0.0021**	0.0009*	0.0006	0.0003	-0.0036***	0.0014	-0.0001	-0.0027***	-0.0002	0.0013**	0.0001
	(0.0009)	(0.0004)	(0.0006)	(0.0007)	(0.0009)	(0.0009)	(0.0009)	(0.0009)	(0.0006)	(0.0005)	(0.0001)
Farm experience – wife	-0.0004	-0.0005*	-0.0001	0.0012*	0.0016**	0.0001	-0.0006	0.0003	-0.0011**	-0.0005*	-0.0000
	(0.0006)	(0.0003)	(0.0004)	(0.0006)	(0.0006)	(0.0008)	(0.0007)	(0.0007)	(0.0004)	(0.0003)	(0.0001)
Occupation – husband	-0.0347	-0.0009	-0.0564***	-0.0146	0.0193	0.0500	-0.0234	0.0861**	0.0124	-0.0274**	-0.0104**
	(0.0289)	(0.0174)	(0.0168)	(0.0255)	(0.0263)	(0.0355)	(0.0315)	(0.0389)	(0.0245)	(0.0126)	(0.0052)
Occupation – wife	0.0406*	-0.0033	0.0129	-0.0120	-0.0405*	-0.0281	0.0215	0.0592***	-0.0519**	0.0032	-0.0015
	(0.0238)	(0.0111)	(0.0129)	(0.0237)	(0.0210)	(0.0354)	(0.0263)	(0.0217)	(0.0213)	(0.0153)	(0.0026)

Table 2.10 Continued

Variable	Slenderness	Stickiness	Aroma	Head rice recovery	Lodging tolerance	Disease resistance	Insect resistance	Abiotic stress tolerance	Reduction in shattering	Earliness	Uninvested
Time preference – husband	0.0009	0.0022***	-0.0032	-0.0038	-0.0117**	0.0060***	0.0074***	-0.0017	0.0024*	0.0018**	-0.0002
	(0.0015)	(0.0005)	(0.0028)	(0.0037)	(0.0046)	(0.0021)	(0.0022)	(0.0034)	(0.0014)	(0.0008)	(0.0004)
Time preference – wife	0.0049	-0.0023	-0.0031	-0.0029	0.0010	0.0020	-0.0045	-0.0004	0.0032	0.0018	0.0004
	(0.0031)	(0.0019)	(0.0030)	(0.0034)	(0.0039)	(0.0039)	(0.0043)	(0.0036)	(0.0027)	(0.0020)	(0.0005)
Income	-0.0002	0.0001	-0.0002	-0.0001	-0.0003*	0.0001	0.0000	0.0003**	0.0002	0.0001	-0.0000
	(0.0002)	(0.0001)	(0.0001)	(0.0001)	(0.0002)	(0.0002)	(0.0002)	(0.0002)	(0.0001)	(0.0001)	(0.0000)
Farm size	-0.0159*	-0.0028	-0.0029	-0.0274***	0.0176**	0.0119	0.0181*	0.0159**	-0.0062	-0.0073	-0.0011
	(0.0090)	(0.0050)	(0.0056)	(0.0084)	(0.0082)	(0.0095)	(0.0095)	(0.0071)	(0.0060)	(0.0058)	(0.0008)
Percent lease area	0.0227	-0.0068	0.0197	0.0129	-0.0074	-0.0227	-0.0177	-0.0008	-0.0220*	0.0230**	-0.0009
	(0.0173)	(0.0088)	(0.0120)	(0.0154)	(0.0185)	(0.0197)	(0.0190)	(0.0184)	(0.0121)	(0.0099)	(0.0025)
Proportion of area planted	-0.0706	-0.0735***	-0.0706**	-0.1309***	0.2108***	0.1050	0.0341	-0.0589	0.0877	-0.0269	-0.0062*
	(0.0718)	(0.0279)	(0.0327)	(0.0472)	(0.0767)	(0.1080)	(0.0703)	(0.0502)	(0.0844)	(0.0351)	(0.0033)
Rice marketing											
Proportion sold	-0.0140	-0.0068	0.0058	-0.0588**	0.0311	0.0256	0.0333	-0.0694*	0.0731***	-0.0264	0.0063
	(0.0333)	(0.0209)	(0.0304)	(0.0262)	(0.0405)	(0.0378)	(0.0396)	(0.0379)	(0.0243)	(0.0175)	(0.0048)
Output price	-0.0056	-0.0041	0.0003	0.0007	0.0036	0.0067	0.0070	-0.0066	-0.0016	0.0002	-0.0006
	(0.0040)	(0.0031)	(0.0032)	(0.0033)	(0.0046)	(0.0047)	(0.0046)	(0.0046)	(0.0034)	(0.0022)	(0.0004)
Distance to market	-0.0004	-0.0010	0.0007	0.0030***	-0.0020	-0.0014	-0.0011	0.0024**	0.0003	-0.0008	0.0002
	(0.0014)	(0.0008)	(0.0008)	(0.0010)	(0.0015)	(0.0016)	(0.0015)	(0.0011)	(0.0010)	(0.0007)	(0.0002)
Buyers' standard requirement	-0.0202	0.0230***	-0.0005	0.0060	0.0009	-0.0280	0.0329*	-0.0177	0.0128	-0.0126	0.0033
	(0.0138)	(0.0089)	(0.0100)	(0.0137)	(0.0177)	(0.0183)	(0.0187)	(0.0173)	(0.0132)	(0.0078)	(0.0023)
Respondent dummy variable											
Respondent – husband	0.0029	-0.0020	-0.0068	-0.0093	0.0456**	-0.0083	-0.0533***	0.0440**	-0.0144	-0.0033	0.0050**
	(0.0153)	(0.0081)	(0.0123)	(0.0149)	(0.0180)	(0.0207)	(0.0196)	(0.0176)	(0.0129)	(0.0082)	(0.0025)
Respondent – wife	-0.0133	-0.0104	0.0184*	0.0030	0.0237	0.0177	-0.0578***	0.0340*	-0.0108	-0.0093	0.0050**
	(0.0166)	(0.0090)	(0.0109)	(0.0143)	(0.0175)	(0.0195)	(0.0184)	(0.0184)	(0.0121)	(0.0089)	(0.0020)

Notes: Partial effects after multinomial fractional response model estimation.
N = 732, Log pseudolikelihood = -1501.47.
Standard errors clustered at the decision-unit level in parentheses.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Interestingly, climate change information is negatively related to investments in earliness. Compared to those who did not receive such information, farmers who received climate change information invested 1.6% less in earliness. This is contrary to our expectations; we would have expected farmers to invest more in earliness when climate becomes more erratic. More research is needed to corroborate this finding.

The variables wet season and hybrid, used to characterise the replacement varieties, were found to be significantly associated with investment preferences in some traits. For wet season varieties, farmers tended to invest a substantial amount more – 17.2% – in lodging tolerance, and in earliness by 1.6%. They invested 6.5% less in head rice recovery and also less in two grain quality traits: 3.5% less in slenderness and 2.1% less in stickiness.

These findings show that farmers were making trade-offs in terms of traits to be prioritized for improvement. They appear to have prioritized stress tolerance traits at the expense of investment in grain quality traits. This is consistent with our expectation that farmers will invest more in stress tolerance traits in the wet season due to uncertainties in the weather conditions and higher risk of pest and diseases. We also see the same trend for hybrid varieties. Farmers invested 5.5% more in lodging tolerance and 2.2% more in earliness (if the replacement variety is a hybrid as compared to an inbred), and they invested 5.0% less in stickiness. This counters our hypothesis that farmers will invest more in grain quality traits if the replacement variety is a hybrid and suggests that farmers may be preferring a less sticky rice.

With respect to rice production constraints, we logically find that farmers who experienced abiotic stress in the past invested significantly more in abiotic stress tolerance (7.0%), and significantly less in insect resistance (5.2%) and stickiness (2.4%). Those who had problems with lodging invested significantly more in earliness (3.7%) and less in slenderness (6.1%). Farmers who experienced problems with grain shattering invested more in earliness (1.9%) and slenderness (4.4%), and invested less in disease resistance (5.1%) and abiotic stress tolerance (3.5%). The result for abiotic stress is consistent with our hypothesis that farmers will invest in the VTIs, addressing the constraint they experienced in the past. The result for the two other production constraints are different from what we expected: farmers who experienced these constraints invested in other VTIs not directly addressing the constraints. This suggests that farmers may view some constraints as needing urgent investment to address, while others may not be as important.

Education, farming experience and primary occupation are significantly associated with investments in some of the traits included in our analysis. We found significant relationships between education and four out of the 11 traits, but this association is weak. For example, a one-year increase in the husband's education leads to more investment in lodging tolerance, but the size of effect is small (only a 0.6% increase). An increase in the wife's education by one year leads to an increase in investment in head rice recovery, and a decrease in investment in stickiness.

It is noteworthy that there are some interesting differences in the relationship between farming experience and VTIs for husbands and wives. A one-year increase in farming experience by the husband is associated with a significant, albeit small, increase in investments in slenderness (0.2%), stickiness (0.1%), and earliness (1.3%). An increase in the husband's farming experience is also related to a decrease in investments in lodging tolerance (3.6%) and abiotic stress tolerance (2.7%). Conversely, an increase in the farming experience of the wives leads to more investments in head rice recovery (1.2%) and lodging tolerance (1.6%), and less in shattering reduction (1.1%) and earliness (0.1%).

In terms of the primary occupation of the husband and wife, we find that if the husband's work is mainly in farming, we see more investment in abiotic stress tolerance, but less in aroma and earliness. If the wife works on-farm, we also see more investments in abiotic stress tolerance and slenderness, but less in lodging tolerance and reduction in shattering. The results reveal that farmers were making trade-offs such that they were investing more in some traits and less in others. Further, some of these results are consistent with our hypotheses that education, farming experience and primary occupation will affect farmers' investment decisions in VTIs.

Time preferences also affect investment decisions. Husbands' higher discount factor is associated with an increase in investments in stickiness, disease resistance, insect resistance, reduction in shattering, and earliness. It is also associated with decrease in investment in lodging tolerance. The increase in investment in earliness confirms our hypothesis that with higher discount factor, farmers are more likely to invest in technologies that have shorter time gaps before benefits can be realized (Pannell, Llewellyn and Corbeels 2014). The decrease in investment in lodging tolerance may imply that farmers prioritized traits for which the replacement varieties are less superior (e.g. disease and insect resistance).

Farm size is also found to be significantly associated with investment preferences. Households with larger farm area invested more in lodging tolerance, insect resistance, and abiotic stress tolerance, as well as invested less in head rice recovery. This is consistent with our hypothesis that farmers with larger farm areas will invest more in the VTIs, although we hypothesized that they will also invest in grain quality traits.

In addition, the results showed that farmers with larger farm size were making trade-offs such that they prioritized stress tolerance traits over grain quality traits. The proportion of the leased area has both a positive and a negative association with preferences for VTIs. Households with more leased areas tend to invest more in earliness and less in reduction in shattering. This supports the hypothesis that farmers with leased area will invest more in earliness to escape severe weather conditions, and that an early maturing variety will allow them to plant the next season rice earlier or plant high-value crops in-between seasons. The results also imply that farmers may not be willing to plant long-maturing varieties due to the lag time until they can reap the benefits. The latter is consistent with the hypothesis that indebted farmers tend to prefer earlier harvests to reimburse their debts.

Farmers were also making trade-offs in their preferences for stress tolerance and grain quality traits as the area they planted increased. In particular, a unit increase in area planted is associated with a 21.1% increase in investment in lodging tolerance. This is also associated with lower investments in the following VTIs: 13.1% in head rice recovery; 7.4% in stickiness; and 7.1% in aroma. We expected that a larger area being planted will influence farmers to invest both in grain quality and stress tolerance traits. Results however showed that farmers made trade-offs instead, such that they prioritized a stress tolerance trait over grain quality traits.

In accordance with our expectations that market-related variables will have a positive effect on overall investment by farmers, distance to market and standard requirements by buyers are positively associated with investments in the VTIs. The distance to the market is positively related to investments in head rice recovery and abiotic stress tolerance. The farther the farm is to the market, the more the farmers invested in these VTIs (but the size of the effect is small, only less than 1%). When farmers reported that their buyers imposed quality standards, they tended to invest more in stickiness and insect resistance. The results for the proportion of production sold differed from our hypothesis that this variable will influence farmers to invest in the VTIs. The higher the rate of selling, the more that farmers tended to invest in reduction of shattering, and the less in head rice recovery. They also tended to invest less in abiotic stress tolerance, but the association is weak.

Finally, the gender of the investor also significantly affected investment preferences. We find that both husband and wife, relative to their joint decisions, tended to invest less in insect resistance but more in abiotic stress tolerance. This implies that during consensus, households tended to prioritize insect resistance and deprioritize abiotic stress tolerance a bit. Husbands also invested more in lodging tolerance. An interesting finding is that the uninvested portion of the endowment fund has a significant and positive marginal effect. This finding implies that both husband and wife had the tendency to invest less and save a portion of their endowment fund during the individual rounds of the experiment, and maximize investment of the fund during the joint round.

2.4.3 **Determinants of investment preferences – Gender-disaggregated data**

A gender-disaggregated analysis is presented below. As previously discussed, this analysis is motivated by the significant differences between husband and wife in their characteristics and investments in VTIs. Moreover, the estimation results on the pooled data reveal significant differences in the investment preferences depending on whether the respondent is the husband or the wife, relative to their joint decision. With these, a gender-disaggregated analysis is carried out to further examine individual investment preferences and the factors that influence these. Table 2.11 and Table 2.12 show the results of the regression for husbands and wives, respectively. Table 2.13 presents the results of the regression for joint decision.

Market information had a significant influence on the wife (Table 2.12) and joint investment decisions (Table 2.13). Wives who received market information tended to invest more in stickiness and aroma, while couples invested more in slenderness if they received such information during the experiment. Climate change information significantly influenced investments in the VTIs by husbands (Table 2.11) and joint husband and wife (Table 2.13). Husbands tended to invest more in slenderness, while jointly, they tended to invest less in stickiness if they received climate change information.

Wet season replacement variety had a significant effect on investments across gender (Tables 2.11 and 2.12) and joint decision (Table 2.13). Husband and wife, individually and jointly, tended to invest more in lodging tolerance if the replacement variety is for wet season. A hybrid replacement variety had also significant effect on preferences of husband and wife, individually (Tables 2.11 and 2.12) and jointly (Table 2.13).

Table 2.11 Average marginal effects on husbands' investments in the VTIs

Variable	Slenderness	Stickiness	Aroma	Head rice recovery	Lodging tolerance	Disease resistance	Insect resistance	Abiotic stress tolerance	Reduction in shattering	Earliness	Uninvested
Market information	0.0102	0.0090	-0.0144	0.0203	-0.0108	-0.0078	-0.0271	0.0193	0.0100	-0.0034	-0.0052
	(0.0234)	(0.0138)	(0.0130)	(0.0216)	(0.0305)	(0.0296)	(0.0315)	(0.0301)	(0.0198)	(0.0139)	(0.0046)
Climate change information	0.0500*	-0.0052	-0.0184	-0.0073	-0.0305	-0.0240	0.0242	0.0211	0.0069	-0.0232	0.0064
	(0.0284)	(0.0155)	(0.0144)	(0.0205)	(0.0323)	(0.0293)	(0.0347)	(0.0302)	(0.0207)	(0.0143)	(0.0048)
Wet season	-0.0089	-0.0050	-0.0113	-0.0404*	0.1541***	-0.0031	-0.0242	-0.0588*	-0.0109	0.0106	-0.0022
	(0.0204)	(0.0194)	(0.0146)	(0.0227)	(0.0334)	(0.0311)	(0.0392)	(0.0331)	(0.0197)	(0.0167)	(0.0017)
Hybrid	-0.0127	-0.0804**	0.0008	-0.0143	0.0664*	-0.0200	0.0171	-0.0089	0.0376*	0.0120	0.0023
	(0.0242)	(0.0361)	(0.0140)	(0.0245)	(0.0359)	(0.0366)	(0.0427)	(0.0367)	(0.0216)	(0.0191)	(0.0039)
Farm experience	0.0014	0.0007	0.0012	0.0008	-0.0025**	0.0006	-0.0005	-0.0021*	-0.0005	0.0007	0.0002
	(0.0014)	(0.0006)	(0.0008)	(0.0009)	(0.0011)	(0.0012)	(0.0016)	(0.0011)	(0.0007)	(0.0007)	(0.0002)
Education	0.0067	-0.0012	-0.0023	-0.0007	0.0020	-0.0018	0.0027	-0.0059	0.0042	-0.0024	-0.0014
	(0.0058)	(0.0027)	(0.0035)	(0.0045)	(0.0065)	(0.0054)	(0.0062)	(0.0056)	(0.0036)	(0.0025)	(0.0010)
Primary occupation	0.0025	0.0093	-0.0512**	-0.0087	-0.0022	-0.0564	0.0425	0.1175*	-0.0067	-0.0270	-0.0196
	(0.0458)	(0.0260)	(0.0245)	(0.0356)	(0.0417)	(0.0447)	(0.0513)	(0.0652)	(0.0361)	(0.0177)	(0.0124)
Time preference	0.0004	0.0037***	-0.0013	-0.0122	-0.0095	0.0065*	0.0123***	0.0029	-0.0024	0.0016	-0.0020
	(0.0035)	(0.0011)	(0.0030)	(0.0112)	(0.0081)	(0.0039)	(0.0038)	(0.0038)	(0.0050)	(0.0011)	(0.0020)
Farm size	-0.0436**	-0.0023	0.0047	-0.0202*	0.0147	0.0103	0.0223	0.0134	0.0163*	-0.0154**	-0.0003
	(0.0182)	(0.0060)	(0.0069)	(0.0116)	(0.0123)	(0.0142)	(0.0166)	(0.0102)	(0.0086)	(0.0074)	(0.0008)

Notes: Partial effects after multinomial fractional response model estimation.
N = 244, Log pseudolikelihood = -508.82.
Standard errors clustered at the decision-unit level in parentheses.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 2.12 Average marginal effects on wives' investments in the VTIs

Variable	Slenderness	Stickiness	Aroma	Head rice recovery	Lodging tolerance	Disease resistance	Insect resistance	Abiotic stress tolerance	Reduction in shattering	Earliness	Uninvested
Market information	0.0232	0.0308**	0.0432**	-0.0205	-0.0022	-0.0126	-0.0296	-0.0113	-0.0080	-0.0090	-0.0041
	(0.0243)	(0.0128)	(0.0194)	(0.0231)	(0.0285)	(0.0285)	(0.0262)	(0.0276)	(0.0186)	(0.0117)	(0.0035)
Climate change information	-0.0261	-0.0081	-0.0118	-0.0197	0.0196	0.0069	0.0357	-0.0142	0.0295	-0.0099	-0.0018
	(0.0247)	(0.0115)	(0.0192)	(0.0237)	(0.0280)	(0.0321)	(0.0265)	(0.0283)	(0.0195)	(0.0126)	(0.0028)
Wet season	-0.0588**	0.0026	-0.0129	-0.1086***	0.1530***	0.0414	0.0151	-0.0029	-0.0433*	0.0190	-0.0046
	(0.0234)	(0.0144)	(0.0244)	(0.0257)	(0.0429)	(0.0373)	(0.0277)	(0.0316)	(0.0221)	(0.0116)	(0.0031)
Hybrid	-0.0374	-0.0077	-0.0111	-0.0561**	0.0495	0.0284	0.0158	-0.0086	0.0064	0.0251*	-0.0044
	(0.0274)	(0.0155)	(0.0273)	(0.0255)	(0.0485)	(0.0409)	(0.0328)	(0.0345)	(0.0246)	(0.0134)	(0.0031)
Farm experience	0.0007	-0.0008*	-0.0004	0.0005	0.0007	0.0007	-0.0003	-0.0008	-0.0007	0.0001	0.0002*
	(0.0011)	(0.0005)	(0.0007)	(0.0009)	(0.0010)	(0.0014)	(0.0010)	(0.0010)	(0.0007)	(0.0005)	(0.0001)
Education	-0.0060	-0.0073**	-0.0050	0.0009	0.0057	0.0068	0.0026	0.0007	0.0020	-0.0009	0.0006
	(0.0055)	(0.0030)	(0.0037)	(0.0048)	(0.0049)	(0.0061)	(0.0050)	(0.0060)	(0.0036)	(0.0022)	(0.0006)
Primary occupation	0.0222	0.0024	0.0046	-0.0034	0.0088	-0.0503	0.0187	0.0889***	-0.0591*	-0.0344	0.0015
	(0.0439)	(0.0162)	(0.0251)	(0.0373)	(0.0381)	(0.0581)	(0.0345)	(0.0311)	(0.0336)	(0.0278)	(0.0043)
Time preference	0.0032	0.0018	-0.0083*	-0.0009	-0.0021	0.0051	-0.0019	0.0001	0.0037	0.0009	-0.0016*
	(0.0055)	(0.0023)	(0.0049)	(0.0047)	(0.0057)	(0.0069)	(0.0060)	(0.0059)	(0.0035)	(0.0029)	(0.0009)
Farm size	0.0001	0.0012	-0.0013	-0.0237	0.0092	0.0100	0.0085	0.0173	-0.0207**	0.0021	-0.0027
	(0.0091)	(0.0054)	(0.0077)	(0.0164)	(0.0111)	(0.0106)	(0.0102)	(0.0133)	(0.0089)	(0.0051)	(0.0024)

Notes: Partial effects after multinomial fractional response model estimation.
N = 244, Log pseudolikelihood = -516.88.
Standard errors clustered at the decision-unit level in parentheses.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 2.13 Average marginal effects on joint investments in the VTIs

Variable	Slenderness	Stickiness	Aroma	Head rice recovery	Lodging tolerance	Disease resistance	Insect resistance	Abiotic stress tolerance	Reduction in shattering	Earliness	Uninvested
Market information	0.0398*	0.0199	0.0268	-0.0032	-0.0125	-0.0260	-0.0083	-0.0092	-0.0177	-0.0094	-0.0003
	(0.0217)	(0.0150)	(0.0173)	(0.0226)	(0.0242)	(0.0319)	(0.0292)	(0.0239)	(0.0186)	(0.0145)	(0.0002)
Climate change information	-0.0183	-0.0333*	0.0097	0.0157	0.0340	0.0072	-0.0044	0.0026	-0.0015	-0.0118	0.0002
	(0.0269)	(0.0196)	(0.0156)	(0.0244)	(0.0241)	(0.0329)	(0.0318)	(0.0244)	(0.0179)	(0.0151)	(0.0002)
Wet season	-0.0479*	-0.0421**	-0.0234	-0.0059	0.2349***	-0.0205	-0.0629	-0.0229	-0.0117	0.0027	-0.0003
	(0.0260)	(0.0183)	(0.0162)	(0.0340)	(0.0567)	(0.0442)	(0.0435)	(0.0298)	(0.0304)	(0.0207)	(0.0004)
Hybrid	-0.0087	-0.0728***	-0.0014	0.0494	0.1046*	0.0059	-0.0203	-0.0716**	0.0105	0.0047	-0.0002
	(0.0283)	(0.0282)	(0.0190)	(0.0381)	(0.0596)	(0.0476)	(0.0471)	(0.0322)	(0.0319)	(0.0234)	(0.0004)
Farm experience	0.0010	0.0006	0.0008	0.0013	-0.0011	0.0017	0.0005	-0.0030***	-0.0016*	-0.0001	0.0000
	(0.0016)	(0.0007)	(0.0008)	(0.0011)	(0.0011)	(0.0014)	(0.0016)	(0.0012)	(0.0009)	(0.0007)	(0.0000)
Education	-0.0056	-0.0011	-0.0010	0.0083	0.0030	0.0075	-0.0045	-0.0130*	0.0092*	-0.0029	0.0001
	(0.0071)	(0.0040)	(0.0049)	(0.0061)	(0.0067)	(0.0073)	(0.0077)	(0.0068)	(0.0050)	(0.0038)	(0.0000)
Primary occupation	-0.0049	0.0056	0.0051	-0.0023	-0.0073	-0.0187	0.0051	0.0605	-0.0505	0.0075	-0.0001
	(0.0388)	(0.0236)	(0.0240)	(0.0412)	(0.0361)	(0.0701)	(0.0397)	(0.0427)	(0.0321)	(0.0197)	(0.0005)
Time preference	0.0001	0.0044**	-0.0068	-0.0084	-0.0052	0.0084*	0.0112**	-0.0107	0.0023	0.0045***	0.0001**
	(0.0035)	(0.0021)	(0.0056)	(0.0082)	(0.0049)	(0.0051)	(0.0054)	(0.0066)	(0.0021)	(0.0011)	(0.0001)
Farm size	-0.0211	0.0001	-0.0090	-0.0200	0.0117	0.0123	0.0159	0.0325***	-0.0069	-0.0159*	0.0003***
	(0.0138)	(0.0067)	(0.0079)	(0.0143)	(0.0120)	(0.0144)	(0.0149)	(0.0072)	(0.0088)	(0.0082)	(0.0001)

Notes: Partial effects after multinomial fractional response model estimation.
N = 244, Log pseudolikelihood = -503.55.
Standard errors clustered at the decision-unit level in parentheses.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Farmer characteristics such as farming experience and time preferences significantly influenced investment preferences across gender (Tables 2.11 and 2.12) and joint husband and wife (Table 2.13). Higher farming experience led husbands and wives, individually and jointly, to invest less in different VTIs. For example, husbands invested less in lodging tolerance, wives in stickiness, and jointly, they invested less in abiotic stress tolerance. A higher discount factor led husbands and couples to invest more in stickiness, disease resistance, and insect resistance. Wives, on the other hand, invested less in aroma. Farm size had also significant effect on the investment preferences of husbands and wives, individually (Tables 2.11 and 2.12) and jointly (Table 2.13).

2.5 Discussion and Conclusions

In this study, we used data from a framed field experiment to investigate farmers' investment preferences for VTIs by examining their choice of a replacement variety and the traits of this variety that they want to see being improved by public rice breeding. Existing trait-based elicitation methods obtain preferences from the variety traits per se. In this study, we focused on trait improvements, which farmers can identify and provide given the extent of their farming experience. Randomly selected rice farming households in Nueva Ecija, Philippines participated in the experiment, where they were asked to allocate a certain amount of an endowment fund among the ten VTIs. Based on farmers' allocation decisions, their investments generated real returns, which were paid at the end of the experiment.

Our findings showed that farmers' preferences for a replacement variety was mainly dominated by two varieties. Most of the farmer-respondents selected the NSIC Rc 222 in the wet season and SL-8H in the dry season as the replacement varieties. NSIC Rc 222 was also the second top choice replacement variety for the dry season. When we examined the traits of these varieties that the farmers would like to be improved, we found they focused on stress tolerance traits. We see this is the case as NSIC Rc 222 has already the grain quality traits, specifically being long and slender, that the market requires. Farmers focused on investing in the resistances and grain shape of the dominant replacement variety in the dry season as these are the traits of this variety that farmers perceived needed to be improved.

Overall, we see that the farmers chose a replacement variety that is high yielding and that already has the quality traits that the consumers prefer. In selecting traits for improvements, they then tended to prioritize the agronomic traits and resistances to pests and diseases. More than 80% of the varieties released after 2005 (NSIC Rc 222 was released in 2009) have no resistance to several insects and diseases (Laborte et al. 2015). Thus, improvements in these traits are critical.

We also examined the factors that influenced investment preferences of farmers for VTIs. The factors that influenced the farmers to significantly invest in trait improvements are access to information (tested through our information treatments), cropping season, variety type, farmer's time preference, and access to land.

Although there were distinct differences in the type of varieties grown in the study site in each cropping season, there were similarities in the preferred traits for improvement across variety types and seasons. Wet season varieties, which are mostly inbreds, require improvements in stress tolerance to different biotic and abiotic factors since occurrence of pests and diseases is more likely in this season. There are also more uncertainties in the weather conditions in the wet season. Our results show that farmers also prioritized improvements in stress tolerance traits (such as lodging tolerance) of hybrids, which are commonly grown in the dry season. These findings imply that trait improvements of farmers' replacement varieties should focus on stress tolerance traits.

Access to land was also an important consideration in prioritizing trait improvements. Our results showed that the larger the farm size and area planted, the more the farmers invested in stress tolerance traits and less in grain quality traits. On the other hand, a higher proportion of leased area influenced the farmers to invest more in earliness. Again, these findings suggest that improvements in stress tolerance traits and earliness (an agronomic trait) of replacement varieties which already have the desired grain quality should be the priority. Our results also showed that there are gender differences in the investment preferences for trait improvements, but there are also similarities. Both husband and wife tended to prefer improvements of stress tolerance traits.

Overall, results of the study can guide breeders and donors to make rice breeding programs more market-driven and climate-resilient, which could help targeting and fostering the adoption of improved varieties. In general, our results suggest that two distinct variety product profiles can be identified – one for the wet season and one for the dry season. Improvements in wet season varieties, which are mostly inbreds, should focus on stress tolerance (against lodging, pests and diseases). These should also be the priorities in improving the dry season varieties, which are mostly hybrids. However, improvements in the dry season varieties should also include grain quality traits, specifically slenderness and head rice recovery.

Beyond these applied findings, the novel approach of our methodology can be used to transform the way preferences for variety traits are elicited. The investment game methodology can also provide a new opportunity for farmers to be truly involved in the agricultural research process early on through participation in resource allocation and priority setting.

Our study, however, has some limitations. For example, with regard to its sample selection, generalization of the findings to a larger population is also limited. Further, variety choice is site-specific and it is recommended that similar research is done to other major rice-growing areas to help in the development of rice variety product profiles that are better targeted geographically. Preferences and trade-offs of other actors in the rice value chain (e.g. rice millers) can also be elicited using our methodology. Their preferences are also important and so it may be worthwhile to also engage them in this kind of research. Through this, it will be possible to have portfolios of trait improvements for rice breeding research that capture and integrate preferences across the rice value chain.

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Chapter 3 – Statement of Authorship

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Overall percentage (%)	65%		
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By signing the Statement of Authorship, each author certifies that:

i. the candidate's stated contribution to the publication is accurate (as detailed above);

ii. permission is granted for the candidate to include the publication in the thesis; and

iii. the sum of all co-author contributions is equal to 100% less the candidate's stated contribution.

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Chapter 3: Understanding Filipino Rice Farmer Preference Heterogeneity for Varietal Trait Improvements: A Latent Class Analysis

Abstract

Using an experimental methodology based on investment games, this study examines whether smallholder rice farmers from Nueva Ecija, Philippines have heterogeneous preferences for improvements in ten rice varietal traits. On average, farmers invested the most in VTIs that can potentially reduce losses caused by lodging, insects, and diseases. A latent class cluster approach was employed to identify different segments of rice producing households and their distinct preferences. The identified clusters were characterised post-hoc using household, farm, and marketing characteristics. We found four classes of farmers with distinct preferences for improvements in variety traits. The results also revealed that the clusters are significantly different in terms of household, farm, and marketing characteristics. The findings can guide breeding research in the development of varieties that have the traits farmers identified for improvement, and that will address distinct farmer segments and needs.

Chapter 3: Understanding Filipino Rice Farmer Preference Heterogeneity for Varietal Trait Improvements: A Latent Class Analysis

3.1 Introduction

Rice genetic enhancement research has produced a wide range of improved modern rice varieties. These varieties paved the way for the dramatic increases seen in rice production in many developing countries from the 1960s to 2000s. During this period, Asian rice paddy production more than tripled, increasing from approximately 216 million tons in 1961 to 687 million tons in 2008 (International Rice Research Institute 2017). In fact, rice crop improvement research has generated the largest documented impacts seen from investment in agricultural research, accounting for 86% of the total documented impacts in Southeast Asia (Maredia and Raitzer 2012). Annual gains from adoption of modern varieties in South and Southeast Asia are estimated at US$10.8 billion from the late 1960s to late 1990s (Hossain et al. 2003).

In the Philippines, more than 200 inbred varieties and around 80 hybrids were released from the mid-1960s to 2016 (National Seed Industry Council 2016). Interestingly, Raitzer et al. (2015) reported that during the early 1990s to late 2000s the Philippines had the largest number of varietal releases per unit of rice area and the fastest varietal replacement when compared to other countries such as Indonesia or Bangladesh.

Although numerous rice varieties have been released for different production ecosystems, farmer adoption rates are low.[8] For example, Launio et al.

[8] From 1992 to 2012, the most widely adopted varieties in the Philippines changed from IR 64 to PSB Rc 18 to PSB Rc 82, and to NSIC Rc 222 during the 2012 dry season.

(2008) used surveys of farm households in major rice producing provinces in the Philippines covering the 1992–1993, 1996–1997 and 2001–2002 crop years. Launio et al. (2008) found that around 70–80% of the surveyed rice areas were planted to only ten different varieties in any given period. The same trend was reported by Laborte et al. (2015) using farm household surveys conducted from 1966 to 2012 in six provinces collectively referred to as Central Luzon. The authors found that less than ten varieties were planted to 75% of the total rice area in the study sites.

The low level of adoption of varieties released after 2005 may be because, compared to the varieties released earlier, the new varieties have generally had lower average yield, shorter duration, and lower head rice recovery. Furthermore, most of the varieties released more recently can be characterized as having limited-to-no resistance to pests and diseases such as brown plant hopper (BPH), blast, bacterial leaf blight (BLB), and tungro (Laborte et al. 2015).

Considering the characteristics of the few varieties adopted by Filipino farmers in the field, it seems that generally, farmers place more value on rice varieties that have the following traits: high yield, good grain quality, and biotic stress tolerance (resistance to pests and diseases). While these traits appear to be most important to farmers, previous literature (Birol, Smale and Yorobe Jr 2012, Kassie et al. 2017, Ward et al. 2014) suggests that farmer preferences for variety traits are heterogeneous. This is because farmers are often diverse in terms of their socioeconomic characteristics, household and farm assets, behaviour, and attitudes. Furthermore, rice farmers also operate facing different production and marketing systems (Briones and Dela Peña 2015, Dawe, Moya and Casiwan 2006).

3.1.1 **Objectives**

An improved understanding of rice farmers' unique preferences for varietal traits, as well as the specific traits of adopted varieties that farmers would prefer to see improved, may help breeders focus their research, and thus, subsequently increase adoption rates in the field. Therefore, the main objectives of this chapter are twofold: 1) to explore the existence of variation (heterogeneity) in preferences for rice varietal trait improvements (VTIs); and if farmer preferences are heterogeneous, and 2) to examine the factors that help explain farmer preferences for VTIs.

In this paper, farmer preferences were elicited for *improvements* in varietal traits (referred to as varietal trait improvements (VTIs)). Most prior trait-based studies have elicited preferences for specific traits. However, previous research has shown that farmers are able to identify and suggest improvements in the technologies they use in order to make them more suited to their individual needs (Pingali, Rozelle and Gerpacio 2001). Therefore, in this study, we focused on trait improvements because a practical aim of the study was to provide feedback to breeders and donors in order to provide guidance for research priority setting and resource allocation.

Farmer preferences for VTIs were elicited using an experimental methodology based on the investment game literature (Ahmed 2011, Berg, Dickhaut and McCabe 1995, Buchan, Croson and Solnick 2008, Cochard, Nguyen Van and Willinger 2004, Gneezy, Güth and Verboven 2000, Ortmann, Fitzgerald and Boeing 2000). The methods are explained in detail in Section 3.3, but briefly, for the experiment, farmers were provided with tablet-computing devices and were asked to participate in an 'Investment Game'. The tablets contained a novel

Investment Game Application (IGA), which was developed by staff at the International Rice Research Institute (IRRI). The IGA was developed to elicit preferences and values for rice VTIs (see Demont et al. 2015).

Farmers were given an endowment fund of 100 Philippine pesos (PHP hereafter) for the Investment Game. Farmers were first asked to identify a replacement variety (for the variety that they were currently planting), and then asked to indicate the traits of this variety that they wanted to have improved. They were then asked to invest in the VTIs they preferred. The experiment was conducted in Nueva Ecija, a major rice-producing province in the Philippines, with 122 rice-farming households as the participants.

Farmers' investment shares for different VTIs were calculated for each household. A relatively new cluster analysis method, Latent Class (LC) Cluster Analysis, was then used to identify distinct segments of farmers, which differed in their preferences for VTIs as well as their household characteristics. Previous studies have used latent class analysis and found evidence of unique segments of farmers having different preferences and attitudes (e.g. Ochieng and Hobbs 2016, Schlecht and Spiller 2012, Umberger et al. 2015). These previous studies recognized the importance of accounting for heterogeneity in farmer preferences when developing and targeting tailored agricultural policies and programs. Thus, this paper contributes to the growing literature in this area of research; and as far as we are aware, this is the first study that accounts for heterogeneity in preferences for improvements in variety attributes. Moreover, our paper also adds to the empirical applications of LC cluster approach to agricultural issues at the farmer/producer level.

The remainder of this paper is organized as follows. In Section 3.2 the relevant literature on adoption and LC cluster analysis used to account for farmer preference heterogeneity is briefly summarised. Section 3.3 provides an overview of the study sites, sampling strategy and experimental design and methods used to elicit farmer preferences and values for VTIs. We also discuss the empirical approach employed to analyse the experimental data. Section 3.4 reports the findings from the analysis of the experimental data and provides the discussion of the results. Section 3.5 provides the conclusions.

3.2 Analysing Preference Heterogeneity in Technology Traits

3.2.1 **Technology adoption and farmer preferences for variety attributes**

Technology adoption among smallholder farmers depends on many factors. Several previous studies found that farmers' decisions to adopt a certain variety are influenced by socioeconomic, demographic, and institutional factors (Adesina and Baidu-Forson 1995, Adesina and Zinnah 1993, Kshirsagar, Pandey and Bellon 2002, Pingali, Rozelle and Gerpacio 2001, Sall, Norman and Featherstone 2000).

More recently, studies have shown that adoption decisions are also conditioned by preferences of farmers for specific technology (variety) attributes (Fisher and Snapp 2014, Ghimire, Wen-chi and Shrestha 2015, Hintze, Renkow and Sain 2003, Horna, Smale and Oppen 2007, Joshi and Bauer 2006, Lunduka, Fisher and Snapp 2012).

In examining farmer preferences for variety attributes, it is also important to take into account possible heterogeneity in the preferences. Kline and Wichelns

(1998) argued that it is imperative to account for preference heterogeneity since preferences among decision makers may vary due to differences in their socioeconomic characteristics, environment, and tastes.

Differences in preferences have implications in the development of policies and programs to suit different production and marketing systems (Ouma, Abdulai and Drucker 2007). As such, several studies have examined heterogeneity in farmer preferences for variety traits. For example, Ward et al. (2014), used a choice experiment, and found heterogeneity in preferences for drought tolerant rice varieties among farmers in Bihar, India. They found that differences in preferences were influenced by whether the drought tolerant trait was expressed in a hybrid or inbred variety. The authors recommended making the drought tolerance trait available in both the inbred and hybrid varieties.

Kassie et al. (2017) also examined preferences for the drought tolerant trait in maize. They found that the heterogeneity in preferences for drought tolerant maize among farmers in Zimbabwe was influenced by gender and occupation of the household head, and by the household size. Birol et al. (2012) examined farmers' preferences for genetically modified (GM) maize using a choice experiment. Using the results of the choice experiment, the authors grouped maize farmers from the Philippines into two groups: the 'reluctant GM maize farmers' and the 'willing GM maize farmers'. They suggested developing policies focused on targeting the needs of the two different segments of farmers. For example, policies related to marketing and extension of GM maize varieties should be targeted to those who were most willing to pay for the GM attribute.

3.2.2 Accounting for preference heterogeneity

Agricultural farms in the Philippines are diverse such that one can observe many farmers operating on small subsistence farms as well as few farmers who operate large farms (Koirala, Mishra and Mohanty 2016). Moreover, rice production systems vary considerably due to differences in soil, climate, and economic development conditions (Dawe, Moya and Casiwan 2006). Considering these differences, preferences for varieties and variety traits may also be expected to differ across individual farmers. Heterogeneity in preferences elicited through stated choice models is usually accounted for using mixed logit models (McFadden and Train 2000) and latent class models to segregate or group respondents (Swait 1994).

Increasingly, LC cluster analysis (Vermunt and Magidson 2002) is being used to explore and better understand variations in preferences. In this paper, we used this clustering technique to identify clusters or segments of farmers with distinct preferences for variety trait improvements.

The premise in LC cluster analysis is that there exist unobservable or latent segments of individuals and that an individual belongs to a particular segment. Individuals within a segment are homogeneous in their preferences, but preferences across segments differ. LC cluster analysis is a model-based clustering approach, which makes it different from the standard cluster analysis techniques. In the LC approach, individuals' class membership probabilities are computed from their observed preferences and from estimated model parameters (Vermunt and Magidson 2002).

Over the years, LC analysis has advanced such that observable variables with mixed scale types (nominal, ordinal, continuous, and counts) and covariates can be used to predict class membership (Vermunt and Magidson 2003).

LC cluster analysis has been previously used to account for heterogeneity in farmer preferences. Ochieng and Hobbs (2016) examined how cow-calf producers in Western Canada differed in terms of their response to different kinds of incentives available to encourage adoption of E. coli vaccine. The authors find evidence of three clusters of producers with distinct preferences for adoption incentives.

Umberger et al. (2015) employed LC cluster analysis to determine the differences in the buyer attributes that influence market channel choices of smallholder potato farmers in Indonesia. Their analysis revealed the existence of four distinct clusters of potato producers, each having different preferences for buyer attributes, attitudes, and socio-demographic characteristics.

Schlecht and Spiller (2012) accounted for heterogeneity in the attitudes and preferences of German dairy farmers towards marketing contracts. A principal component factor analysis (PCA) was first done on the attitudes of farmers toward marketing contracts in order to reduce the factors to be used in the LC cluster analysis. Using the resulting four factors from the PCA, the LC cluster analysis revealed three segments of dairy farmers, each with different attitudes towards market contracts and long-terms business relationships.

3.3 Experimental Approach and Analysis

3.3.1 **Ethics approval**

The experiment protocol was approved by The University of Adelaide Human Research Ethics Committee with Approval Number H-2016-010 (Appendix 6). A written informed consent was obtained from all individual respondents before the start of the experiment (Appendices 7-8).

3.3.2 **Experimental design**

The experiment was framed around a hypothetical context wherein a public breeding program receive a grant from a donor. The grant was distributed in small shares among farmers. As shareholders in the breeding program, farmers were given the opportunity to allocate their share to several alternative breeding programs for improving varietal traits. This was done through the use of IGA, a tablet application written in Microsoft Excel 2010 and designed to run on Windows 8 computer tablets. In the IGA, farmers select their preferred traits to be improved by pulling the VTI bars to the level that they wanted a particular trait to be improved. This is done using the up and down spin buttons (Figure 3.1).

Each level of improvement and combination of improvements had a corresponding cost, which was to be deducted from the farmer's share. Each level of improvement is also subject to a relative investment risk, which is defined as one minus the "probability of success", i.e. the probability that the level of improvement selected would be achieved through the public breeding program.

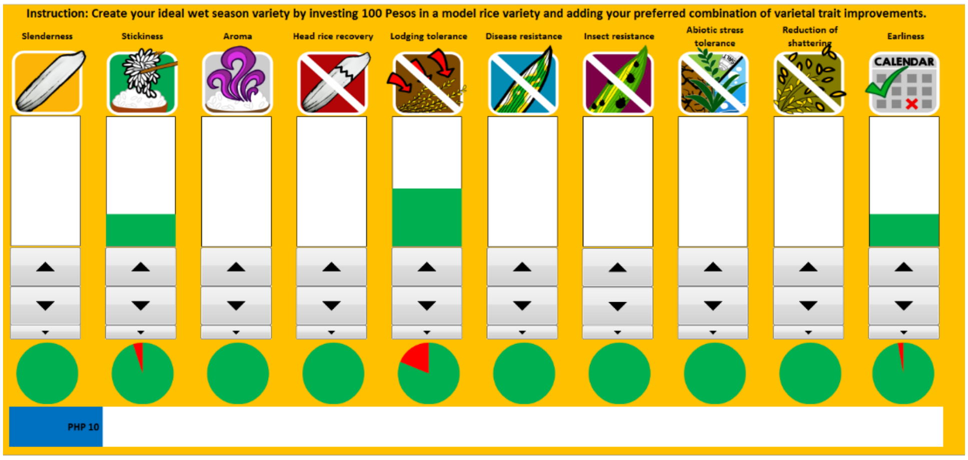

Figure 3.1 Investment Game Application (IGA) with example allocations in stickiness, lodging tolerance, and earliness. The blue horizontal bar at the bottom shows the status of the endowment fund, while the pie charts below the VTI bars indicate the riskiness of each investment – green segments represent the probability that the target VTI will be achieved; the red segments represent the odds of achieving a random VTI somewhere between zero and the target VTI

The initial improvement of a trait is more expensive compared to succeeding levels due to fixed start-up costs such as the establishment of new laboratory or field experiments. The costs of improving the traits, either individually or combination of several traits, were estimated through an expert elicitation workshop of breeders from IRRI and National Agricultural Research Systems (NARS) partners (Demont et al. 2015).

Similar to a common investment game where there are two players – a sender and a receiver, the investment game in this study also involved a sender, which is the farmer and a receiver, which is IRRI. Farmers decided how much of their endowment fund to send to the receiver, that is, how much will be invested in public breeding research. The amount they sent to the receiver can be considered as an indication of a trusting behaviour (Berg, Dickhaut and McCabe 1995, Kocher et al. 2015). IRRI would then return a pay-off (return to investment) to the farmer depending on the portfolio of VTIs chosen. This can be seen as an indication that the receiver was keeping the trust or reciprocating the sender's trusting behaviour (Berg, Dickhaut and McCabe 1995).

The amount that IRRI returned was the farmer's return to his/her investment portfolio composed of VTIs, subject to the risk incurred by public breeding research programs in achieving the selected VTIs. Returns to investment in public breeding research will normally be realized only after a new variety is released and adopted. This process usually takes about six years. However, in this study, breeding investment was framed as an investment with instantaneous return such that returns were calculated and given immediately after playing the game.

Determining the replacement variety

At the start of the experiment, farmers were asked to identify a replacement variety. The experimenter explained first to the participants that the replacement variety could be their most preferred variety, which they may or may not have previously grown. The replacement variety was what they were asked to improve upon to obtain their ideal variety.

Selecting VTIs

Farmers were then asked to choose from ten VTIs to invest in. These VTIs can be broadly categorized into (i) grain quality traits – slenderness, aroma, stickiness, and head rice recovery; (ii) stress tolerance traits – lodging tolerance, disease resistance, insect resistance, abiotic stress tolerance, and reduction in shattering; and (iii) an agronomic trait – earliness. The specific baseline and target metrics on which the IGA was calibrated are shown in Table 3.1.

Table 3.1 Traits and trait-specific metrics on which the IGA is calibrated

Trait	Metric	Baseline	Target
Grain quality traits			
Slenderness	Length/width ratio	2.4	3.2
Stickiness	Amylose content (%)	27%	22%
Aroma	Price premium (%) (market benchmark=100%)	0%	100%
Head rice recovery	% head rice obtained from a sample of paddy	45%	60%
Stress tolerance traits			
Lodging tolerance	Crop losses eliminated (%)	20%	80%
Disease resistance	Crop losses eliminated (%)	50%	90%
Insect resistance	Crop losses eliminated (%)	80%	95%
Abiotic stress tolerance	Crop losses eliminated (%)	0%	90%
Reduction in shattering	Crop losses eliminated (%)	80%	95%
Agronomic trait			
Earliness	Number of days the duration is shortened	0	14

Source: Demont et al. (2015)

The experiment was comprised of four information treatments, including a ‘control’ to test whether there would be differences in the preferences of farmers when given access to particular information. The first information treatment was the control, where no information was provided. The second was the market information treatment, which included information on the most preferred rice traits of urban (Metro Manila) consumers (Custodio et al. 2016)[9]. The third treatment was climate change information. The information provided in this treatment included increasing climate variability and the rise in frequency of extreme weather events, which can produce more frequent droughts, floods, and more uncertainty in rainy/wet season onset. The fourth information treatment combined both market information and climate change information.

[9] Metro Manila is a major market for the rice produced in Nueva Ecija. Given the trends in consumption patterns and urbanization, this major market can provide farmers opportunities to increase their incomes if they are able to provide the grain quality traits demanded by the consumers.

Each participating household repeated the IGA over six rounds. Husband (H) and wife (W) played the IGA for two seasons (wet (WS) and dry (DS)) independently and simultaneously. They then played the IGA jointly (J) for two seasons as well. In each round, participants had an available endowment fund amounting to PHP 100 (around AUD 2.95)[10] to invest in the VTIs. However, this amount was not given in cash at the beginning of the experiment. Rather, a final pay-off was instead given at the end of the experiment. On top of the final pay-off was a fixed show-up fee amounting to PHP 250 (AUD 7) paid to each household. This was equivalent to around three hours of paid agricultural labour per participant.[11] This number of hours corresponds to the average time farmers had to give up for participating in the experiment.[12]

3.3.3 **Sampling**

3.3.3.1 Study sites

We purposively selected Nueva Ecija to be the study site. Nueva Ecija is a major rice producing, and predominantly irrigated province in the Philippines. This allowed us to capture farmers' preferences for VTIs in both wet and dry seasons. Our sample consists of 122 rice-producing households, with both husband and wife participating.

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[10] At the time of the experiment (February 2016), one Australian dollar (AUD) was equivalent to approximately PHP 34.
[11] At the time of the experiment, the minimum daily wage rate for agricultural labour in the province was PHP 334 (Philippine Statistics Authority 2016).
[12] Pre-testing of the IGA experiment was conducted in Victoria, Laguna, Philippines in May 2015. The session took two hours to finish (Demont et al. 2015). The IGA experiment was then conducted in Eastern India in October 2015 and in Bangladesh in September–October 2016 (Ynion et al. 2015; 2016).

3.3.3.2 Sampling approach

We used a multi-stage sampling approach to obtain our survey sample. In the first stage, we purposely selected three municipalities, i.e. Muñoz, Talavera, and Guimba. In the second stage, we randomly selected four villages in each municipality. In the final stage, we randomly selected ten households per village.

Several steps were carried out in the random selection of the villages and rice-producing households. First, we approached the Municipal Agriculture Office (MAO) in each of the municipality to obtain a master list of rice farming households. The master lists include information on the names of the farmers, their respective rice areas classified either under irrigated or rainfed. Second, we approached the local officials of the villages selected and asked them to check and verify the names included in the master list. This was done to determine who among the list met the screening criteria for participant selection. The screening criteria were as follows: (i) both husband and wife should be involved in rice production or marketing activities; (ii) the household is planting rice in both wet and dry seasons; and (iii) the household is selling a portion of their rice production. Once the list was verified and checked, a new list per village was generated to include only those households that satisfied the selection criteria. We used a spreadsheet program to randomly select ten households per village from these lists to be invited to participate in the experiment. We also randomly selected another set of ten households per village to serve as a back-up list in case of no-show at the onset of the experiment.

3.3.3.3 Recruitment of participants

The randomly selected households were invited through the designated local field coordinators in each of the selected villages. The local field coordinator was a village official in-charge of the Agriculture Committee in his or her village. The households were invited to participate through a letter, which explains the details of the research, and the schedule of the experiment. The invitation letters were given two weeks before the scheduled experiment. Invited households were then reminded of the schedule two days before the actual experiment.

3.3.4 **Implementation and procedures**

The experimental sessions were held in local training halls and in local village halls. There were a total of 12 experimental sessions – one for each village selected. The sessions were conducted over the course of six days, each day had one in the morning and one in the afternoon. The 12 sessions were divided in four groups of three sessions for each of the four treatments. The assignment of the information treatments was randomly drawn prior to the start of all experimental sessions. Each session ran through the following stages: (i) registration, (ii) introduction of the research team, (iii) explanation of the experiment, (iv) presentation and explanation of the IGA and VTIs, (v) training on the IGA, (vi) six consecutive rounds of IGA, (vii) short post-experiment survey, and (viii) payment of returns and closure of the session. The sessions were conducted using the local language, Filipino. A household survey questionnaire was also administered to gather data on socio-demographic variables, rice varieties grown, constraints in rice production and marketing, and marketing practices. For reasons of efficiency in time management, this survey was also administered during the experimental sessions to households that were not being administered the IGA. This implies that some households responded to the questionnaire either before or after being administered the IGA.

Prior to administering the IGA, farmers were trained first in the methodology of investing with budget constraints by using the "Training on Investment Game Application" (TIGA). In TIGA, farmers invested in their optimal dish by adding to a fixed amount of rice, a vegetable or meat dish, using a budget amounting to PHP 50 (Figure 3.2). The purpose of TIGA is for farmers to get familiarized with the application, particularly in terms of the budget constraint involved and the use of spin buttons in the tablet. It is important that the participants be given the chance to use the tablet before the actual game as most of them are not familiar and have not used a tablet before.

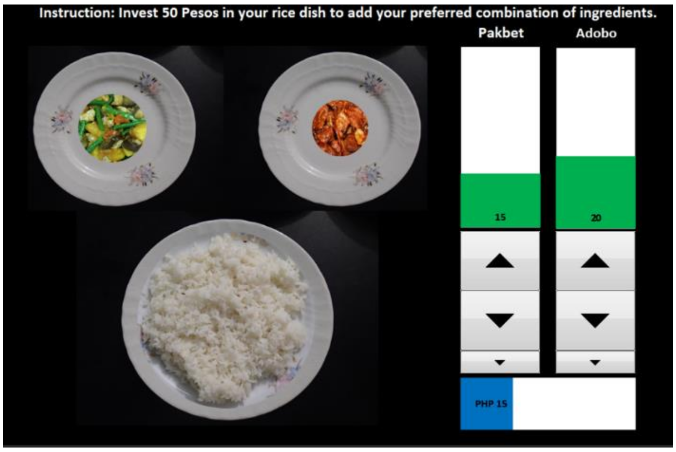

Figure 3.2 Training on Investment Game Application (TIGA) with example allocation of PHP15 to Pakbet (vegetable dish) and PHP20 to adobo (meat dish). The blue horizontal bar at the bottom shows the remaining budget

After the training and explanation of their tasks, husband and wife then played the IGA independently and simultaneously. Each of them was assigned an agent who facilitated the IGA and the post-experiment survey. Husbands and wives also answered the post-experiment survey independently. This was administered immediately after they played the IGA. The post-experiment survey included questions on the motivations behind their allocation decisions in IGA and a short quiz (two questions) to verify how well they had understood the experiment. After playing the IGA independently, husband and wife were asked to play the IGA jointly. A different agent was assigned per couple for the consensus round. To provide equal opportunity in answering the IGA during the consensus round, husband and wife were given separate stylus pens and the tablet was placed in the middle of their table. However, no further instructions were given and households were free to decide on whom should be dominating the discussions.

The final pay-off was determined by the "binding" round, which was randomly selected among the six rounds by using a dice (1 – H/WS, 2 – H/DS, 3 – W/WS, 4 – W/DS, 5 – J/WS, 6 – J/DS), as is commonly done in experimental economics (e.g., Lusk and Shogren 2007). After all households completed the six rounds of IGA, one volunteer was requested to roll the dice to draw the binding round. Depending on the VTI levels and risk levels associated with each VTI in the investment portfolio, IGA computes a stochastic return to investment (Demont et al. 2015). The resulting cash returns were placed in an envelope and distributed to the couples one at a time. A single-blind payment protocol was used where the research team knew the participants' earnings but the participants did not know other participants' earnings. On average, each household earned PHP 1,210 (around AUD 36), which is equivalent to four daily wages for agricultural labour[13], with a maximum amount of PHP 2,300 (around AUD 68). This was on top of the PHP 250 show-up fee.

3.3.5 **Latent class clustering analysis**

The LC clustering method was used to identify the existence of distinct segments of rice farming households based on their preferences for the ten rice VTIs. Households' investment shares for each of the ten VTIs were used as proxies for preferences. Thus, investment shares / preferences were used as 'indicator variables' in the LC clustering. Preferences were continuous variables representing households' investment (joint husband and wife allocation) of their endowment fund across the ten different VTIs.

Following Vermunt and Magidson (2016), the basic LC cluster model for continuous indicator variables under the assumption of local independence among all indicators and without covariates can be specified as:

$$f(y_i) = \sum_{x=1}^{K} P(x) \prod_{t=1}^{T} f(y_{it}|x)$$

where, y_i is a vector of indicator variables (household investment shares), x is a latent class variable, $f(y_i)$ is the probability density of a particular set of vector y_i, $f(y_{it}|x)$ is the probability density of predictor t given x.

To identify the optimal number of clusters, the most widely used model selection tools are information criteria such as the Akaike Information Criteria (AIC) and Bayesian Information Criteria (BIC). When comparing models with

[13] At the time of the experiment, the typical daily wage rate for agricultural labour in the province was around PHP 334.

different numbers of clusters, the lower the value of the AIC or BIC, the better the fit (Vermunt and Magidson 2005).

Additionally, LC cluster models can also be assessed based on how well the latent classes are separated using the classification likelihood criterion (CLC) and the approximate weight of evidence (AWE). The lower the value of these classification statistics, the better (Vermunt and Magidson 2016). However, as these formal guides/rules can sometimes be difficult to achieve in real practice, the selection of the number of clusters can also be based on the parsimony and interpretability of the model (Swait 1994).

A basic assumption of the LC model is the local independence assumption, which states that indicators are mutually independent given that an individual belongs to a certain latent class (Vermunt and Magidson 2016). A violation of this assumption would mean lack of fit of an LC model. This assumption can be tested using the bivariate residuals (BVR): a BVR value larger than 3.85 implies a correlation between a pair of indicators that the model failed to capture/explain (Vermunt and Magidson 2005). We examined this in our paper and found local dependencies among our set of indicators. To relax the local independence assumption, we allowed direct associations between pairs of indicators that had BVR values greater than 3.85 (Vermunt and Magidson 2016). The LC cluster analysis was carried out using Latent Gold 5.1 (Vermunt and Magidson 2005, Vermunt and Magidson 2016).

A post-hoc analysis was carried out to examine possible differences among clusters in terms of preferences for VTIs, and household, farm, and marketing characteristics.

3.4 Results and Discussion

3.4.1 **Household investment shares in rice VTIs**

Table 3.2 shows the mean investment share for each VTI by cropping season. Interestingly, there are some differences in mean investments across the wet and dry season. In the wet season, the VTI 'lodging tolerance' had the highest mean investment share (21% in the wet season versus only 6% in the dry season). However, in the dry season, the VTI 'insect resistance' received the highest mean investment share (23% in the dry season versus 19% in the wet season). Mean investment shares for the grain quality traits: 'slenderness', 'aroma' and 'head rice recovery' were significantly higher in the dry season than in the wet season. Mean investment in 'abiotic stress tolerance' was significantly higher in the wet season compared to the dry season.

Table 3.2 Mean joint investment shares by VTI and cropping season

VTI	Wet season (n=122)				Dry season (n = 122)				Mean Diff.
	Mean	Std. Dev.	Min	Max	Mean	Std. Dev.	Min	Max	
Grain quality traits									
Slenderness	0.07	0.14	0.00	0.70	0.11	0.17	0.00	0.72	-0.04***
Stickiness	0.04	0.11	0.00	0.50	0.04	0.11	0.00	0.55	0.01
Aroma	0.03	0.09	0.00	0.40	0.05	0.12	0.00	0.45	-0.02**
Head rice recovery	0.05	0.13	0.00	0.55	0.10	0.18	0.00	0.65	-0.05***
Stress tolerance traits									
Lodging tolerance	0.21	0.21	0.00	1.00	0.06	0.13	0.00	0.47	0.15***
Disease resistance	0.15	0.20	0.00	0.63	0.17	0.21	0.00	0.68	-0.02
Insect resistance	0.19	0.20	0.00	1.00	0.23	0.20	0.00	1.00	-0.04*
Abiotic stress tolerance	0.11	0.20	0.00	0.80	0.08	0.17	0.00	0.69	0.04*
Reduction in shattering	0.10	0.12	0.00	0.53	0.12	0.14	0.00	0.54	-0.02
Agronomic trait									
Earliness	0.04	0.10	0.00	0.45	0.04	0.10	0.00	0.48	0.00

Source: IGA Philippines Survey 2016

Note: Mean difference is wet season investment share minus dry season investment share.

***, **, * denote statistical significance at the 1%, 5%, and 10% levels, respectively.

3.4.2 **LC cluster analysis**

Using Latent GOLD software version 5.1, we estimated models ranging from one- to six-clusters. The BIC on the log-likelihood (LL) was used to identify the best cluster model, as measured by the lowest BIC value (Table 3.3). The four-cluster solution has the lowest BIC value. Further, a four-cluster model with local dependencies among the indicators yielded an improved model fit (i.e. lower BIC value and classification error). Thus, the results presented and discussed in detail are based on the four-cluster model with local dependencies.

Table 3.3 Analysis of model selection

Model	**LL**	**BIC(LL)**	**Number of parameters**	**Classification error**
1-Cluster	1240.16	-2288.15	40	0.000
2-Cluster	1485.16	-2677.28	61	0.000
3-Cluster	1590.66	-2787.38	82	0.000
4-Cluster	1652.22	-2809.63	103	0.004
5-Cluster	1675.56	-2755.42	124	0.001
6-Cluster	1748.15	-2799.73	145	0.006
4-Cluster[a]	2140.16	-3670.21	127	0.000

LL = Log-likelihood, BIC = Bayesian information criterion
Note: [a] Final model includes local dependencies among indicators that had BVR values greater than 3.85.

3.4.3 **Characterization of the clusters**

Table 3.4 shows the replacement varieties selected by each cluster. Table 3.5 summarizes the statistics for the rice VTIs for each of the four clusters. Cluster names/labels are also provided, and these labels attempt to characterise each cluster based on the VTI or VTIs with the highest investment share(s) for the cluster.

Table 3.6 shows the results of the post-hoc analysis of the four clusters' household, farm, and marketing characteristics. It is worth noting that a multinomial logit (MNL) regression was also carried out to examine determinants of cluster membership (see Appendix Table 3.A1). The significant variables in the MNL regression were almost identical to the post-hoc analysis; however, for ease of comparison we opted to discuss in detail the results from the post-hoc analysis.

Table 3.4 Replacement varieties selected by each cluster

	Cluster 1		Cluster 2		Cluster 3		Cluster 4	
Season / Replacement variety	**Stress Tolerance Focused**		**Mixed-focus**		**Insect Resistance & Earliness Focused**		**Grain Quality Focused**	
	Freq.	Percent	Freq.	Percent	Freq.	Percent	Freq.	Percent
Wet Season								
NSIC Rc 222	47	75.81	32	88.89	11	84.62	10	90.91
NSIC RC 216	11	17.74	3	8.33	2	15.38	0	0.00
Others	4	6.45	1	2.78	0	0.00	1	9.09
Dry Season								
SL-8H	43	69.35	21	58.33	9	69.23	6	54.55
NSIC Rc 222	7[a]	11.29	9	25.00	2	15.38	5[a]	45.45
Others	12	19.35	6	16.67	2	15.38	0	0.00

Source: IGA Philippines Survey 2016
Note: Using Chi-square test, the same superscript letters in each row indicate statistically significant differences in values between columns at the 5% level.

Table 3.5 Mean VTI investment shares by cluster

Season/VTI	Cluster 1 Stress Tolerance Focused	Cluster 2 Mixed-focus	Cluster 3 Insect Resistance & Earliness Focused	Cluster 4 Grain Quality Focused
Cluster size	50%	30%	11%	9%
Wet Season				
Grain quality traits				
Slenderness	0.03^{a}	0.10	0.02^{b}	$0.25^{a,b}$
Stickiness	0.03	0.03	0.08	0.10
Aroma	0.00^{a}	0.00^{b}	0.00^{c}	$0.31^{a,b,c}$
Head rice recovery	0.03	0.04	0.17	0.07
Stress tolerance traits				
Lodging tolerance	0.23^{a}	0.23^{b}	0.18	$0.04^{a,b}$
Disease resistance	$0.23^{a,b,c}$	$0.10^{a,d}$	0.05^{b}	$0.00^{c,d}$
Insect resistance	0.21^{a}	0.18	0.23^{b}	$0.06^{a,b}$
Abiotic stress tolerance	0.09	0.18	0.10	0.04
Reduction in shattering	0.12^{a}	0.11	0.08	0.04^{a}
Agronomic trait				
Earliness	0.02	0.04	0.08	0.09
Dry Season				
Grain quality traits				
Slenderness	$0.05^{a,b}$	0.16^{a}	0.12	0.24^{b}
Stickiness	0.02	0.05	0.00	0.11
Aroma	0.03^{a}	0.04^{b}	0.00^{c}	$0.25^{a,b,c}$
Head rice recovery	0.05	0.15	0.23	0.06
Stress tolerance traits				
Lodging tolerance	$0.12^{a,b,c}$	0.01^{a}	0.00^{b}	0.00^{c}
Disease resistance	$0.33^{a,b,c}$	0.00^{a}	0.00^{b}	0.06^{c}
Insect resistance	0.23	0.28^{a}	0.25	0.09^{a}
Abiotic stress tolerance	0.06	0.12	0.02	0.07
Reduction in shattering	0.11	0.18^{a}	0.08	0.03^{a}
Agronomic trait				
Earliness	0.00^{a}	0.00^{b}	$0.29^{a,b,c}$	0.09^{c}

Note: Means within a row with the same superscript letters are statistically different at the 5% level (post-hoc Games-Howell test).

Table 3.6 Means of household, farm, and marketing characteristics

Variable	Description	Cluster 1 Stress Tolerance Focused	Cluster 2 Mixed-focus	Cluster 3 Insect Resistance & Earliness Focused	Cluster 4 Grain Quality Focused
Age – husband	Age of husband in years	49.85[a]	48.31[b]	52.15[c]	61.73[a,b,c]
Age – wife	Age of wife in years	47.10[a]	44.81[b]	49.31	58.18[a,b]
Education – husband	Years in school of husband	8.34	8.39	8.54	8.82
Education – wife	Years in school of wife	8.19	8.08	8.62	7.64
Farm experience – husband	Years of farming experience of husband	27.68	23.75	30.31	31.73
Farm experience – wife	Years of farming experience of wife	17.98	16.31	20.69	26.82
Training attendance – husband	1 – attended agricultural training in the past, 0 – otherwise	0.71	0.61	0.85	0.73
Training attendance – wife	1 – attended agricultural training in the past, 0 – otherwise	0.13	0.19	0.31	0.18
Membership in organization – husband	1 – member of an organization, 0 – otherwise	0.44	0.50	0.46	0.64
Membership in organization – wife	1 – member of an organization, 0 – otherwise	0.37	0.28	0.23	0.64
Time preference – husband	Preference for present values as measured by a discount factor	1.71[a]	0.53[a]	4.54	1.36
Time preference – wife	Preference for present values as measured by a discount factor	1.73	1.00	1.42	0.93
Willingness to invest in farming – husband	1 – extremely unlikely, 2 – unlikely, 3 – neutral, 4 – likely, 5 – extremely likely	4.97	4.97	5.00	4.64
Willingness to invest in farming – wife	1 – extremely unlikely, 2 – unlikely, 3 – neutral, 4 – likely, 5 – extremely likely	4.77[a]	4.75[b]	4.85	5.00[a,b]
Past experience – husband	1 – investment preference for VTIs based on past experience, 0 – otherwise	0.65	0.44	0.62	0.82
Past experience – wife	1 – investment preference for VTIs based on past experience, 0 – otherwise	0.45	0.44	0.38	0.36

Table 3.6 Continued

Variable	Description	Cluster 1 Stress Tolerance Focused	Cluster 2 Mixed-focused	Cluster 3 Insect Resistance & Earliness Focused	Cluster 4 Grain Quality Focused
Household size	Number of household members	4.56	4.53	5.69	4.27
Income	Annual family income in ‘000 PHP	69.10	76.08	74.82	92.83
Farm size	Total landholdings in hectares (own + lease)	1.50[a]	1.22	0.86[a]	0.98
Percent leased area	Proportion of leased area to total landholdings	0.43	0.53	0.31	0.49
Yield	Production per hectare in kilograms	6.26	6.15	6.52	5.81
Distance to market	Distance of the farm to market in km	3.78	5.58	3.08	2.36
Proportion sold	Proportion of total production sold	0.67	0.63	0.57	0.53
Buyers’ standard requirement	1 – buyers require certain quality standards, 0 – otherwise	0.69	0.47	0.69	0.55
Knows the end market	1 – knows the end market for their rice crop, 0 – otherwise	0.29	0.44	0.31	0.45
Market information	1 – with market information, 0 – otherwise	0.40	0.56	0.46	0.82
Climate change information	1 – with climate change information, 0 – otherwise	0.50	0.50	0.54	0.64

Note: Means within a row with the same superscript letters are statistically different at the 5% level (post-hoc Games-Howell test).

Cluster 1 is the largest segment with 50% of the households (Table 3.5). Most of the households in Cluster 1 selected NSIC Rc 222 in the wet season and SL-8H in the dry season as their replacement varieties (Table 3.4). These (dominant) replacement varieties are relatively inferior to other varieties with respect to other traits, such as tolerance to stress and resistance to pests and diseases. Hence, compared to other clusters, Cluster 1 invested significantly more in lodging tolerance and disease resistance in the wet season. They had also high investment shares in insect resistance and reduction in shattering in both the wet and dry seasons. On the other hand, they invested significantly less in slenderness and aroma in both seasons. This cluster was thus labelled the 'Stress Tolerance Focused Cluster'. Husbands in this cluster had a significantly higher discount factor compared to husbands in Cluster 2, while the wives had the highest discount factor compared to the wives in other clusters (Table 3.6). Households in this cluster had the largest farm size compared to other clusters and they also had the highest proportion of production that was sold versus saved for home use.

Previous literature has found farm size to be a determinant of household income in rice growing villages in the Philippines (Estudillo, Sawada and Otsuka 2008, Takahashi and Otsuka 2009). This may explain why households in Cluster 1 placed higher priority towards the stress tolerance traits. If farmers can plant varieties with improved resistance and tolerance to different biotic and abiotic factors, then they have a higher probability of maximizing production per unit of area, which can then lead to higher incomes.

Cluster 2, which accounts for 30% of the households, had significantly higher investment shares in lodging tolerance in the wet season compared to other clusters. Moreover, households in this cluster had significantly higher investments in slenderness, insect resistance, and reduction in shattering in the dry season. This cluster was labelled the ‘Mixed-focus Cluster’. Households in the ‘Mixed-focus Cluster’ prioritized these traits to address the poor tolerance to stress and resistance to pest performance of the dominant replacement varieties NSIC Rc 222 and SL-8H (Table 3.4). The ‘Mixed-focus Cluster’ also considered consumer preferences by investing in slenderness, a trait that is lacking in SL-8H.

Couples in the ‘Mixed-focus Cluster’ were the youngest and had the least experience in rice farming compared to the couples in other clusters (Table 3.6). Husbands in this cluster had the lowest discount factor. This may explain why they did not invest in earliness; as there may be little “urgency” for them in terms of having an early harvest. Two characteristics may explain why households in the ‘Mixed-focus Cluster’ invested both in grain quality and stress tolerance traits. Their farm was the farthest from the market. This may imply that distance of the farm to market is not a constraint to technology adoption for this cluster. This may be due to the presence of several buying stations and agents in the villages competing for paddy rice (Dela Peña 2014), which enables farmers to sell their harvest without travelling far from their area.

The ‘Mixed-focus Cluster’ also had a high share of households who were aware of the end market for their rice crop. In the Philippines, there is the “suki” system, where farmers have an opportunity (and often a preference) to sell to a specific buyer or trader because of familiarity with the buyer (Dawe et al. 2008, Dela Peña 2014). This kind of farmer-buyer relationship may imply the presence of trust and openness, which facilitates the exchange of information that can help both parties in their decision-making.

Cluster 3 accounts for 11% of the households (Table 3.5). Most of the households in Cluster 3 selected NSIC Rc 222 as their replacement variety in the wet season (Table 3.4). To address the limited resistance of NSIC Rc 222 to pests, Cluster 3 households invested significantly more in insect resistance in the wet season. In the dry season, majority of the households in this cluster identified SL-8H as their replacement variety (Table 3.4). Although SL-8H is an early maturing variety, farmers still preferred to shorten the days to maturity by investing more in the earliness. This cluster was thus labelled as the 'Insect Resistance and Earliness Focused Cluster'. In terms of grain quality traits, households in this cluster had high investments in head rice recovery in both wet and dry seasons, but invested significantly less in slenderness in the wet season and aroma in both seasons.

Several characteristics may provide explanation why households in this cluster prioritized insect resistance, earliness, and head rice recovery. The discount factor of the husbands was the highest among other clusters and they had the smallest farm size (Table 3.6). Farmers can still earn higher income even with a smaller farm area if they can improve the quality of their rice harvest, which can command higher prices in the market. With higher discount factor, households tend to invest more in earliness since growing early maturing varieties can allow early harvest and potentially avoiding severe weather conditions (Laborte et al. 2015). Early maturing varieties can also provide farmers the opportunity to plant high-value crops in between seasons, or plant the next season rice earlier. Thus, smallholder farmers can both maximize production per unit of area and increase their incomes.

Cluster 4, the smallest cluster with 9% of the households, was labelled as the 'Grain Quality Focused Cluster' as they invested around 60% of their endowment fund in aroma, slenderness, and stickiness combined (Table 3.5). Their investments in slenderness and aroma are significantly higher compared to other clusters.

Most households in the ‘Grain Quality Focused Cluster’ selected NSIC Rc 222 in the wet season and SL-8H in the dry season as their replacement varieties (Table 3.4). In the dry season, the proportion of Cluster 4 households that identified NSIC Rc 222 as their replacement variety was significantly higher than the proportion of Cluster 1 households that also chose NSIC Rc 222 as their replacement variety (Table 3.4). Although NSIC Rc 222 has already the grain quality traits that consumers prefer (long and slender), Cluster 4 households invested more in aroma. NSIC Rc 222 is a non-aromatic variety. In the dry season, Cluster 4 households also invested more in slenderness, a trait that is lacking in the replacement variety SL-8H.

The couples in the ‘Grain Quality Focused Cluster’ were significantly older, and were the most experienced in rice farming (Table 3.6). Compared to other clusters, the husbands in Cluster 4 were the most educated, while the wives were the most willing to invest in rice farming. Perhaps because of their extensive farming experience and higher level of education, households in this cluster become aware that good quality grains (e.g. aromatic rice varieties) can command higher prices in the market. This may explain their higher investment shares in grain quality traits.

3.5 Conclusions

This paper examined heterogeneity in farmer preferences for improvements in rice variety traits using data gathered from experimental games conducted in Nueva Ecija, Philippines. A latent class cluster approach was employed to identify different segments of rice producing households and their distinct preferences. The identified clusters were characterised post-hoc using household, farm, and marketing characteristics. The results suggest that accounting for heterogeneity in preferences is important as farmers have different socio-economic characteristics, and operate in different production and marketing systems, all of which appear to influence their investments in VTIs.

The LC cluster analysis revealed four segments of rice farming households, each with unique preferences for VTIs. This is in line with previous studies that have identified different segments of farmers based on their preferences for variety attributes (Birol, Smale and Yorobe Jr 2012, Dalton, Yesuf and Muhammad 2011, Kassie et al. 2017, Ward et al. 2014). The identified clusters were: stress tolerance focused (50%), mixed-focused cluster (30%), insect resistance and earliness focused (11%), and grain quality focused (9%).

Results also suggest that different farmers have different priorities in terms of their needs for variety traits. As such, breeding research will have to continue to develop different varieties with different sets of traits to address the distinct characteristics and needs of the farmers. Varieties resistant to pests and diseases and those tolerant to abiotic stress will appeal to farmers with larger farm size. This was particularly true for households in the largest segment (50%) of farmers, the ‘Stress Tolerance Focused Cluster’. With these types of varieties and larger farm area, they will be able to maximize production per unit of area, and consequently increase their incomes.

Early maturing varieties would be preferred or demanded by farmers with higher discount factor or those who place higher values on the present relative to the future. Households in the ‘Insect Resistance and Earliness Focused Cluster’ (11%) will benefit from this variety as they have high discount factor. Varieties with improved grain quality traits will appeal to both young with less farming experience (‘Mixed-focus Cluster’) and older with more experience farmers (‘Grain Quality Focused’). Farmers who are informed on marketing related matters, such as the end market for their rice crop, will most likely demand such varieties as well (e.g. those in the ‘Mixed-focus Cluster’).

Although we found four unique segments of farmers, there are limitations in terms of the generalization of the findings to a larger population of farmers. This is because our sample selection is limited to just one province in the Philippines and it is focused on rice farmers. Farmers in other areas or provinces would also have distinct profiles and operate facing production and marketing systems with different characteristics. As such, it is recommended that similar research is done on other rice-producing provinces to identify further differences in preferences, which can help in the development of rice varieties that are better suited to the unique preferences and needs of the farmers.

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Appendix

Table 3.A1. Multinomial logistic regression results for cluster membership determinants

Variable	Cluster 2 Mixed-focus	Cluster 3 Insect Resistance & Earliness Focused	Cluster 4 Grain Quality Focused
Age – husband	-0.0117 (0.0546)	0.0462 (0.0834)	1.7546* (0.9312)
Age – wife	-0.0079 (0.0580)	0.0202 (0.0816)	-0.7430* (0.3970)
Education – husband	-0.0090 (0.1190)	-0.0202 (0.1542)	-0.4454 (0.6507)
Education – wife	-0.0114 (0.1275)	0.2431 (0.1825)	-2.0115 (1.3348)
Time preference – husband	-0.7451** (0.3065)	0.0806 (0.0644)	0.2323 (0.2198)
Time preference – wife	-0.1135 (0.1519)	-0.1205 (0.1763)	-5.0527* (2.8051)
Past experience – husband	-0.6818 (0.5190)	-0.1442 (0.7654)	20.4711 (12.8456)
Past experience – wife	-0.0689 (0.5103)	0.1460 (0.7268)	-1.8292 (4.2704)
Annual family income	0.0056 (0.0055)	0.0075 (0.0073)	0.1536* (0.0820)
Farm size	-0.4773 (0.3061)	-1.2478* (0.7474)	-0.0146 (2.1542)
Percent lease area	0.8540 (0.6618)	0.4602 (0.8416)	2.1177 (3.1300)
Distance to market	0.0650 (0.0459)	0.0092 (0.0805)	-0.4837 (0.3303)
Proportion sold	-0.3498 (1.4089)	-1.8185 (1.9953)	-31.3158* (17.1560)
Market information	0.5769 (0.5090)	0.1643 (0.7205)	7.5657 (5.6328)
Climate change information	-0.2501 (0.5290)	0.3752 (0.7465)	8.2377* (4.6143)
Constant	1.3742 (2.5810)	-5.2958 (3.8108)	-62.2584* (37.7351)

Notes: The coefficients reflect the effect of the variables on the likelihood of cluster membership relative to membership in stress tolerance focused (Cluster 1 = base outcome).
N = 122, Log likelihood = -94.53.
Standard errors in parentheses; * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Chapter 4 – Statement of Authorship

Title of Paper	Using Experiments to Understand Gender Influence on Intrahousehold Decision Making for Investment in Rice Varietal Trait Improvements
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Principal Author

Name of Principal Author (Candidate)	Rio Lawas Maligalig		
Contribution to the Paper	Led and conducted data collection, contributed to development of experiment protocol, performed data analysis and interpretation, and wrote manuscript.		
Overall percentage (%)	65%		
Certification:	This paper reports on original research I conducted during the period of my Higher Degree by Research candidature and is not subject to any obligations or contractual agreements with a third party that would constrain its inclusion in this thesis. I am the primary author of this paper.		
Signature		Date	21/12/2017

Co-Author Contributions

By signing the Statement of Authorship, each author certifies that:

i. the candidate's stated contribution to the publication is accurate (as detailed above);
ii. permission is granted for the candidate to include the publication in the thesis; and
iii. the sum of all co-author contributions is equal to 100% less the candidate's stated contribution.

Name of Co-Author	Dr Matty Demont		
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Chapter 4: Using Experiments to Understand Gender Influence on Intrahousehold Decision Making for Investment in Rice Varietal Trait Improvements

Abstract

We examined household decision making on investment in future rice varietal trait improvements (VTIs) using an experimental investment game methodology. In the investment game, couples from rice farming households had to select, first individually and then jointly, a replacement rice variety to improve. They were asked to allocate a research endowment fund to specific traits that they would like to see improved. Specific objectives were to examine (i) how a couple's joint decision relates to their individual decisions with respect to the choice of a replacement variety and investment in VTIs, and (ii) which factors increase wives' intrahousehold decision-making power with respect to the choice of VTIs. For 72% of the household observations, the replacement variety selected by the husband and wife in the individual round, was the same as the replacement variety they selected in the joint round. Total agreement in replacement variety choice was more likely if the wife was working on-farm and was a member of an organization. Agreement was less likely if the wife was the sole decision maker or dominated the decision-making process with respect to storing and marketing rice. The wife had more influence on the joint decision on VTIs if she was employed off-farm, but less influence if she has the same religion as her husband. The findings have implications not only for variety development, but also on the importance of considering gender roles in technology adoption decisions and extension programs.

Chapter 4: Using Experiments to Understand Gender Influence on Intrahousehold Decision Making for Investment in Rice Varietal Trait Improvements[14]

4.1 Introduction

Women make significant contributions to the agriculture sector in many developing countries (Food and Agriculture Organization 2011). Until recently, the common belief is that women in rural areas of developing countries are disadvantaged such that they do not have equal access to resources and opportunities compared to men. However, this may not be the case in four Southeast Asian countries: Myanmar, Thailand, Indonesia, and the Philippines. For example, a recent study by Akter et al. (2017) revealed that compared to men, women in these countries actually have the same level of access to resources, including land and production inputs. Further, Akter et al. (2017) found that women, may, in fact, have greater control over household income. As a result, they may have relatively higher participation and more influence in household decisions compared to women in other developing countries.

Farming households, like any other households, are faced with multiple decisions on tasks and activities. One particular area of decision making in farm production is which agricultural technologies to adopt. A key area that has been examined in the adoption literature is farmer preferences for technology attributes. Numerous empirical studies focus on this as adoption decisions are influenced not only by socio-economic, demographic or institutional factors, but also by how farmers perceive the specific traits of the technology (Adesina and Baidu-Forson

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1995, Adesina and Zinnah 1993, Pingali, Rozelle and Gerpacio 2001, Sall, Norman and Featherstone 2000).

Most of the studies that have been conducted on farmer preferences for variety traits elicited preferences of the household head, either male or female, implicitly assuming that his or her preferences represent that of the whole household (Asrat et al. 2010, Ghimire, Wen-chi and Shrestha 2015, Hintze, Renkow and Sain 2003, Horna, Smale and Oppen 2007, Joshi and Bauer 2006, Kshirsagar, Pandey and Bellon 2002, Mahadevan and Asafu-Adjaye 2015, Pant, Gautam and Wale 2011).

In some previous studies, preferences for variety traits were elicited from both male and female farmers (Dalton, Yesuf and Muhammad 2011, Ortega and Ward 2016). For example, in a previous study on Participatory Varietal Selection (PVS) programs, female farmers were specifically invited to test on their own fields and evaluate selected varieties (Courtois et al. 2001, Paris et al. 2008, Paris et al. 2001). The aim was to better understand women’s preferences in order to develop interventions that could help them make more informed decisions.

Despite common assumptions, empirical evidence from previous studies suggests that farm production decisions, including adoption, are decided within a household with participation of both husband and wife (Alwang, Larochelle and Barrera 2017, Doss, Meinzen-Dick and Bomuhangi 2014, Gilligan et al. 2014, Lambrecht, Vanlauwe and Maertens 2016, Marenya, Kassie and Tostao 2015, Sumner, Christie and Boulakia 2016, Tiruneh et al. 2001, Twyman, Useche and Deere 2015). However, adoption literature rarely examines the intrahousehold dynamics and process of decision making in technology adoption.

4.1.1 **Study objectives**

The main objective of this paper is to answer the following questions: How does a smallholder farming couple's joint decision relate to their individual decisions with respect to the choice of replacement variety? What are the factors that are related to a stronger influence of the wife on the joint decision with respect to the choice of rice varietal trait improvements (VTIs)? To answer these questions, we conducted a framed field experiment using the Investment Game Application (IGA) with selected rice farming households in Nueva Ecija, Philippines.

4.1.2 **Contribution to the literature and overview of methods**

Our study adds to the literature in three ways. First, we contribute to the adoption literature as we examine farmer preferences for *both* individual and joint household decision making in the context of improvements in rice variety traits. We examine the relative influence of a spouse in a joint decision, which has not previously been given much consideration in past adoption studies. Second, we contribute methodologically as we employ a new and innovative experimental investment game to elicit both individual and joint preferences. The information elicited via the investment game provides insights into the dynamics of decision making in farming households. Lastly, we contribute to the growing body of literature on gender and intrahousehold decision making by considering specifically farming households and their intrahousehold preferences for technology attributes.

The Philippines presents an interesting setting to examine the dynamics of intrahousehold decision making. Based on the statistics on the marital status of the population of 15 years old and over, 55% are married with the majority of the households having a male as head (Philippine Statistics Authority 2016a). In rural households, resources are typically pooled (Eder 2006) and husbands usually entrust part or all their income to their wives (Pajaron 2016, Upadhyay and Hindin 2007). Wives share the control over these resources with the husband and they decide jointly on how to allocate them. They also decide jointly on household plans and activities. Moreover, in the Philippines, wives usually have more control in decisions related to household budgeting and/or expenditures (David 1994, Eder 2006, Hindin and Adair 2002). In rice farming households, decisions on household and farm activities are jointly made by husbands and wives, although the level of influence a spouse has in the process still depends on several factors such as education level and on-farm employment (Hwang et al. 2011, Quisumbing 1994). In terms of land ownership, the passage of a new Land Law in 2001 ensured that both husband and wife are identified as owners. Since then, 78% of land titles have been granted for joint ownership (Asian Development Bank 2013). Within this setting we examine household preferences in the context of joint decision making.

Due to difficulties in observing the actual household decision making processes, empirical work on intrahousehold issues have increasingly relied on experimental games. Through experimental methods, one can gain a deeper understanding of the dynamics of intrahousehold decision making and resource allocation (Doss 2013). For example, Beharry-Borg, et al. (2009) used a choice experiment to elicit couples' individual and joint preferences for beach sites to visit in Tobago while on vacation. Dosman and Adamowicz (2006) combined stated and revealed preference techniques to obtain both individual and household choice of vacation sites to visit. Several studies used experimental games with real pay-offs to examine couple's individual and joint decisions. These studies examined how decisions made individually by couples differ from the decisions they made jointly (Bateman and Munro 2005, Munro, Bateman and McNally 2008) and which spouse has more influence on the joint decision (Carlsson et al. 2012, Carlsson et al. 2013, de Palma, Picard and Ziegelmeyer 2011).

Similar to these studies, we employ experimental games with real pay-offs to elicit intrahousehold preferences for rice VTIs. Stated preference methods on future products which are not yet available rely on hypothetical scenarios, which make them prone to hypothetical bias (Hensher 2010, List and Gallet 2001, Little and Berrens 2004, Murphy et al. 2005).

Using an experimental methodology based on investment games, we elicited preferences of husbands and wives, individually and jointly, for VTIs. The investment game is designed to reduce hypothetical bias. Similar to a common investment game where there are two players – a sender and a receiver, the investment game in this study also involves a sender, which is the farmer and a receiver, a public research institution (i.e. International Rice Research Institute (IRRI)).

Farmers were given an endowment fund and were asked to decide how much they would send to the receiver. This amount can essentially be considered to be a proxy for the amount the farmer was willing to contribute to or invest in public breeding research for specific VTIs and can also be considered as an indication of a trusting behaviour (Berg, Dickhaut and McCabe 1995, Kocher et al. 2015). Participant farmers were told that IRRI would return an amount to the farmer depending on the expected performance of the portfolio of VTIs chosen. This can be seen as an indication that the receiver is keeping the trust or reciprocating the sender's trusting behaviour (Berg, Dickhaut and McCabe 1995). By rewarding farmers with a return on their investment, the experiment is less hypothetical than other elicitation methods (such as contingent valuation and discrete choice experiments). Farmers faced real incentives to contribute to breeding research instead of keeping most or all of their endowment fund.

The remainder of this paper is organized as follows. The next section discusses the models of household decision making, which provide the basis for our conceptual framework. Section 4.3 describes the experimental approach. Section 4.4 discusses the estimation strategy, followed by the presentation of empirical results in Section 4.5. Section 4.6 provides discussion and conclusions.

4.2 Conceptual Approach

4.2.1 Models of household decision making

Early models of household decision making assumed a unitary framework, wherein a household is considered as a single production or consumption unit (Becker 1965). In this framework, it is assumed that the household pools its resources, such as income, labour, land, and information. The allocation of such resources among household members is assumed to be determined by a single member, who is either motivated by self-interest or altruistic behaviour, and with the assumption that all members share the same preferences (Alderman et al. 1995, Doss and Meinzen-Dick 2015, Haddad, Hoddinott and Alderman 1997, Thomas and Chen 1994).

However, these assumptions can be misleading since preferences may differ in a household, and resources are not necessarily pooled (Attanasio and Lechene

2002, Duflo and Udry 2004, Hoddinott and Haddad 1995, Lundberg, Pollak and Wales 1997). The realisation that the aforementioned assumptions regarding household decision making may be flawed, led to the development of different collective models.

The collective models can be broadly classified into cooperative and non-cooperative models (Alderman et al. 1995, Haddad, Hoddinott and Alderman 1997). There are two types of cooperative models. The first one assumes that household decisions will always lead to pareto-efficient outcomes such that “no one can be made better off without someone being made worse off” (Alderman et al. 1995, p. 5). The second type of cooperative models relies on a game theory model in which a specific bargaining process is used to reach household allocation decisions (Manser and Brown 1980, McElroy 1990, McElroy and Horney 1981).

The second group of collective models, the non-cooperative approach, do not assume that households necessarily attain efficient allocation of resources. Rather, they assume that household members are not obligated to have a binding contract with each other (Alderman et al. 1995).

Ultimately, decision making and allocation of resources within a household are determined by the relative influence or bargaining power of each household member (Quisumbing 2003). Bargaining power cannot be observed directly; at best it can be represented by different proxies or indicators (Doss 2013).

Several studies considered the relative contribution to household income, participation in the labour market, and property or asset ownership as key determinants of authority in household decisions (Antman 2014, Attanasio and Lechene 2002, Doss 2006, Doss et al. 2014, Quisumbing and Maluccio 2003, Swaminathan, Lahoti and Suchita 2012, Twyman, Useche and Deere 2015). Other factors such as education (Alwang, Larochelle and Barrera 2017, Bertocchi, Brunetti and Torricelli 2014), social and political assets (Carlsson et al. 2012, Carlsson et al. 2013, Orr et al. 2016), and gender institutions and ideology (Bradshaw 2013, Mabsout and van Staveren 2010) have also been previously used as proxies. Participation or involvement in the decision-making process is also one of the factors that has been examined in the influence of the bargaining power of an individual within a household (Lépine and Strobl 2013, Reggio 2011, Smith et al. 2003, Sraboni et al. 2014).

4.2.2 **Conceptual basis**

Our conceptual framework is influenced by the insights provided by different models of intrahousehold resource allocation and decision making. We specifically examine the influence of bargaining power indicators on the outcomes of household decision making on improvements in rice variety traits. We examine this through an experimental methodology, which is increasingly used in recent years to understand intrahousehold dynamics.

In the study setting, a husband and wife from a rice farming household face both an individual, and a joint, two-stage decision-making process concerning improvements in rice variety traits. In the first stage, they had to select a replacement rice variety they wanted public rice breeding programs to improve upon. In the second stage, they had to decide which traits of this variety they wanted the rice breeding programs to focus on. To do this, they had to allocate an endowment fund to the different variety traits they wanted public rice breeding programs to focus on improving.

Both the husband and wife were aware of the amount of the endowment fund available to them during the individual decision-making process. However, both also had to decide independently on how to allocate the fund. Their individual decisions that were made in the previous round (i.e. on the choice of replacement variety and with respect to VTIs), were not known to their respective spouses. During the joint round, the same amount of endowment fund was provided. However, they needed to decide as a couple on how to allocate this to the VTIs they preferred. No structured guidelines on how to go about the joint decision-making process were set or implemented. These procedures are commonly adopted in social psychology literature (e.g., Laughlin and Hollingshead 1995).

We expected husband and wife to have different preferences for varieties and VTIs, which may have been conditioned or influenced by their different roles (experiences) and responsibilities in the household. Considering this, the outcome we will look at is the outcome of the joint decision making. The outcome of the decision making will depend on the bargaining power of each spouse. We consider a set of indicators of bargaining power and examine how they relate to the couple's joint decision on the replacement variety and on the relative influence of the wife on the VTIs.

4.3 Experimental Approach

4.3.1 Ethics approval

The University of Adelaide's Human Research Ethics Committee approved the study protocols and all data collection instruments (Ethics Approval Number H-

2016-010) (Appendix 6). Written informed consent was obtained from all individual participants prior to the actual experiment (Appendices 7-8).

4.3.2 **Study site and sampling**

We purposively selected Nueva Ecija to be the study site. Nueva Ecija is a major rice producing and predominantly irrigated province in the Philippines. This allowed us to capture rice farming households' preferences for VTIs in both wet and dry seasons. Our sample consisted of 122 rice-producing households, with both the husband and wife participating in the study.

We used a multi-stage sampling approach to obtain our survey sample. In the first stage, we purposely selected three municipalities, i.e. Muñoz, Talavera, and Guimba. In the second stage, we randomly selected four villages in each municipality. In the final stage, we randomly selected ten households per village.

We followed several steps in randomly selecting the villages and the rice producing households. First, we approached the Municipal Agriculture Office (MAO) in each of the municipality to obtain a master list of rice farming households. The master lists included information on the names of the farmers, and their respective rice areas, classified either under irrigated or rain-fed. Second, we approached the local officials of the villages selected and asked them to check and verify the names included in the master list. This was done to determine who among the list met the screening criteria for participant selection. The screening criteria were as follows: (i) both husband and wife should be involved in rice production or marketing activities; (ii) the household is planting rice in both wet and dry seasons; and (iii) the household is selling a portion of their rice production. Once the list was verified and checked, a new list per village was generated to include only those households that satisfied the selection criteria. We used a spreadsheet program to randomly select ten households per village from these lists to be invited to participate in the experiment. We also randomly selected another set of ten households to serve as a back-up list in case of no-show at the onset of the experiment.

The randomly selected households were invited through the designated local field coordinators in each of the selected villages. The local field coordinator was a village official in-charge of the Agriculture Committee in his or her village. The households were invited to participate through a letter, which explained the details of the research, and the schedule of the experiment. The invitation letters were sent two weeks before the scheduled experiment. Invited households were then reminded of the schedule two days before the actual experiment.

4.3.3 **Experimental design**

The experiment was framed around a hypothetical context wherein a public rice breeding program received a grant from a donor. The grant was distributed in small shares among farmers. As shareholders in the breeding program, farmers were given the opportunity to allocate their share to several alternative breeding programs for improving varietal traits. This was done through the use of IGA, a tablet-based application written in Microsoft Excel 2010 and designed to run on Windows 8 computer tablets.

In the IGA, farmers selected their preferred traits to be improved by pulling the VTI investment bars to the level they wanted a particular trait to be improved. This was done using the up and down spin buttons (Figure 4.1). Each level of improvement and combination of improvements had a corresponding cost, which was to be deducted from the farmer's share. Each level of improvement was also subject to a relative investment risk, which was defined as one minus the "probability of success", i.e. the probability that the level of improvement selected would be achieved by the public breeding program. The initial improvement of a trait is more expensive compared to the succeeding levels due to fixed start-up costs such as establishment of new laboratory or field experiments. The costs of improving the traits, either individual traits or a combination of several traits, were estimated through an expert elicitation workshop of breeders from IRRI and National Agricultural Research Systems (NARS) partners (Demont et al. 2015).

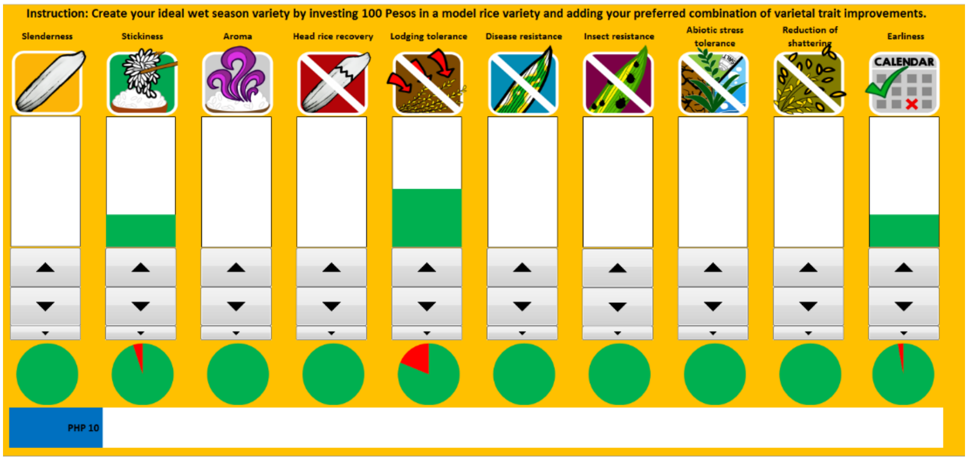

Figure 4.1 Investment Game Application (IGA) with example allocations in stickiness, lodging tolerance, and earliness. The blue horizontal bar at the bottom shows the status of the endowment fund, while the pie charts below the VTI bars indicate the riskiness of each investment – green segments represent the probability that the target VTI will be achieved; the red segments represent the odds of achieving a random VTI somewhere between zero and the target VTI

As previously discussed, the investment game in this study involved a sender, which was the farmer, and a receiver, which was IRRI. Farmers decided how much of their endowment fund to send to the receiver, that is, how much they would invest in public breeding research. IRRI then returned a pay-off (return on investment) to the farmer depending on the portfolio of VTIs chosen. The return on investment sent by the receiver back to the sender reduces the hypothetical bias of the experiment.

The amount that IRRI returned was the farmer's return to his/her investment portfolio composed of VTIs, subject to the risk incurred by public breeding research programs in achieving the selected VTIs. Returns to investment in public breeding research will normally be realized only after a new variety is released and adopted. This process will normally take about six years. In our study, breeding investment was framed as an investment with instantaneous return such that returns were calculated and given immediately to the farmer after they played the game.

Determining the replacement variety

At the start of the experiment, farmers were asked to identify a 'replacement variety'. The moderator of the experiment explained to participants that the replacement variety should be their most preferred variety, and that their selected replacement variety would provide the base upon which they would invest in breeding research to obtain their ideal variety. The moderator further explained that they may or may not have previously grown their replacement variety.

Selecting VTIs

After choosing a replacement variety, farmers then selected from among ten VTIs that they preferred to be improved. These VTIs can be broadly categorized into (i) grain quality traits – slenderness, aroma, stickiness, and head rice recovery; (ii) stress tolerance traits – lodging tolerance, disease resistance, insect resistance, abiotic stress tolerance, and reduction in shattering; and (iii) agronomic trait – earliness. The specific baseline and target metrics on which the IGA was calibrated is shown in Table 4.1.

Table 4.1 Traits and trait-specific metrics used to calibrate the IGA

Trait	Metric	Baseline	Target
Grain quality traits			
Slenderness	Length/width ratio	2.4	3.2
Stickiness	Amylose content (%)	27%	22%
Aroma	Price premium (%) (market benchmark = 100%)	0%	100%
Stress tolerance traits			
Head rice recovery	% head rice obtained from a sample of paddy	45%	60%
Lodging tolerance	Crop losses eliminated (%)	20%	80%
Disease resistance	Crop losses eliminated (%)	50%	90%
Insect resistance	Crop losses eliminated (%)	80%	95%
Abiotic stress tolerance	Crop losses eliminated (%)	0%	90%
Reduction in shattering	Crop losses eliminated (%)	80%	95%
Agronomic trait			
Earliness	Number of days the duration is shortened	0	14

Source: Demont et al. (2015)

The experiment was comprised of four information treatments that were used to test whether access to different pieces of forward-looking information affected farmers' investment preferences. The first information treatment was the control, where no information was provided. The second was the market information treatment, which included information on the most preferred rice traits of urban (Metro Manila) consumers (Custodio et al. 2016)[15]. The third treatment was climate change information. The information provided in this treatment included increasing climate variability and the rise in frequency of extreme weather events, which can produce more frequent droughts, floods, and

[15] Metro Manila is a major market for the rice produced in Nueva Ecija. Given the trends in consumption patterns and urbanization, this major market can provide farmers opportunities to increase their incomes if they will be able to provide the grain quality traits demanded by the consumers.

more uncertainty in rainy/wet season onset. The fourth information treatment combined both market information and climate change information.

The IGA was repeated over six rounds by each participating household. The husband (H) and wife (W) played the IGA for two seasons (wet (WS) and dry (DS)) both independently and simultaneously (jointly). They then played the IGA jointly (J) for two seasons as well. In each round, participants had an available endowment fund amounting to 100 Philippine pesos (PHP hereafter) (around AUD 2.95)[16] to invest in the VTIs. However, this amount was not given at the beginning of the experiment. Rather, a final pay-off was instead given at the end of the experiment.

On top of the final pay-off, a fixed 'show-up fee' amounting to PHP 250 (AUD 7) was paid to each household. This was equivalent to around three hours of paid agricultural labour per participant[17]. This number of hours corresponds to the average time farmers had to give-up to participate in the experiment[18].

4.3.4 Implementation and procedures

The 12 experimental sessions – one for each village selected – were held in local training and village halls. The sessions were conducted over the course of six days, each day had one in the morning and one in the afternoon. The 12 sessions were divided in four groups of three sessions for each of the four treatments. The assignment of an information treatment was randomly drawn prior to the start of

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[16] At the time of the experiment (February 2016), one Australian dollar (AUD) was equivalent to approximately PHP 34.
[17] At the time of the experiment, the minimum daily wage rate for agricultural labour in the province was PHP 334 (Philippine Statistics Authority 2016b).
[18] Pre-testing of the IGA experiment was conducted in Victoria, Laguna, Philippines in May 2015. The session took 2 hours to finish (Demont et al. 2015). The IGA experiment was then conducted in Eastern India in October 2015 and in Bangladesh in September–October 2016 (Ynion et al. 2015; 2016).

all experimental sessions. Each session ran through the following stages: (i) registration, (ii) introduction of the research team, (iii) explanation of the experiment, (iv) presentation and explanation of the IGA and VTIs, (v) training on the IGA, (vi) six consecutive rounds of IGA, (vii) short post-experiment survey, and (viii) payment of returns and closure of the session. The sessions were conducted using the local language, Filipino.

A household survey questionnaire was also administered to gather data on socio-demographic variables, rice varieties grown, constraints in rice production and marketing, and marketing practices. For reasons of efficiency in time management, this survey was also administered during the experimental sessions to households that were not being administered the IGA. This implies that some households responded to the questionnaire either before or after being administered the IGA.

Prior to administering the IGA, farmers were trained first in the methodology of investing with budget constraints by using the "Training on Investment Game Application" (TIGA). In TIGA, farmers invested in their optimal dish by adding a vegetable or meat dish to a fixed amount of rice, using a budget amounting to PHP 50 (AUD 1.47) (Figure 4.2). The purpose of the TIGA was to familiarise farmers with the application, particularly in terms of the budget constraint involved and the use of spin buttons on the tablet. It was important that the participants be given the opportunity to use the tablet before the actual game as most of them were not familiar or had not used a tablet before.

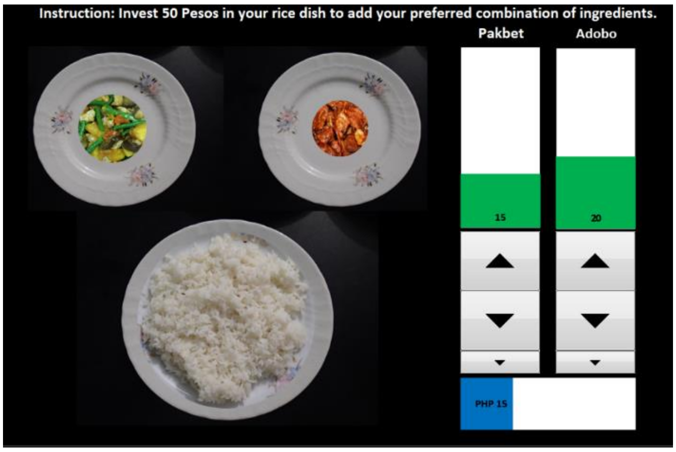

Figure 4.2 Training on Investment Game Application (TIGA) with example allocation of PHP15 to Pakbet (vegetable dish) and PHP20 to adobo (meat dish). The blue horizontal bar at the bottom shows the remaining budget

After the training and explanation of their tasks, husband and wife then played the IGA independently, as well as together. Each of them was assigned an agent who facilitated the IGA and the post-experiment survey. The post-experiment survey was also answered independently by husbands and wives. This was administered immediately after they played the IGA. The post-experiment survey included questions on the motivations behind their allocation decisions in IGA and a short quiz (two questions) to verify how well they had understood the experiment. After playing the IGA independently, husband and wife were asked to play the IGA jointly. A different agent was assigned per couple for the consensus round. To provide equal opportunity in answering the IGA during the consensus round, husband and wife were given separate stylus pens and the tablet was placed at the middle of their table. However, no further instructions were given and households were free to decide on whom should be dominating the discussions.

The final pay-off was determined by the "binding" round, which was randomly selected among the six rounds by using a dice (1 – H/WS, 2 – H/DS, 3 – W/WS, 4 – W/DS, 5 – J/WS, 6 – J/DS), as is commonly done in experimental economics (e.g., Lusk and Shogren 2007). One volunteer was requested to roll the dice to draw the binding round after all households completed six rounds of the IGA. The IGA computed a stochastic return to investment, which is a function of the individual VTI levels and risk levels associated with each VTI in the investment portfolio (Demont et al. 2015). The resulting cash returns were placed in an envelope and distributed to the couples one at a time. A single-blind payment protocol was used where the research team knew the participants' earnings but the participants did not know other participants' earnings. On average, each household earned PHP 1,210 (around AUD 36), which is roughly equivalent to four daily wages for agricultural labour[19], with a maximum of PHP 2,300 (around AUD 68). This was on top of the PHP 250 show-up fee.

4.4 Estimation Strategy

4.4.1 Joint decision on the replacement variety

Our first objective was to examine how a couple's joint decision relates to the couple's individual decisions with respect to the choice of a replacement variety. To estimate this, we used three categories of how couple's individual decisions relate to their joint decision: (i) total agreement, where spouse's individual replacement variety choice is exactly the same with their joint replacement variety; (ii) joint decision the same with either husband or wife; and (iii) joint decision not same with either husband or wife. We estimated the probability that the decision of the couple falls into one of these categories and the factors that condition this using a multinomial logit (MNL) specification:

[19] At the time of experiment, the typical daily wage rate for agricultural labour in the province was around PHP 334.

$$Y = \alpha + \beta_X X + \beta_H H + \beta_P P + \varepsilon_c$$

where Y represents the agreement/disagreement in the replacement variety, X is a matrix of couple characteristics, H is a matrix of household level characteristics, P are two specific farming decisions, and ε_c is the error term, clustered at the household level. α, β_X, β_H, and β_P are the vectors of coefficients to be estimated. Summary statistics of the dependent and independent variables are presented in Table 4.2.

In the MNL framework, the probability that household *i* falls into category *j* (P_{ij}) is specified as:

$$P_{ij} = \frac{exp\left(\alpha_j + X'_j\beta_j + H'_i\beta_j + P'_i\beta_j\right)}{\sum_{k=1}^{3} exp(\alpha_k + X'_i\beta_k + H'_i\beta_k + P'_i\beta_k)}, \qquad j = 1,2,3$$

where the coefficients and variables were described above. The marginal effect estimates show the change in probability of the j^{th} outcome given a change in the independent variable.

Table 4.2 Summary statistics for dependent and independent variables used in the multinomial logit model

Variable	**Definition**		**Freq.**	**Percent**	
Dependent variables					
Total agreement	Joint replacement variety is exactly the same with the couple's individual replacement variety		175	71.72	
Joint decision same with one of the spouses	Joint replacement variety is same with either husband or wife replacement variety		47	19.26	
Joint decision not same with either spouse	Joint replacement variety is not same with either husband or wife replacement variety		22	9.02	
Independent variables		**Mean**	**Std. Dev.**	**Min**	**Max**
Couple characteristics					
Difference in age	Gap in age (age of wife – age of husband)	-3.06	4.97	-20	13
Difference in education	Gap in education (years in school of wife – years in school of husband)	-0.26	2.87	-6	9
Difference in farming experience	Gap in rice farming experience (experience of wife – experience of husband)	-8.59	13.47	-50	24
Difference in attendance to training	-1 – only husband attended training, 0 – either both attended or both did not attend, 1 – only wife attended training	-0.52	0.58	-1	1
Difference in membership in organization	-1 – only husband is a member, 0 – either both are members or both are not members, 1 – only wife is a member	-0.12	0.66	-1	1
Difference in time preference	Gap in discount factor (wife discount factor– husband discount factor)	-0.22	4.88	-48	8.5
Difference in willingness to invest in farming*	Gap in willingness to invest in farming (willingness of wife – willingness of husband)	-0.15	0.54	-2	3
Difference in future perspective	-1 – only husband considered the future, 0 – either both considered the past or both considered the future, 1 – only wife considered the future	0.16	0.70	-1	1
Husband's primary occupation is farming	1 – primary occupation of husband is farming, 0 – otherwise	0.93	0.26	0	1
Wife's primary occupation is farming	1 – primary occupation of wife is farming, 0 – otherwise	0.09	0.29	0	1
Household characteristics					
Farm size	Total farm size in hectares (own + leased area)	1.30	1.04	0.18	6
Proportion of production sold	Proportion of rice production that is sold	0.63	0.22	0	1
Buyer requirement	1 – buyers require certain quality standards, 0 – otherwise	0.61	0.49	0	1
Farming decisions					
Wife decides on amount of rice to sell or store	1 – only wife decides or wife dominates, 0 – otherwise	0.11	0.32	0	1
Wife decides how to spend income from crop sale	1 – only wife decides or wife dominates, 0 – otherwise	0.82	0.39	0	1

Source: IGA Philippines Survey 2016

Note: * Willingness to invest in farming measured on a Likert scale: 1 - extremely unlikely; 2 - unlikely; 3 - neutral; 4 - likely; 5 - extremely likely.

4.4.2 Household and individual characteristics

The couple characteristics were specified as the difference between wife and husband (Table 4.2). On average, wives were three years younger, 0.26 years less educated, and had nine years less rice farming experience in comparison with their husbands. Only the husband attended agricultural training in the past, for more than half of the couples. The majority of the couples were either both members of an organization or both were not members. We also found distinct differences in the types of groups to which the husbands and wives belong. The husbands were members of production-oriented groups, such as the water users' association and credit cooperative. Wives, on the other hand, belonged to civic groups, such as the women's club and senior citizens association.

We included the differences in time preference and willingness to invest in rice farming of husband and wife (Table 4.2). We measured time preference through a discount factor which we estimated from a series of hypothetical questions relating to their preference of receiving a specific amount of cash now or a higher amount in a month's time (Coller and Williams 1999, Harrison, Lau and Williams 2002). We found that there was a difference of 0.22% with the wives having lower discount factor at 1.41% compared to husbands' discount factor of 1.63%.

Respondents were also asked to assess their willingness to invest in rice farming on a Likert scale, with five representing "extremely likely" and one as "extremely unlikely". We found a difference of 0.15 with wives having slightly lower willingness to invest at 4.80 compared to husbands' 4.94. We also asked the couples individually what they considered in prioritizing or selecting traits for improvement. We found that almost half of the couples had the same consideration: either both considered their past and current experience, or both thought about the future. But we also found that more than one third of the couples had different considerations: wives thought about the future while the husbands considered their past and current farming experience.

The differences in husband and wife characteristics and attitudes have gender implications in the sense that it is not only about women, but gender in general. For example, pronounced differences in favour of men may be associated with husbands dominating and exerting more influence in the household decision-making process. We then hypothesized that the differences would be more likely associated with non-agreement in the joint replacement variety decision.

In terms of occupation, 93% of the husbands indicated that they were primarily working in farming, while conversely, only about 9% of the wives were working in farming. We expected on-farm employment of the husband to be related to being less likely for couples to have total agreement on the joint replacement variety. The husband may dominate in this case such that the choice of a replacement variety is the same as his individual choice. We hypothesized that total agreement is more likely if the wife was also working on-farm. Working in the field would mean that the wife had knowledge of the performance of the varieties they grow as well as the other varieties available. With this, total agreement was expected to be more likely as compared to the husband dominating.

To control for the household's production- and marketing-related factors, we included relevant variables: farm size, proportion of the production that is sold, and whether buyers require certain paddy standards. On average, the households had 1.30 hectares of farm land, which included both owned and leased area. Of the total farm size, about 45% was leased. About 64% of the total production was sold, while the rest was for home consumption. Around 61% of the households said that their buyer/s required certain quality standards in terms of moisture content and cleanliness of the paddy.

Lastly, we included two specific farm decision-making questions: who in the household decides on the amount of rice to sell or store, and who in the household decides on how to spend income from crop sale (Table 4.3). In deciding on the amount of rice to sell or store, only 11% of the households said that either only the wife decides or the wife dominates in this decision-making area. On the other hand, around 82% said that either only the wife decides or the wife dominates in deciding how to spend the income from crop sale. We expected that these decision-making areas would also influence the joint decision on the replacement variety.

Table 4.3 Participation in crop choice and post-harvest decision making

Variable	Mean	Std. Dev.	Min	Max
Crop choice				
What crop to grow in the field	0.01	0.09	0	1
What rice variety to plant	0.02	0.13	0	1
Post-harvest operations				
Amount of rice to store or sell	0.11	0.32	0	1
Where to sell rice or other crops	0.09	0.29	0	1
When to sell rice or other crops	0.07	0.26	0	1
Selecting crop types and seed for the next growing season	0.02	0.16	0	1
Who decides how to spend income from crop sale	0.82	0.39	0	1
Where to store seeds	0.02	0.13	0	1

Source: IGA Philippines Survey 2016

Note: Who decides: 1 – wife only or wife dominates, 0 – otherwise.

4.4.3 **Relative influence of the wife on the joint VTIs**

We examined the factors that are related to a stronger influence of the wife on the joint decision. For this, we constructed a measure of the wife's influence on the joint decision with respect to the choice of VTIs. In this analysis, we only included those couples with the same replacement variety, both individually and jointly. Of the 244 observations (122 households x 2 seasons), 175 had the same replacement variety, both individually and jointly.

When conducting the IGA exercise, players were essentially constructing a portfolio of ten VTIs. These ten VTIs can be represented as a point in a ten-dimensional space. The entire experiment generates six points per household, i.e. four individual (husband and wife over two seasons) and two collective (joint decision over two seasons). We can reasonably assume that the closer the distance between the individual and collective decisions, the higher the intrahousehold decision-making power. Therefore, to construct a measure of intrahousehold decision-making power, we first compute the Euclidian distance between the portfolio of the ten VTIs selected by each individual in the household to the portfolio of ten VTIs chosen jointly using the following formula:

$$d_{mis} = \sqrt{\sum \left(VTI_{msk} - VTI_{jsk}\right)^2}$$

where d_{mis} is the distance of all the VTIs k chosen by spouse m of the i^{th} household in season s to the VTIs k chosen jointly in household j, $i=j$. We then construct a measure (λ) of wife's influence on the joint decision using the following formula:

$$\lambda_{wis} = \frac{1 - d_{wis}}{d_{wis} + d_{his}}$$

This measure of the wife's relative influence on the joint decision was used as the dependent variable in a fractional response model. Summary statistics of the dependent and independent variables are presented in Table 4.4.

Previous studies in the literature found that the wife's traits, *relative to her husband's traits*, rather than just her absolute traits, can better capture the strength of her bargaining power (Grossbard-Shechtman and Neuman 1988). Thus, we included variables that are related to the wife's socio-demographic characteristics and attitudes as well as her relative position compared to her husband in terms of these variables. On average, wives were 48 years old. Around 22% of them were older than their husbands. Wives had eight years of formal schooling and interestingly, about 27% of them were more educated compared to the husbands. Moreover, they had 19 years of rice farming experience and only 7% had more farming experience than the husbands. Only 17% attended agricultural training in the past, while about 39% were members of an organization. As discussed above, we found that only the husband attended agricultural training in more than half of our sample couples but the majority of them were either both members or both not members of an organization.

Table 4.4 Summary statistics for dependent and independent variables used in the fractional regression model

Variable	Definition	Mean	Std. Dev.	Min	Max
Dependent variable					
Wife's influence	Relative influence of the wife on the selected VTIs for the joint replacement variety	0.48	0.20	0	1
Independent variables					
Age of wife	Age of wife in years	47.65	10.75	22	73
Education of wife	Number of years in school of wife	8.17	2.30	2	14
Farming experience of wife	Years of rice farming experience of wife	19.35	13.66	0	50
Wife with off-farm work	1 – wife's primary occupation is in services or commerce, 0 – otherwise	0.30	0.46	0	1
Attendance to training of wife	1 – attended agricultural training in the past, 0 – otherwise	0.17	0.38	0	1
Membership in organization of wife	1 – member of an organization, 0 – otherwise	0.39	0.49	0	1
Time preference of wife	Preference for present values as measured by a discount factor	1.46	2.07	-0.5	9
Willingness of wife to invest in farming	1 – extremely unlikely, 2 – unlikely, 3 – neutral, 4 – likely, 5 – extremely likely	4.80	0.42	3	5
Wife future perspective	1 – investment preference for VTIs based on the future, 0 – otherwise	0.56	0.50	0	1
Couple has same religion	1 – couple has same religion, 0 – otherwise	0.95	0.21	0	1
Wife is older	1 – wife is older than the husband, 0 – otherwise	0.22	0.41	0	1
Wife is more educated	1 – wife is more educated than the husband, 0 – otherwise	0.27	0.45	0	1
Wife more experienced in farming	1 – wife has more rice farming experience than the husband, 0 – otherwise	0.07	0.25	0	1
Difference in attendance to training	-1 – only husband attended training, 0 – either both attended or both did not attend, 1 – only wife attended training	-0.53	0.58	-1	1
Difference in membership in organization	-1 – only husband is a member, 0 – either both are members or both are not members, 1 – only wife is a member	-0.06	0.67	-1	1
Difference in time preference	Gap in discount factor (wife discount factor – husband discount factor)	-0.30	5.69	-48	8.5
Difference in willingness to invest in farming	Gap in willingness to invest in farming (willingness of wife – willingness of husband)	-0.14	0.52	-2	3
Difference in future perspective	-1 – only husband considered the future, 0 – either both considered the past or both considered the future, 1 – only wife considered the future	0.18	0.68	-1	1
Proportion of production sold	Proportion of production sold	0.63	0.23	0	1
Buyer requirement	1 – buyers require certain quality standards, 0 – otherwise	0.63	0.48	0	1
Market information	1 – with market information, 0 – otherwise	0.52	0.50	0	1
Climate change information	1 – with climate change information, 0 – otherwise	0.55	0.50	0	1
Wet season	1 – wet season, 0 – otherwise	0.57	0.50	0	1

Source: IGA Philippines Survey 2016

Wives' discount factor was 1.46% on average, which was 0.30% lower than the husband's discount factor. When asked about their willingness to investing in rice farming, on a Likert scale, wives' average rating was 4.80. This was 0.14 points lower compared to the husbands' rating. Moreover, 56% of the wives claimed to take future trends into account in prioritizing traits for improvement. And as discussed above, more than one-third of the couples had different considerations such that the wives considered the future while the husbands considered their past and current farming experience.

We included a variable representing whether or not the wife engaged in off-farm employment. Studies show that employment opportunities outside the farm provide women an outside option or fall-back position that can improve their bargaining power in household decision making (Doss 2013, Twyman, Useche and Deere 2015). Off-farm employment allows them to contribute to household income, learn social and other skills, and provide knowledge and information which can help them participate in household decision making. Thus, we hypothesized that wives with off-farm work (e.g. vegetable or meat/fish vending, managing small shop/store, dressmaking/tailoring) will have more influence on the joint investment decision with respect to the VTIs.

We then included a variable that represents similarity in religion. We found that 95% of the couples had the same religion, Roman Catholic, which is the predominant religion in the Philippines. We wanted to examine whether having the same religious beliefs would affect wives' relative influence on the joint VTIs. We also included variables related to marketing – production sold and buyer requirement – to account for the wife's important role in post-harvest decisions. Lastly, we included dummy variables on the information treatment to examine whether access to particular information (market and climate change information) would change wives' relative influence.

4.5 Results

4.5.1 Replacement varieties and VTIs selected

Table 4.5 presents the replacement varieties selected individually and jointly by season. The table shows that one variety dominated in the wet season. NSIC Rc 222, an inbred variety. This variety was identified as the preferred replacement variety by 78% of the husbands and 79% of the wives. This was also identified by 82% of the couples during the joint round. As for the dry season, a major variety identified by both husband and wife individually and jointly was SL-8H, a hybrid variety. NSIC Rc 222 was also one of the dominant replacement varieties identified in the dry season.

Table 4.5 Replacement varieties selected

Season	Variety	Husband (n=122)		Wife (n=122)		Joint (n=122)	
		Freq.	Percent	Freq.	Percent	Freq.	Percent
Wet season	NSIC Rc 222	95 [a]	77.87	96 [a]	78.69	100 [a]	81.97
	NSIC Rc 216	17 [a]	13.93	14 [a]	11.48	16 [a]	13.11
	Others	10 [a]	8.20	12 [a]	9.84	6 [a]	4.92
Dry season	SL-8H	71 [a]	58.20	67 [a]	54.92	79 [a]	64.75
	NSIC Rc 222	34 [a]	27.87	34 [a]	27.87	23 [a]	18.85
	Others	17 [a]	13.93	21 [a]	17.21	20 [a]	16.39

Source: IGA Philippines Survey 2016
Note: Using Chi-square test, different superscript letters in each row indicate statistically significant difference in values between columns at the 5% level

We then examined the agreement in the replacement varieties selected during the individual and joint rounds (Table 4.2). For 72% of the observations, the replacement variety selected by husband and wife individually was the same as the replacement variety they selected during the joint round. This may imply that the wife was also aware or had some knowledge on the varieties that their household was planting. This may also imply that although the husband dominates in decisions regarding crop choice (Table 4.3), the wife was informed of the decisions made by the husband regarding which variety to plant. Further, it may also suggest that the wife was involved in the decision-making process. This total agreement in the choice of replacement variety may also be due to the fact the wife had higher involvement in post-harvest decisions, which allowed her to be familiar with the rice varieties.

For the remainder of the observations, we found that 19% have their joint replacement variety the same as either the husband's or the wife's replacement variety. Specifically, the joint replacement variety was the same as the husband's replacement variety in 15% of the observations, and the same as the wife's replacement variety in 4% of the observations. Lastly, we found that in 9% of the observations, the joint replacement variety was not the same as either spouse's choice.

Table 4.6 shows the investment allocations made by husband and wife individually and jointly across the different VTIs. Husband and wife individually prioritized stress tolerance traits, such as lodging tolerance, disease resistance, and insect resistance by investing more in these VTIs in the wet season. More than 70% were allocated in stress tolerance traits. Jointly, husband and wife also invested more than 70% in stress tolerance traits during the wet season. In the dry season, wives increased their investments in grain quality traits, specifically slenderness and head rice recovery. Husbands, on the other hand, invested more in stress tolerance traits in the dry season. In the joint decision, we also see increased investments in grain quality traits.

4.5.2 Factors affecting joint replacement variety decisions

We estimated a multinomial logit model to determine the factors that affect the joint decision making on the replacement variety. Interpretation of the estimated coefficients in this kind of model is not straightforward; therefore marginal effects are presented in Table 4.7. We found that if only the wife was a member of a group, the more likely that there was total agreement in replacement variety decisions and less likely that either spouse dominated. It was also less likely that the replacement variety was totally different from the couple's individual decision. This may imply that social and communication networks where the wives participate, may provide an opportunity to exchange information about farming practices (Meinzen-Dick et al. 2014). Through this, wives may become more knowledgeable on most preferred rice varieties (that could serve as replacement varieties in our experiment). This may provide the capability to participate and state her views during the joint-decision round.

Table 4.6 Investments allocated to the VTIs by husband and wife individually and jointly by season

VTI	Wet Season						Dry Season					
	Husband (n=122)		**Wife (n=122)**		**Joint (n=122)**		**Husband (n=122)**		**Wife (n=122)**		**Joint (n=122)**	
	Mean	Std. Dev	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
Grain quality traits												
Slenderness	0.09	0.17	0.06	0.13	0.07	0.14	0.09	0.16	0.09	0.19	0.11	0.17
Stickiness	0.05	0.13	0.03	0.09	0.04	0.11	0.02	0.09	0.03	0.09	0.04	0.11
Aroma	0.03	0.09	0.06	0.13	0.03	0.09	0.04	0.11	0.06	0.15	0.05	0.12
Stress tolerance traits												
Head rice recovery	0.05	0.13	0.04	0.13	0.05	0.13	0.08	0.16	0.12	0.20	0.10	0.18
Lodging tolerance	0.24	0.23	0.22	0.21	0.21	0.21	0.13	0.20	0.10	0.18	0.06	0.13
Disease resistance	0.16	0.20	0.19	0.21	0.15	0.20	0.15	0.19	0.17	0.22	0.17	0.21
Insect resistance	0.14	0.21	0.15	0.19	0.19	0.20	0.17	0.23	0.15	0.18	0.23	0.20
Abiotic stress tolerance	0.11	0.18	0.13	0.19	0.11	0.20	0.16	0.24	0.13	0.21	0.08	0.17
Reduction in shattering	0.08	0.12	0.08	0.12	0.10	0.12	0.12	0.15	0.12	0.15	0.12	0.14
Agronomic trait												
Earliness	0.04	0.09	0.03	0.08	0.04	0.10	0.03	0.10	0.03	0.08	0.04	0.10
Uninvested	0.01	0.02	0.01	0.02	0.00	0.00	0.01	0.04	0.01	0.02	0.00	0.00

Source: IGA Philippines Survey 2016

Table 4.7 Marginal effect estimates on the joint replacement variety decision

Variable	**Total agreement**	**Joint same with one of the spouses**	**Joint not same with either spouse**
Couple characteristics			
Difference in age	0.0023	0.0011	-0.0034
	(0.0060)	(0.0054)	(0.0034)
Difference in education	0.0024	-0.0009	-0.0016
	(0.0111)	(0.0097)	(0.0069)
Difference in farming experience	0.0011	-0.0028	0.0017
	(0.0025)	(0.0021)	(0.0017)
Difference in attendance to training	-0.0364	0.0257	0.0107
	(0.0568)	(0.0490)	(0.0287)
Difference in membership in organization	0.1447***	-0.0922**	-0.0525*
	(0.0495)	(0.0439)	(0.0294)
Difference in time preference	-0.0027	0.0047	-0.0021
	(0.0056)	(0.0045)	(0.0023)
Difference in willingness to invest in farming	0.0098	-0.0486	0.0387*
	(0.0469)	(0.0464)	(0.0221)
Difference in future perspective	-0.0006	-0.0119	0.0124
	(0.0431)	(0.0366)	(0.0283)
Husband's primary occupation is farming	-0.0503	-0.0473	0.0976***
	(0.0993)	(0.0976)	(0.0207)
Wife's primary occupation is farming	0.2179***	-0.1704***	-0.0475
	(0.0698)	(0.0447)	(0.0541)
Household characteristics			
Farm size	-0.0255	0.0162	0.0093
	(0.0325)	(0.0233)	(0.0192)
Proportion of production sold	-0.0393	0.0107	0.0286
	(0.1250)	(0.1068)	(0.0689)
Buyer requirement	0.0520	-0.0488	-0.0032
	(0.0659)	(0.0602)	(0.0359)
Farming decisions			
Wife decides on amount of rice to sell or store	-0.2652*	0.1758	0.0894
	(0.1394)	(0.1158)	(0.1082)
Wife decides how to spend income from crop sale	0.0986	-0.0652	-0.0334
	(0.0751)	(0.0724)	(0.0573)

Notes: The coefficients are marginal effects after multinomial logit estimation.
N = 244, Log pseudo likelihood = -171.84
Clustered standard errors at the household level in parentheses.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

If the wife's primary occupation was farming, then the couple was more likely to agree on replacement variety and it was less likely that either spouse dominated the decision. It was also less likely that the replacement variety was totally different from the couple's individual decisions. This confirms our hypothesis that partaking in on-farm work provides opportunities for the wife to be informed and knowledgeable on the varieties they use as well as with those varieties widely adopted. Again, this may have given her the capacity to participate and express her opinion or preference during the joint decision on their replacement variety.

If the wife was the main decision maker or dominated the decision-making process regarding the amount of rice to sell or store, then total agreement in the replacement variety decision was less likely to occur. This may reflect differences in the roles that the husband and wife played within the household. As the wife was mainly in charge of the household budget and expenditure, she may have had different considerations or preferences in deciding on the amount of rice to sell and store. One consideration could be the grain quality traits that are not only important for selling but also for home consumption. This may have then translated to the difference in the preferred replacement variety.

4.5.3 **Relative influence of the wife on joint VTI decisions**

Table 4.8 shows the marginal effects of the fractional response model results with respect to the wife's relative influence on the joint VTIs. The results suggest that the wife's off-farm employment had a significant and positive relation to her influence on the couple's joint decision making. If the wife was engaged in income-generating activities outside of the farm, her relative influence on the joint

VTI decision increased by 7.3%. This is consistent with our hypothesis that off-farm employment can contribute to a wife's influence in the decision-making process. Off-farm work is likely to provide the wife with an opportunity to add to household income, gain knowledge and new information, and this can empower her to participate and have a say in household decision making.

Table 4.8 Results of the regression on wife's relative influence on the joint VTIs

Variable	Marginal effect	SE
Age of wife	-0.0018	0.0019
Education of wife	-0.0147^{**}	0.0074
Farming experience of wife	-0.0033^{**}	0.0015
Wife partakes in off-farm work	0.0727^{**}	0.0363
Attendance to training of wife	-0.0454	0.0564
Membership in organization of wife	0.0060	0.0532
Time preference of wife	0.0089	0.0070
Willingness of wife to invest in farming	0.0494	0.0585
Wife's future perspective	0.1393^{**}	0.0609
Couple has same religion	-0.2312^{***}	0.0607
Wife is older	-0.0379	0.0356
Wife is more educated	-0.0019	0.0395
Wife more experienced in farming	0.0327	0.0655
Difference in attendance to training	-0.0133	0.0410
Difference in membership in organization	-0.0014	0.0329
Difference in time preference	-0.0020	0.0018
Difference in willingness to invest in farming	0.0147	0.0402
Difference in future perspective	-0.0503	0.0440
Proportion of production sold	-0.0027	0.0650
Buyer requirement	0.0077	0.0381
Market information	-0.0280	0.0353
Climate change information	-0.0069	0.0411
Wet season	0.0216	0.0261

Notes: The coefficients are marginal effects after fractional response model estimation.
N = 174, Log pseudolikelihood = -117.66.
Standard errors are clustered at the household level.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

The wife's future perspective also had a significant effect on her relative influence in household decision making with respect to investment in VTIs. If the wife considered the future when making household decisions, her influence on the joint VTI decision increased by 14%. This may suggest that the wife has more developed planning skills as compared to the husband. These skills may have been developed as a result of her role in budgeting household expenses, or possibly as a result of involvement in economic and social activities outside of the farm (Eder 2006).

Having the same religion is negatively associated with the wife's relative influence. Compared to couples whose religion was not the same, the wife's relative influence on the joint VTIs decreased by 23% compared to if she and her husband had the same religion. This may be explained by the influence of the church and religious beliefs in the Philippines in shaping beliefs with respect to the roles that men and women 'should' play in the family. Bible passages depict the husband-wife relationship based on obedience and submission of the wife to the husband. Moreover, as far as the church is concerned, a woman should serve her husband and children at home and serve God in church (Collantes 2016, Eviota 1994). Thus, it may be the case that in household decision making, the husband has the final say. However, the effect of religion on the wife's relative influence should be taken with caution given that most of our sample households have the same religion.

Contrary to expectations, a wife's education and farming experience had a negative effect on her intrahousehold decision-making power in terms of deciding on future VTIs needed for a certain replacement variety. A one-year increase in the wife's education is associated with about a 1% decrease in her influence on the joint decision. A possible explanation is that wives with more years of schooling may have more opportunities off-farm, which may reduce their participation in farming decisions. She may also decide not to participate at all in the decision-making process.

A wife's farming experience is weakly associated with her influence on the joint decision. A one-year increase in her farming experience is related to a less than 1% decrease in her relative influence. This suggests that although the wife has experience in farming, the husband prevails in the decision-making process as he is more experienced in farming compared to the wife (see Table 4.2).

4.6 Discussion and Conclusions

In this study, we examined household decision making related to replacement variety and investment in research to improve the traits of this replacement variety (VTIs). To do this, we conducted a framed field experiment with 122 rice farming households in Nueva Ecija, Philippines. Both the husband and wife of these households were invited to participate, and they were asked to indicate their preferences for investment in VTIs both as individuals and jointly with their spouse.

We were particularly interested in examining how a couple's joint decision relates to their individual decisions with respect to the choice of a replacement variety. We also examined the factors that are related to a stronger influence of the wife on the joint decision with respect to the choice of VTIs. Our study provides valuable insights on the importance of considering gender and intrahousehold dynamics when undertaking research on agricultural technology preferences and adoption decisions.

We found that for most of the sample households (72% of the observations), the replacement variety identified individually and jointly by husband and wife was the same. This implies that although husbands dominated in the crop choice decisions, wives were aware and had knowledge of the varieties their household was planting as well as the other varieties available. This may also imply that farming decisions were discussed within the household and were not made solely by the husband.

Another important finding is regarding the differences in the characteristics and attitudes between husband and wife. Except for the differences in group membership and willingness to invest in rice farming, all other differences in husband and wife characteristics and attitudes did not influence the household decision making on the replacement variety and the VTIs. Although there were significant differences between husband and wife in some of the traits and attitudes we examined, we found that wives were still able to participate and influence household decision making and even had greater control over household income. This may imply that there is gender equity among our sample households. This finding is consistent with a recent work on women empowerment in four Southeast Asian countries. For example, Akter et al. (2017) found that in their Philippine study sites, decisions regarding rice farming are made jointly by husband and wife and that the wives have greater control over household income.

The factors that had more influence in the household decision-making processes were the wife's absolute traits such as on-farm and off-farm employment, education, farming experience, and her future perspective.

It is worth highlighting the influence of both on-farm and off-farm employment in household decision-making processes. Wives who do farm work are more likely to be knowledgeable in terms of the varieties and are also more likely to participate in decisions related to farming. As Twyman et al. (2015) suggest, participating in farm work can provide the wife with an "earned right" (p. 485) to have a say in decisions related to farming. This finding has implications in terms of making different agricultural training and extension services available to wives that could improve their knowledge on agricultural technologies as well as on management practices. On the other hand, off-farm employment provides the wife a fall-back position that can increase her influence and bargaining power. This bargaining power affects not only the wife's participation in household decision making, but can also affect other important outcomes such as food and education expenditures and health outcomes (Doss 2013).

It is also worth highlighting the significance of religious beliefs in women's relative influence within the household. We found that most of our sample households had the same religion and that the wife's influence in the decision making decreases when she had the same religion with her husband. This result suggests of the important role that religion plays in household decision making. Moreover, such factors, including local traditions and culture should be taken into consideration to better examine and understand intrahousehold dynamics.

Overall, the results of our study have implications in terms of the methodological approach in preference elicitation and variety development. As men and women have different preferences and roles within the household, it is important that methods for eliciting preferences should consider interviewing not only the household head, but also other household members involved in household and farm production decision-making processes. The results of such preference elicitation can then feed into the priority setting of breeding programs as well as extension and training programs.

Breeding research should take into account intrahousehold preferences for VTIs. Our findings suggest that husband and wife have different preferences but decisions on the replacement variety and the VTIs were discussed to come up with a joint or optimal variety profile for the household. This reinforces previous findings that farm decisions are not solely made by the household head, rather the spouse or other decision makers in the household are also involved.

Our study, however, has limitations with regard to its sample selection of rice farmers in one region of the Philippines. This means that generalization of the findings to a larger population is also limited. Specifically, variety choice is site-specific and it is recommended that similar research is done in other major rice-growing areas to help in the development of rice variety product profiles that better target their preferences and needs. Furthermore, this research could be extended to consider other agricultural commodity sectors where significant public dollars are invested in research and development of new crop varieties.

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Chapter 5: Summary, Conclusions, and Implications

5.1 Introduction

Investments in research and development will continue to play an important role in ensuring sustainable food systems, particularly in the midst of the global demand and supply side challenges discussed in previous chapters. For example, as dollars invested in research become scarcer, rice breeding research programs face difficulties meeting both the needs of rice farmers and the demands of other value chain actors. Value chain actors include rice consumers with increasingly heterogeneous preferences and demands for rice varieties and variety traits.

In light of these production and market dynamics, difficult and informed decisions have to be made by private and public sector research investors, as well as rice breeders. These decisions include where to invest, and how to allocate increasingly scarce research and development funds in order to get the greatest return on investment. To facilitate successful adoption of new and improved varieties, it is of critical importance to consider and incorporate farmers' preferences and needs in early phases of breeding. This step will increase the probability that the rice varieties developed are suitable to local conditions and at the same time responsive to market requirements.

Participatory techniques, such as Participatory Plant Breeding (PPB) and Participatory Varietal Selection (PVS), have been developed to incorporate farmers' preferences in the varietal development process. Through these techniques, breeders have been able to collaborate with farmers and gain a better understanding of their individual preferences and demands. This information has been used to guide in the development of more suitable varieties (Almekinders and Elings 2001, Atlin 2004, Morris and Bellon 2004). Information on farmers' preferences may be more useful, if *prior* to the actual variety development, preferences were elicited on trait improvements, rather than on the traits. Furthermore, because limited research resources for breeding programs need to be efficiently allocated, farmers' preferences *subject to financial constraints* should also be explored.

Using the Investment Game Application (IGA), an experimental methodology for eliciting preferences developed at the International Rice Research Institute (IRRI), this thesis examined preferences of Filipino farmers, at both the individual and household level, for varietal trait improvements (VTIs) in rice. Through this experimental methodology, farmers were given the opportunity to be involved early in the breeding research process. Specifically, they were asked to allocate research funds to varietal traits that they thought should be prioritized in variety improvement research. Thus, the process of preference elicitation in this study was participatory and less hypothetical as farmers' risk preferences were also taken into account in the context of investors in public rice breeding and related resource allocation decisions.

The thesis had four specific objectives. The first objective, addressed in Chapter 2, was to examine farmers' investment preferences for VTIs and the factors that influence their investment allocation decisions. Chapter 2 also addressed the second objective, which was to examine whether there were differences in the investment preferences for VTIs of husband, wife, and joint husband and wife.

The third objective, addressed in Chapter 3, was to examine farmers' preference heterogeneity and to identify segments or clusters of farmers based on household (joint husband and wife) preferences for VTIs.

The fourth objective, addressed in Chapter 4, was to explore the influence of gender and intrahousehold dynamics in decision making when selecting replacement varieties and when deciding how to allocate public funds towards research breeding programs aimed at improving specific varietal traits.

The objectives were addressed using data from a framed field experiment conducted in February 2016 using the IGA. Participants in the experiment were randomly selected from rice farming households in three municipalities in Nueva Ecija, a major rice-producing province in the Philippines. Participants were selected based on the following criteria: (i) both husband and wife were involved in rice production or marketing; (ii) the household was planting rice in both the wet and dry seasons; and (iii) the household was selling a portion of their rice production. Overall, 122 households participated in the experiment, with both husband and wife joining.

5.2 Summary of Main Findings

Chapter 2 provided an overview of the main findings with respect to the replacement varieties farmers preferred to have improved. Interestingly, one variety dominated in each season (NSIC Rc 222 in the wet season and SL-8H in the dry season). In most cases, this was the variety that farmers were using at the time they participated in this study. As for the specific traits needing improvement, on average farmers prioritized stress tolerance traits. This was because the main replacement varieties already had some of the grain quality traits that consumers prefer. The VTIs that farmers had relatively stronger preferences for included specific traits which address specific climate and weather concerns.

The replacement variety identified during the joint decision round was generally the same as the choice made by husbands and wives in the individual rounds. In terms of the specific VTIs selected, both husband and wife individually prioritized stress tolerance traits during the wet season. The same outcome was observed for the joint decision. However, for the dry season, the results were different. Wives increased their investments in grain quality traits. Couples also increased the amount they invested in grain quality traits during the joint decision round. Conversely, the investment allocations made by husbands during the dry season were almost the same as their investment allocations in the wet season.

A fractional multinomial regression was also used in Chapter 2 to explore the factors that influence farmers' investment allocation decisions. Results of the regressions showed that factors related to access to land, such as total farm size, percent leased area, and proportion of area planted, had significant influence on farmers' investment preferences. We also found that as farm size, percent leased area, and proportion of area planted increased, farmers made specific trade-offs between grain quality traits and stress tolerance traits. The gender disaggregated analysis showed that factors such as cropping season, a hybrid replacement variety, farming experience, and time preferences significantly influenced investment allocations when participants were making decisions both as individuals and jointly with their spouse.

The analysis presented in Chapter 3 further examined farmers' preferences for VTIs by accounting for heterogeneity in preferences. Through a latent class

(LC) cluster analysis, four clusters of households were identified: Stress Tolerance Focused (50%), Mixed-focused (30%), Insect Resistance and Earliness Focused (11%), and Grain Quality Focused (9%). Each cluster had heterogeneous preferences for improvements in variety traits. Each cluster also had distinct characteristics that helped to explain why they invested more or prioritized some traits over other traits.

Chapter 4 explored intrahousehold and gender dynamics in household decision-making with respect to choices of replacement varieties and investments in VTIs. Interestingly, for 72% of the observations, there was total agreement in the replacement variety, this means that the replacement variety identified by husband and wife individually was the same with the replacement variety identified during the joint decision round. Total agreement in replacement variety was more likely if only the wife had membership in an organization and if she was also involved in on-farm work. The wife's relative influence on the joint decision on VTIs was positively affected by her off-farm work and if she considered the future in investing in VTIs. On the other hand, as the wife's education and farming experience increased, her relative influence on household decisions decreased.

5.3 Implications for Public Rice Breeding Research

This thesis contributes to a better understanding of the different aspects of farmers' preferences for replacement varieties and for investment in research for VTIs in three main ways.

First, the findings revealed farmers' trade-offs and priorities for investment in VTIs by allowing them to allocate research resources using the IGA and by confronting them with resource constraints and risks like those faced by rice breeders. Generally speaking, when deciding how to invest in VTIs, farmers prioritized insect and disease resistance, slenderness, and head rice recovery. However, there were some differences between priority VTIs for the wet season versus the dry season. Using the replacement varieties identified as the basis, and the results of farmers' investment decisions in VTIs, the results suggest that research investments for wet season varieties should focus on tolerance and resistance to different biotic and abiotic factors. Breeding research for dry season varieties should also focus on these traits as well as on grain quality traits, specifically slenderness and head rice recovery.

Farmers' investment decisions with respect to VTIs were reflective of the traits that the identified replacement variety lacked or were relatively less superior in. For example, in the wet season, the dominant replacement variety was NSIC Rc 222, a high yielding inbred with long and slender grains. In selecting for VTIs, farmers prioritized or allocated most of the investment funds to stress tolerance traits, specifically lodging tolerance, insect resistance, and disease resistance. These are the traits in which the identified replacement variety historically underperformed. On the other hand, in the dry season, the dominant replacement variety is SL-8H, a hybrid variety. Hybrid varieties are popular during the dry season due to a more favourable weather which allows yield potential to be maximized.

Second, the empirical findings of Chapter 3 demonstrated that preferences are heterogeneous and that there exist segments or clusters of farmers, each with distinct preferences for trait improvements. Taking into account preference heterogeneity is important, as farmers are also distinct in terms of their characteristics, the production ecosystem where they operate, and the economic or infrastructure development they face.

These findings with respect to the existence of preference heterogeneity imply that breeding research will have to continue to develop varieties with different sets of traits to address the different priorities and unique needs of the farmers. The results also suggest that elicitation of farmers' preferences for trait improvements should be done in multi-location settings as preferences are likely to differ due to the differences in several aspects such as farmer characteristics, production ecosystems, marketing practices, and infrastructure development.

Third, findings revealed that several factors contributed to the wife's influence relative to her husband's influence when making joint decisions on a replacement variety and the traits of this variety to be improved. Thus, it is important to understand intrahousehold decision-making dynamics when considering research investment priorities. Preferences for variety traits are usually elicited only from the household head, but our findings suggest that there are differences in the preferences between husband and wife.

Although during the joint decision-making round husbands and wives discussed their decisions for replacement varieties and investments in VTIs and came up with an optimal variety profile, there are several factors that affected the wife's relative influence in the household decision-making process. Moreover, decisions related to production and marketing are jointly decided, but with some areas being dominated by one spouse, like the decision on how to spend income from crop sales which is dominated by the wife. These results imply that when eliciting preferences, other household members who are also involved in the production and marketing activities should be interviewed together with the household head. This will then make it possible to examine intrahousehold dynamics, which could also influence adoption decisions.

Ultimately, the information presented in this thesis can be used to guide priority setting and resource allocation for public rice breeding research programs. This information will be useful as IRRI launched a new approach to its breeding research in order to increase the adoption of improved varieties and to increase efficiency in resource allocation (Barona-Edra 2013). A critical component of the new breeding program strategy is a thorough understanding of the demand for variety traits of the different actors in the rice value chains. This makes the approach demand-driven and this thesis contributes particularly to understanding better farmers' demand for trait improvements.

It is important to note that while the thesis provides information on what a subset of Filipino farmers think should be prioritized in terms of variety improvement and development, the implications of the results should be addressed with caution as farmers' preferred VTIs are specific to the replacement varieties they identified. Moreover, the replacement variety and its corresponding VTIs are season specific (either wet or dry season). Farmers' distinct choices of a replacement variety in each season reflect the weather and production-related issues faced in each season, and these are likely to be unique to the region of the Philippines where this study was conducted.

5.4 Implications for Rice Research Investments and Policy in the Philippines

Rice self-sufficiency has long been the focus of the Philippine's agricultural policies. While the Food Staples Sufficiency Program (FSSP) from 2011 to 2016 included other staples such as white corn, banana (*saba*), and root crops, emphasis was placed on achieving self-sufficiency in rice by increasing production through yield improvement and area expansion (Department of Agriculture 2012). The overarching goal of FSSP was to improve the Country's food security and reduce poverty. By improving farm productivity, the FSSP program also aimed to make Filipino farmers globally competitive. This is important considering the country's full integration to the Association of Southeast Asian Nations (ASEAN) Economic Community and removal of quantitative restrictions on imported rice as part of the country's commitment to the World Trade Organization (WTO) (Bordey et al. 2016). Different strategies were identified to improve productivity and one of which is through continued investments in research and development in rice varieties.

This thesis provides some considerations for rice research investments in the Philippines. The information gained from the IGA can help breeders to develop varieties that are more likely to be adopted by farmers and valued in the market. Better informed, market-driven rice breeding programs can strengthen rice value chains by: (i) providing farmers better access to markets by incorporating the grain quality traits demanded and anticipating future trends in demand and consumption patterns; and (ii) making rice farming more resilient to changing climate and erratic climatic conditions. This will strengthen rice value chains, such that they can provide a better quality and more stable supply, which will enable them to compete with imported rice through both enhanced quality-competitiveness and improved cost-competitiveness (more resilient, less risk). Furthermore, from a more broad policy perspective, the results suggest that creating a vibrant economy that provides off-farm employment opportunities for women (e.g. in services sector related to agriculture) may also increase their bargaining power in household decision making.

5.5 Future Research

This thesis has provided new information and a better understanding of the different aspects of rice farmers' preferences for VTIs using an experimental methodology that can enhance farmers' participation in agricultural research process and resource allocation. Nevertheless, there are other aspects which can be explored using the same experimental methodology used in this thesis. The following are suggestions of priority areas for further research, however, they are not an extensive list.

First, as the findings of the thesis cannot be generalized to a wider population due to the limitation in sampling, the experiment should also be conducted in other major rice producing areas in the Philippines. As variety choice and preferences for traits are location specific and depend on many factors, examining the preferences of other farmers in other areas will provide more information that can help in developing new and improved varieties that better target the needs of the farmers. Future research using the same experimental methodology should also consider doing the research in rain-fed areas. In this thesis, we only focused on irrigated rice areas. Farmers in the rain-fed areas would mostly likely have different perspectives compared to those in irrigated areas as they have to deal with different biophysical, socioeconomic, and cultural constraints in increasing productivity (Villano and Fleming 2006).

Second, the thesis focused on households with both the husband and wife physically present and involved in rice production and marketing. As such, future research employing this study's experimental methodology may want to consider examining preferences of households with only one spouse present in the household. In farming households in the Philippines, such situations are common in some areas due to migration (local or international) of the other spouse on a seasonal or long-term basis to seek employment and earn higher incomes (Paris et al. 2010). Such situations are likely to affect the household's production activities and intrahousehold dynamics. For example, Hwang et al. (2011) found that when the wife was left to run the household on her own due to the husband's outmigration, her participation in agricultural decision making, especially in deciding what crop to grow, increased sharply. Moreover, Paris et al. (2010) found that remittances sent by migrant spouses contributed significantly to increases in the household's proportion of hired labour, and this relieved wives from drudgery in farm productions. Thus, the preferences of these households for trait improvements may be different if they faced different circumstances compared to those households with both husband and wife present and involved in production and marketing activities.

Third, preferences for trait improvements of other rice value chain actors, such as the millers, can also be elicited using this experimental methodology employed in this thesis. Preferences of other value chain actors are also an important input to breeding research and through this, it will be possible to have portfolios of new and improved varieties that capture and integrate preferences of the different actors across the rice value chains.

Lastly, an extension of this research could examine whether farmers' preferences are different from rice breeders' priorities, and if this is the case understand why such differences exist.

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Appendix 1. Research Methodology Protocol

<u>Activity Protocol</u>

A. Human Ethics Approval
B. Computer-based
- The Investment Game Application (IGA) for tablet was developed by the Market Research Team (MRT) at the International Rice Research Institute (IRRI)

C. Instructions and information
- Instructions to the participants will be given by the Experimenter
- A short training will be given to the participants to familiarize them with the used of the tablet application

D. Payment protocol
- Equal payment of 250 Philippine pesos as compensation for participation
- Participants can earn additional incentive-compatible returns on top of the participation compensation, based on their decisions.

Single blind payment procedure for the additional earnings – participants will know their returns but not the returns of other participants

<u>Implementation of the Activity</u>

A. Recruitment of the participants
- The following are the main criteria which will be used in the selecting for the participants: (i) both husband and wife should be involved in rice production or marketing activities; (ii) the household is planting rice in both wet and dry seasons; and (iii) the household is selling a portion of their rice production.
- The research team will work with the holder of the farmers' list (e.g. the Municipal Agriculture Office and/or the local village office) to develop the sample frame. Participants will firstly be informed by the village leader that they are part of subset and they will be asked if they give permission for the field coordinator to visit their home. If they give permission, the field coordinator will be provided with the respondents' addresses, we will also offer them the option of meeting with the field coordinator at a community venue (where available).
- Each session will invite 20 participants.
    - We will wait for a reasonable time for participants to arrive and after a number of participants of at least 15 the session will start. Once the session has started, a person will be at the door indicating to participants arriving late that the session has already started and no more people is allowed. This will be done in order for all the participants in the sessions have the same information from the very beginning, and for not having disrupt the explanation of the activities to participants who arrive on time.

B. The activity will be in Filipino, the local language

C. The team will be composed of: experimenter, enumerators, field coordinators
D. We will create a "laboratory" in the field

- Could be the local village hall or a classroom in the village school; could also be an event room in a local hotel
- To mitigate peer effects, we will create a sitting arrangement and provide dividers

<u>Experimenter Script</u>

A. Introduction

The Experimenter to give the greetings, introduce the research team, and provide a general introduction of the research methods.

Greetings. *Good morning/afternoon to all of you. First of all, we would like to thank all of you for accepting our invitation to participate in this activity, which will provide breeders feedback on farmers' preferences on rice varietal traits.*

Introduce yourself and the team members. *I am* <insert name of animator, designation, organization>. *I will be the one who will explain our activity for today. Let me introduce our supervisor,* <insert name of supervisor>. *Also here with us are* <insert name of enumerators> *who will help and guide you during the activity.*

Introduce IRRI and The University of Adelaide. *This research is being conducted by IRRI and The University of Adelaide. Researchers from these institutions are involved in the design and implementation of this study and in the data analysis.*

Introduce the activity for today. *Our activity for today involves two parts. In the first part, you will be asked to perform a task, where our enumerators will be with you to assist you. This task will take about 2 hours – from the explanation of the research and instructions to the actual implementation of the task. In the second part, you will answer a short paper-based survey questionnaire, which will also be administered by our enumerators. This will only take about 45 minutes. You can take a break after completing the task and before you start the survey. We will provide some light snacks during your break. If in case you will feel discomfort or tiredness during the conduct of task or the survey, please let the enumerators know.*

We will now proceed with the explanation of the task (Investment Games).

B. Instructions and information

1. Introduction
1.1 Explain purpose of the activity.

a. Fulfil International Rice Research Institute's (IRRI) mission through rice breeding program funded by donors.
The primary mission of IRRI is to reduce poverty and help farmers improve their livelihood. IRRI receives funds from donors to perform different activities which help to achieve these goals. One of them is the development of new rice varieties through IRRI's breeding programs. We want to involve farmers more actively in breeders' decisions on which traits of rice varieties need to be developed and prioritized. With this new strategy, we hope to tailor the varieties better to farmers' and consumers' needs and foster adoption rates.

In this activity, you will be involved in a new approach to public investment in rice breeding. As you know, donors invest funds in IRRI and NARS (National Agricultural Research Systems) breeding programs (e.g. PhilRice) to help these programs in the development of new varieties for farmers. Today, we will give you the opportunity to invest in rice breeding programs based on the traits of the varieties you prefer to be improved. Funds from donors will be distributed to the farmers, who can now decide on their best use for developing the ideal rice varieties they always wanted to have. We believe that farmers are the experts in identifying how their varieties can be improved to increase their livelihood.

To determine the traits of the varieties that farmers want to improve and at what extent of improvement, we will use a tablet application called the Investment Game Application (IGA). This application will help breeders in prioritizing the improvement of rice characteristics farmers want in order to obtain their ideal rice varieties.

b. Opportunity for farmers to become shareholder of rice breeding program. *Today, we will create a real, but temporary market for investment in public rice breeding. Moreover, we endow you with an investment share in real money. By creating your ideal variety, you are in fact investing this money in public rice breeding. This will allow you to gain a real return to your investment, which you can take home. In other words, today you will be an investor of the rice breeding program and decide on how your share should be invested in the development of rice varieties which are suitable to your needs.*

1.2 Motivate farmers on importance of their participation in this activity. *We know that IRRI and NARS breeders produce new rice varieties for the benefit of farmers and consumers. Therefore, it is important to involve the expert knowledge of farmers on the variety characteristics they want to improve before allocating resources within the breeding program. This activity provides you with the opportunity to provide breeders with feedback on your preferences for rice varietal traits. We kindly request for your participation in this activity.*

2. Training on Investment Game Application (TIGA)
Before we proceed to the actual task (investment game), let us have a short training first.

2.1 Goal of the game. *The goal of the game is to compose the ideal rice meal by finding out your preference trade-offs for viands.*

2.2 Instruction on how to play the game. *It's lunch time and as you are passing by a restaurant, you saw a promotional offer of free rice for a meal with two choices: vegetable dish (pakbet) and meat dish (adobo). Reaching your pocket, you found that you have only 50 pesos allotted for lunch meal. What proportion of your budget will you allocate for vegetable and for meat? Just like in a popular product commercial: "Up to what extent your 50 pesos can buy."* The experimenter will show the interface of the Training Investment Game Application (TIGA). He will orient the farmers on its parts (the plates for vegetables and meat dish, the spin button and the budget bar) and how to use the TIGA.

2.3 Hands-on training. The participant will do the training exercise (TIGA) through the guidance of assigned enumerators.

3. Introduction of the Investment Game Application (IGA)
Did you enjoy our short exercise? How was your experience playing with the tablet application? We will do this again later but will use the real "investment game application" (IGA) now, applied to rice varietal improvement. The IGA has four parts:

3.1 Rice varietal traits and logo. *This part shows the rice varietal traits and their corresponding logo.*

3.2 Varietal trait improvements and spin button. *This portion displays the level of varietal improvement of each trait and the spin button below is use to increase and decrease the improvement level.*

3.3 Investment risk (e.g. lottery). *The pie chart located at the bottom of each trait corresponds to the investment risk which is based on the level of varietal improvement. Green color indicates the chance or probability that the breeding program will be successful in developing a variety with exactly your required level of trait improvement. Whereas, red color indicates the chance or probability that the variety which will be developed will have lesser expected level of trait improvement, i.e. somewhere between your required level and zero. The larger the green area, the higher the chance of getting exactly your required level of trait improvement and the bigger the red area, the higher the chance of getting lesser expected level of trait improvement, i.e. somewhere between your required level and zero.*

3.4 Budget bar. *This bar shows your budget status. Blue color indicates the balance of your fund. As you invest in a single trait or multiple traits, there will be a corresponding reduction to your budget.*

3.5 Model variety. *When thinking about the trait improvement, it is important to refer to a "model rice variety". This variety can be your most preferred or a popular variety. You may or may have not grown it in the past or currently* *growing. What's important is that you are familiar with its characteristics and it is the variety that you would like to improve for selling.*

4. Description of rice varietal traits and target on trait improvement

What are the rice traits you want to add or improve in your model variety? According to rice breeders, they can improve 10 rice traits up to a certain point in a span of 6 years. Let me first discuss each rice trait.

4.1 Slenderness (in local language, in PH: Pagkapayat na hugis). *This trait is about the shape of rice grains. Shape of a grain refers to its length and width. Some rice varieties are long and slender, some are short and bold. Looking at the image (referring to the slide presentation of baseline), if your model rice variety, which is mainly for selling, has this length and width (i.e. medium) and you want to make it slender, you can choose this trait and improve it by pressing the upper spin button up to the level of slenderness you want.*

4.2 Stickiness (in local language, in PH: May kalagkitan). *There are rice varieties which are soft and sticky while other varieties are hard and dry. If you want your model rice variety, which is mainly for selling, to have a softer and stickier texture, kindly choose this trait and increase the level of stickiness up to your desired level. For example, if your model variety is hard and dry and you want to make it softer and stickier, increase the level up to your desired level.*

4.3 Aroma (in local language, in PH: Bango). *Here in the Philippines, we can say that rice has a good aroma if it has attractive fragrance and smells like "pandan" leaves. The most popular aromatic rice in Philippine market is Jasmine rice. In South Asia, Basmati is one of the popular aromatic varieties there. If you want to improve the fragrance of your model variety, which is mainly for selling, or eventually transform it into aromatic rice, choose and invest in this varietal trait.*

4.4 Head rice recovery (in local language, in PH: Pagkabuo matapos gilingin). *This trait refers to the amount of recovered whole grain against broken grains after milling. Head rice recovery has 3 categories: Grade 2 (39.0%–47.9%), Grade 1 (48.0%–56.9%) and Premium (57% and above). If your model variety, which is mainly for selling, has around 45% head rice recovery (Grade 2), pulling up the bar up to its maximum can improve its head rice recovery up to 60% (Premium).*

4.5 Lodging tolerance (in local language, in PH: Matibay sa pagdapa). *This trait of rice variety pertains to the tolerance of rice plants from falling down caused by wind and flood. We all know that it's difficult to harvest lodged rice plants and it also lessens your yield. Looking at the image, almost all of the plants were lodged and touching the ground but by increasing the bar up to the middle level, you are increasing the plants that are in upright position. By investing to lodging tolerance at maximum level, you will notice that majority of the plants are in upright position and few are lodged. If your model rice variety, which is mainly for selling, has soft stems and susceptible to lodging, choose this trait to improve.*

4.6 Disease resistance (in local language, in PH: Matibay sa sakit). *One of the causes of poor harvest in rice is the presence of rice diseases caused by bacteria, viruses and fungi such as* <identify diseases that are more prevalent in the locality> *tungro, blast and bacterial blight. Planting a resistant variety is the simplest and, often, the most cost-effective management for diseases. In the image presented, from a field which half of it is infected by a disease, by increasing and investing up to its maximum level, the plants will be almost resistant to a disease. If you want to transform your model rice variety, which is mainly for selling, into a disease-resistant variety, then increase the bar of this trait.*

4.7 Insect resistance (in local language, in PH: Matibay sa insekto). *Black bug, stem borer and green leaf-hopper <Name insects that are prevalent in the locality > are the common insects that give significant damages to rice plants in the Philippines which lead to yield reduction. However, we should also remember that not all insects are harmful to rice. There are also some insects which are rice-friendly. The most effective and cost-efficient way of avoiding insect damage is to plant insect-resistant rice varieties. Suppose your model variety which is mainly for selling, is vulnerable to insects like in this image with bugs almost all over the plant and affecting its health, by increasing the bar up to its maximum level, damage due to insects is decreased making it more insect-resistant.*

4.8 Abiotic stress tolerance (in local language, in PH: Matibay sa tagtuyot, paglubog, at maalat na lupa). *This trait is about the tolerance of rice variety from the damages brought by abiotic factors such as submergence, drought and salinity. If your paddy field is prone to one of these conditions and your model variety, which is mainly for selling, is susceptible to this condition, your variety could be improved to make it more tolerant to abiotic stress by increasing the bar and reaching the maximum level.*

4.9 Reduction of shattering (in local language, in PH: Bawas sa panlalagas). *This rice trait refers to the shedding of mature grains from the panicle caused by birds, wind, rats, and handling. Shattering of grains, somehow, significantly reduces the harvest of our farmers. If the mature grains of your model variety which are mainly for selling are prone to shattering then select this trait and improve it by increasing the corresponding bar.*

4.10 Earliness (in local language, in PH: Mabilis anihin). *This trait refers to early maturity of rice. Some farmers want rice varieties which are early maturing so that they can right away start another cropping season or cultivate non-rice crops or to avoid potential monsoon. Suppose your harvest is scheduled at this date (referring to the calendar in the slide), by increasing the bar up to its maximum level, your harvest date will be earlier by 14 days. If there is a need or you want your model rice variety, which is mainly for selling, to have shorter maturity duration, then you can choose this trait and increase the corresponding bar up to the number of days you want to save.*

5. Demonstration of Investment Game Application (IGA)

And now that you already know the 10 varietal traits and their maximum level of improvements, let us proceed to our task (investment games). The big donors decided to distribute their grants to farmers. These grants were originally allocated to IRRI rice breeding program. Each of you will have an initial amount of PHP100, which you can invest in the breeding program that will improve your model rice variety to become your ideal variety. As mentioned earlier, the model variety can be your most preferred or a popular variety. You may or may have not grown it in the past or currently growing. What's important is that you are familiar with its characteristics and it is the variety that you would like to improve to for selling. Before we start the task (investment games), we will ask you to think of the model rice variety that you would like to improve for selling and for better profitability. Then, choose one or multiple traits among the 10 varietal traits that you want to add or to improve into this particular variety given the limited budget of PHP100.

5.1 Single trait

a. Demonstrate that as you improve a trait, the budget decreases and the risk increases accordingly. *As you increase the level of improvement of a trait, a corresponding cost will be deducted from your budget and a relative investment risk will be added. The initial improvement of a trait is more expensive compared to the succeeding levels because of the fixed cost. The first level of new trait improvement is costly since opening a new research program on this trait will require initial expenses such as establishing a new laboratory and field experiments.*

b. Improvement of one trait will not affect other traits (*ceteris paribus*). *Improving a trait will not affect or influence the level of other traits.*

5.2 Trait combination

a. Demonstrate that once you improve an additional trait, the initial improvement is costly compared to the succeeding improvement because of the fixed cost. *Adding a new trait will initially incur a greater amount of fixed costs compared to the succeeding levels.*

b. Traits are synergistic. *There are combinations of traits that are cheaper to develop in one breeding program compared to separate single-trait breeding programs.*

c. A particular trait combination is antagonistic. <You may choose not to explain this to avoid causing bias against these two traits.> *There are some traits that are counteracting each other. A good example is slenderness and head rice recovery. The more slender the rice, the lesser its head rice recovery since slender rice is brittle and prone to breaking during milling. This is the reason why the improvement of these traits in a single variety is more costly than producing two separate varieties, i.e. one with high slenderness and the other with high head rice recovery.*

The participants will do the task (investment games) twice: one for wet and one for dry season. In each season, the participants will work on the traits they want to add or to improve to their model variety which is mainly for selling in each season.

According to experts, the total cost used in developing a new rice variety through rice breeding program can have a return of investment up to 10 folds after the computation of income earned by all farmers who cultivated this variety. This afternoon, your investment of a maximum of PHP100 may earn around PHP1000 depending on your chosen varietal traits improvement. The duration of breeding new rice variety is around 6 years. But for our task (investment games), we will fast forward the breeding process so that after you put your investment, we can right away compute and pay out the return. The return on investment is based on experts' computation and simulation.

This task is a real investment of real money. After the task, we will give the exact amount of the return on your investment. To determine which season will be chosen as binding round, we will use the outcome from a coin toss. This binding round will be considered in the computation of your return on investment. Initially, we will assign an outcome from the coin toss to each season: Heads – Wet season and Tails – Dry season. After all the participants finished all the rounds of the task (investment games), the coin will be tossed. When the coin comes to rest, the upturned sided of the coin will correspond to the binding round. The file of the binding round for each participant will be opened and the computed amount from their investment will be handed over to them. They will be then asked to leave the venue quietly and not to talk about the task and their returns.

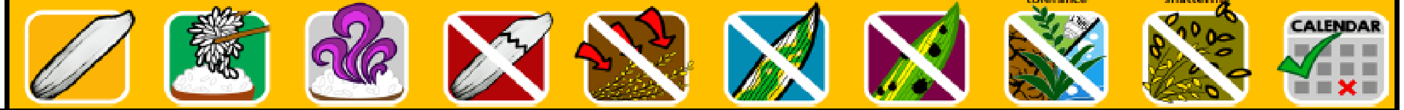
Appendix 2. IGA Accompanying Sheet (Individual)

Household #_____

IGA Accompanying Sheet

Details from respondents and General observations

classification: ☐ Husband ☐ Wife



Model Variety	Slenderness	Stickiness	Aroma	Head rice recovery	Lodging tolerance	Disease resistance	Insect resistance	Abiotic stress tolerance	Reduction of shattering	Earliness
WET: ☐ for consumption ☐ for selling ☐ both						specific rice disease(s):	specific insect(s):	☐ Drought ☐ Submergence ☐ Salinity ☐ Others: _____		no. of days of maturity: ____
DRY: ☐ for consumption ☐ for selling ☐ both						specific rice disease(s):	specific insect(s):	☐ Drought ☐ Submergence ☐ Salinity ☐ Others: _____		no. of days of maturity: ____

Trmt: __________ Ses#: __________ Date: __________

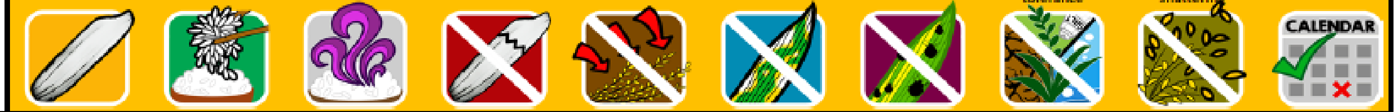
Location: Nueva Ecija, Philippines

Appendix 3. IGA Accompanying Sheet (Joint round)

Household #_____

IGA Accompanying Sheet

Details from respondents and General observations							Dominant member: ☐ Husband ☐ Wife ☐ both participate			
Model Variety	Slenderness	Stickiness	Aroma	Head rice recovery	Lodging tolerance	Disease resistance	Insect resistance	Abiotic stress tolerance	Reduction of shattering	Earliness
WET: ☐ for consumption ☐ for selling ☐ both						specific rice disease(s):	specific insect(s):	☐ Drought ☐ Submergence ☐ Salinity ☐ Others: _____		no. of days of maturity: ____
DRY: ☐ for consumption ☐ for selling ☐ both						specific rice disease(s):	specific insect(s):	☐ Drought ☐ Submergence ☐ Salinity ☐ Others: _____		no. of days of maturity: ____



Date: __________ **Trmt:** __________ **Ses#:** ______ Location: Nueva Ecija, Philippines

Appendix 4. Post-experiment Questionnaire

Household # _____

Classification: Husband Wife

A1. Are you a member of any organization? ___ [1] Yes ___ [2] No
If Yes, what kind of organization?
___ [1] farmer's organization ___ [9] credit cooperative
___ [2] water user association ___ [10] unions, labour unions, trader's union
___ [3] community council ___ [11] political party
___ [4] veterans club ___ [12] professional associations (Dr., Lawyer)
___ [5] youth club ___ [13] business, manufacturing
___ [6] women's club ___ [14] social movement, protest movement
___ [7] senior citizen ___ [90] Other, specify ____________________
___ [8] educational based group (PTA)

A2. Did you participate in any training course in rice farming in the past year?
___ [1] Yes ___ [2] No
If Yes, what type of training?
___ [1] Participatory varietal selection
___ [2] Seed production training
___ [3] Pest Management/Farmer Field School
___ [4] Best management practices
___ [90] Other, specify _______________________________________

ATTITUDES AND PERCEPTIONS
A3. Imagine someone is going to give you some money, would you prefer:
___ [1 or 2]
[1] To be given 1,000 pesos today
[2] To be given 1,250 pesos after one month

[Ask if A3 = 1]
A4. In the same situation, would you prefer: ___ [1 or 2]
[1] To be given 1,000 pesos today
[2] To be given 1,500 pesos after one month

[Ask if A3 = 2]
A5. How much would you have to be given after one month for you to choose to wait rather than receive 1,000 pesos today? _________

A6. How likely would you take risks when investing in rice farming? ____
[1] Extremely unlikely [4] Likely
[2] Unlikely [5] Extremely likely
[3] Neutral
QUESTIONS REGARDING THE CHOICE YOU MADE

A7. What did you consider more in prioritizing the varietal trait improvements in this exercise? ____ [1 or 2]

[1] Own farm experience/ problems faced

[2] Others' farm experience/ problems faced

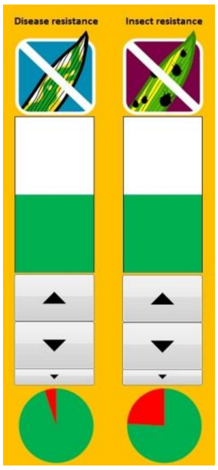
A8. What did you consider more in prioritizing the varietal trait improvements in this exercise? ____ [1 or 2]

[1] Past and current experience/ problems faced

[2] Future trends/problems anticipated

REVIEW QUESTIONS

A9. A farmer decided to invest in two traits with same level of improvement. For which trait is he more likely to achieve the level of improvement? ____ [1 or 2]



[1] Disease resistance

[2] Insect resistance

A10. What is the best strategy in the investment game? ____ [1 or 2]

[1] Invest in as many traits as possible

[2] Invest in the most important traits and try to improve them as much as possible

Appendix 5. Household Survey Questionnaire

GLOBAL FOOD STUDIES | THE UNIVERSITY of ADELAIDE

IRRI INTERNATIONAL RICE RESEARCH INSTITUTE

SURVEY QUESTIONNAIRE

--- CONFIDENTIAL ---

OBJECTIVE: To determine the factors that influence farmers' preferences for varietal trait improvements.
USE OF DATA: The data collected as part of this survey are for research purposes ONLY.
Household-level data will not be shared with non-research organizations.
Only summary results will be included in published reports.

Session (am or pm):	☐ am ☐ pm		
Household ID number:			
Province:			
Municipality:			
Village:			
Name of enumerator:			
Date of interview:			2016
	Day	*Month*	*Year*

A. DEMOGRAPHIC CHARACTERISTICS

Name		Age	Years in school	Years of own rice farming experience	Occupation (primary) [1]	Occupation (secondary) [2]	Religion	Do you have a smartphone? *[1] Yes / [2] No*
A1		A2	A3	A4	A5	A6	A7	A8
Husband								
Wife								

[1] *Record the occupation that takes up most of the time of the household head/spouse*
[2] *Record other job that takes up your time aside from your primary occupation*

A9. Number of household members: ______
Household members are defined as family and non-family members living more than six months in the household and taking food from the same kitchen.

A10. Approximate annual income of the household: ____________
This includes all income of household members including children. For self-employed members, we want the net income, i.e. business revenue minus business expenses.

A11. Do you have household member(s) aged 15-24 years old who is/are active in rice farming? ___ [1] Yes ___ [2] No
If Yes, how many of the following: Male: ____ Female: ____

B. LANDHOLDING INFORMATION

Please fill-up the table for all the plots you own and/or cultivated in 2015.

Land tenure type	Area	Unit
	B1	B2
1. Own land cultivated		
2. Shared in leased-in cultivated		
3. Total land cultivated (1+2)		

C. RICE VARIETIES GROWN AND MARKETING

Please fill-up the table for all the rice varieties you planted in 2015.

Rice variety	Season	Area planted	Area unit	Amount of seed used (kg)	Source of seed *1 – Own harvest* *2 – Neighbour* *3 – Trader* *4 – Input dealer* *5 – Government* *6 – Private seed grower* *90 – Other, specify*	Total grain production (kg)	Quantity sold (kg)	Buyer/s *[See codes below]*			Reason/s for choosing this buyer *[See codes below]*			Unit price received for sale (price/kg)	Distance from the field to place/point of sale (km)
C1	C2	C3	C4	C5	C6	C7	C8	C9a	C9b	C9c	C10a	C10b	C10c	C11	C12

Codes: Buyer [C9a – C9c]		Codes: Reason [C10a – C10c]	
1 – Village shop/retailer	7 – Neighbour	1 – Known for long time	6 – Come to house
2 – Wholesale	8 – Co-farmer	2 – Contract production	7 – Can sell even small quantity
3 – Middleman/broker	9 – Trader	3 – Provides inputs/credit	90 – Other, specify _________
4 – Money lender	10 – Livestock owner/farmer	4 – Short distance	
5 – Input supplier	11 – Dairy farmer	5 – Convenient to sell	
6 – Miller	90 – Other, specify __________		

D. CONSTRAINTS IN RICE PRODUCTION AND MARKETING

D1. Did you experience any constraints in rice production and marketing in the last 2 years? ___ [1] Yes ___ [2] No

If Yes, please fill-up the table below.

Constraint For abiotic stress, disease, and insect, please check the specific constraint/s that was/were encountered	**Did you experience the problem in the last 2 years?** ***Check all that applies***	**Record the severity of the constraint when it occurred** *1 – Not at all a problem, 2 – Minor problem,* *3 – Moderate problem, 4 – Serious problem*	**Notes**
D2	**D3**	**D4**	**D5**
1. Abiotic stress			
Specify: Submergence/flooding			
Drought			
Salinity			
Other, specify ________________________________			
2. Disease			
Specify: Rice tungro			
Rice blast			
Bacterial blight			
Sheath blight			
Other, specify ________________________________			
3. Insect/Pest			
Specify: Brown plant hopper			
Stem borer			
Gall midge			
Other, specify ________________________________			
4. Lodging (rice plants falling down due to wind and flood)			
5. Shattering of grains			
6. Late maturing			
7. Lower price from buyers due to lower head rice recovery			

E. BUYER RELATIONS

E1. Do buyers require certain quality standards of your paddy? ___ [1] Yes ___ [2] No
Quality standards could be in terms of moisture content and cleanliness of the grain (no straw, stones, weed seeds, soil, non-grain materials).

E2. Do millers adapt/adjust prices according to head rice recovery? ___ [1] Yes ___ [2] No ___ [3] Don't Know
General question – you may or may not have experienced this

E3. Do you usually have a written agreement with the buyer? ___ [1] Yes ___ [2] No
If YES, what is/are specified in the agreement with the buyer?

___ [1] Price ___ [4] Variety ___ [7] Sorting by size
___ [2] Quantity ___ [5] Color ___ [8] Seed provided on credit
___ [3] Grade/quality ___ [6] Time of payment ___ [9] Other inputs provided on credit

E4. Do you know the end market for your rice crop? ___ [1] Yes ___ [2] No
If Yes [in E4], how do you know the end market of your rice crop?

___ [1] My first buyer/trader told me
___ [2] I work or communicate directly with traders in end market
___ [3] Heard from my neighbour/other farmers who sold the product to the same buyer
___ [4] Other, specify ________________________________

If Yes [in E4], is your rice crop eventually sold in any of the following type of markets?

___ [1] Traditional markets
___ [2] Supermarkets
___ [3] Processors
___ [4] Exporters
___ [5] Other modern markets (school, restaurant, hotel, etc)

F. INFORMATION AND FINANCING

F1. What is (are) the source(s) of rice farming information?

	1 – Extension worker/technician		5 – Trader		8 – Television		11 – Newspaper/magazine
	2 – Research institution		6 – Input sellers/companies		9 – Radio		12 – Mobile info service
	3 – Co-farmers/relative/neighbour		7 – Farmer group/cooperative		10 – Internet		90 – Other, specify __________
	4 – Village leaders						

F2. What is (are) the source(s) of information on output price?

	1 – Extension worker/technician		5 – Trader		8 – Television		11 – Newspaper/magazine
	2 – Research institution		6 – Input sellers/companies		9 – Radio		12 – Mobile info service
	3 – Co-farmers/relative/neighbour		7 – Farmer group/cooperative		10 – Internet		90 – Other, specify __________
	4 – Village leaders						

F3. Did you borrow cash, seeds, or other inputs in the past year?

	1 – Yes
	2 – No

F4. If Yes, what was (were) the source(s)?

	1 – Bank		4 – Microfinance institution		7 – Trader		10 – Money lender
	2 – Cooperatives		5 – Input seller		8 – Self-help group		90 – Other, specify __________
	3 – NGO		6 – Land owner		9 – Relatives or friends		

G. HOUSEHOLD DECISION MAKING/WOMEN EMPOWERMENT

ACTIVITIES	WHO DECIDES *1 – H only (Husband only)* *2 – H>W (Husband dominates)* *3 – H=W (Both husband and wife)* *4 – W>H (Wife dominates)* *5 – W only (Wife only)* *6 – N/A (Husband and wife not involve)*
Choice of crop	
G1. What crop to grow in the field	
G2. What rice variety to plant	
Post-harvest operations	
G3. Amount of rice to store or to sell	
G4. Where to sell rice or other crops	
G5. When to sell rice or other crops	
G6. Selecting of crop types and seed for the next growing season	
G7. Who decides how to spend income from crop sale	
G8. Where to store seeds	

Appendix 6. Human Research Ethics Approval

THE UNIVERSITY of ADELAIDE

RESEARCH BRANCH
OFFICE OF RESEARCH ETHICS, COMPLIANCE AND INTEGRITY
THE UNIVERSITY OF ADELAIDE

LEVEL 4, RUNDLE MALL PLAZA
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EMAIL hrec@adelaide.edu.au

CRICOS Provider Number 00123M

29 January 2016

Professor W Umberger
School: Global Food Studies

Dear Professor Umberger

ETHICS APPROVAL No: H-2016-010

PROJECT TITLE: Rice farmers' preferences for varietal trait improvements

The ethics application for the above project has been reviewed by the Low Risk Human Research Ethics Review Group (Faculty of Arts and Faculty of the Professions) and is deemed to meet the requirements of the *National Statement on Ethical Conduct in Human Research (2007)* involving no more than low risk for research participants. You are authorised to commence your research on **29 Jan 2016**.

Ethics approval is granted for three years and is subject to satisfactory annual reporting. The form titled *Annual Report on Project Status* is to be used when reporting annual progress and project completion and can be downloaded at http://www.adelaide.edu.au/ethics/human/guidelines/reporting. Prior to expiry, ethics approval may be extended for a further period.

Participants in the study are to be given a copy of the Information Sheet and the signed Consent Form to retain. It is also a condition of approval that you **immediately report** anything which might warrant review of ethical approval including:

- serious or unexpected adverse effects on participants,
- previously unforeseen events which might affect continued ethical acceptability of the project,
- proposed changes to the protocol; and
- the project is discontinued before the expected date of completion.

Please refer to the following ethics approval document for any additional conditions that may apply to this project.

Yours sincerely

PROFESSOR RACHEL A. ANKENY
Co-Convenor
Low Risk Human Research Ethics Review Group
(Faculty of Arts and Faculty of the Professions)

PROFESSOR PAUL BABIE
Co-Convenor
Low Risk Human Research Ethics Review Group
(Faculty of Arts and Faculty of the Professions)

THE UNIVERSITY of ADELAIDE

RESEARCH BRANCH
OFFICE OF RESEARCH ETHICS, COMPLIANCE AND INTEGRITY
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EMAIL hrec@adelaide.edu.au

CRICOS Provider Number 00123M

Applicant: **Professor W Umberger**

School: **Global Food Studies**

Project Title: **Rice farmers' preferences for varietal trait improvements**

The University of Adelaide Human Research Ethics Committee
Low Risk Human Research Ethics Review Group (Faculty of Arts and Faculty of the Professions)

ETHICS APPROVAL No: **H-2016-010** **App. No.: 0000021151**

APPROVED for the period: **29 Jan 2016 to 31 Jan 2019**

Thank you for your responses dated 13.01.2016 and 28.01.2016 to the matters raised.

It is noted this study includes Rio Maligalig, PhD candidate.

PROFESSOR RACHEL A. ANKENY
Co-Convenor
Low Risk Human Research Ethics Review Group
(Faculty of Arts and Faculty of the Professions)

PROFESSOR PAUL BABIE
Co-Convenor
Low Risk Human Research Ethics Review Group
(Faculty of Arts and Faculty of the Professions)

Appendix 7. Consent Form (English)

THE UNIVERSITY of ADELAIDE

Human Research Ethics Committee (HREC)

CONSENT FORM

1. I have read the attached Information Sheet and agree to take part in the following research project:

Title:	**Rice farmers' preferences for varietal trait improvements**
Ethics Approval Number:	**H-2016-010**

2. I have had the project, so far as it affects me, fully explained to my satisfaction by the research worker. My consent is given freely.

3. I have been given the opportunity to have a member of my family or a friend present while the project was explained to me.

4. Although I understand the purpose of the research project it has also been explained that involvement may not be of any benefit to me.

5. I have been informed that, while information gained during the study may be published and the data set made available to other researchers, I will not be identified and my personal results will not be divulged.

6. I understand that I am free to withdraw from the project at any time.

7. I agree to the activities (investment games and survey) being audio/video recorded and photographed. In any use of these records, your name will not be identified. Yes ☐ No ☐

8. I am aware that I should keep a copy of this Consent Form, when completed, and the attached Information Sheet.

Participant to complete:

Name: ______________________ Signature: ________________________ Date:___________

Researcher/Witness to complete:

I have described the nature of the research to____
(print name of participant)

and in my opinion she/he understood the explanation.

Signature: __________________ Position: _________________________ Date:___________

2013_consent_form_for_ participation_non_medicalhealth_research_only.docx

Appendix 8. Consent Form (Filipino)

THE UNIVERSITY of ADELAIDE

Human Research Ethics Committee (HREC)

CONSENT FORM

1. Nabasa ko ang kalakip na pahina na naglalaman ng mga impormasyon at pumapayag ako na maging bahagi ng pagsasaliksik na ito:

Paksa:	**Rice farmers' preferences for varietal trait improvements**
Ethics Approval Number:	**H-2016-0010**

2. Naipaliwanag sa akin nang mabuti ng tagapagsaliksik ang tungkol sa proyektong ito at malaya akong sumasang-ayon sa aking paglahok.
3. Binigyan ako ng pagkakataon na magsama ng kaibigan at miyembro ng pamilya habang ipinapaliwanag ang paglahok ko sa proyektong ito.
4. Datapwat naiintindihan ko ang layunin ng proyektong ito, malinaw naman na naipaliwanag sa akin na ang paglahok ko dito ay maaaring hindi direktang makinabang ako.
5. Ipinagbigay-alam sa akin na lahat ng impormasyon na makukuha ng pag-aaral na ito ay maaaring ilathala at ibahagi sa ibang mga mananaliksik ngunit ang aking katauhan at personal na impormasyon ay hindi isisiwalat.
6. Naiintindihan ko na malaya akong tumiwalag sa proyektong ito anumang oras.
7. Pumapayag ako na idokumento ang aking boses at larawan habang ginagawa ang mga aktibidades (investment games and survey). Hindi ilalagay sa mga paggagamitan ng pag-aaral na ito ang aking pagkakakilanlan sa mga boses at litrato na nakuha. Oo ☐ Hindi ☐
8. Batid ko na magtatago ako ng kopya ng *Consent Form* na ito at ng kalakip na pahina na naglalaman ng impormasyon kapag natapos nang mapunan.

Pupunan ng kalahok:

Pangalan: ____________________ Lagda: ____________________________ Petsa: ___________

Pangalan: ____________________ Lagda: ____________________________ Petsa: ___________

Pupunan ng Tagapagsaliksik:

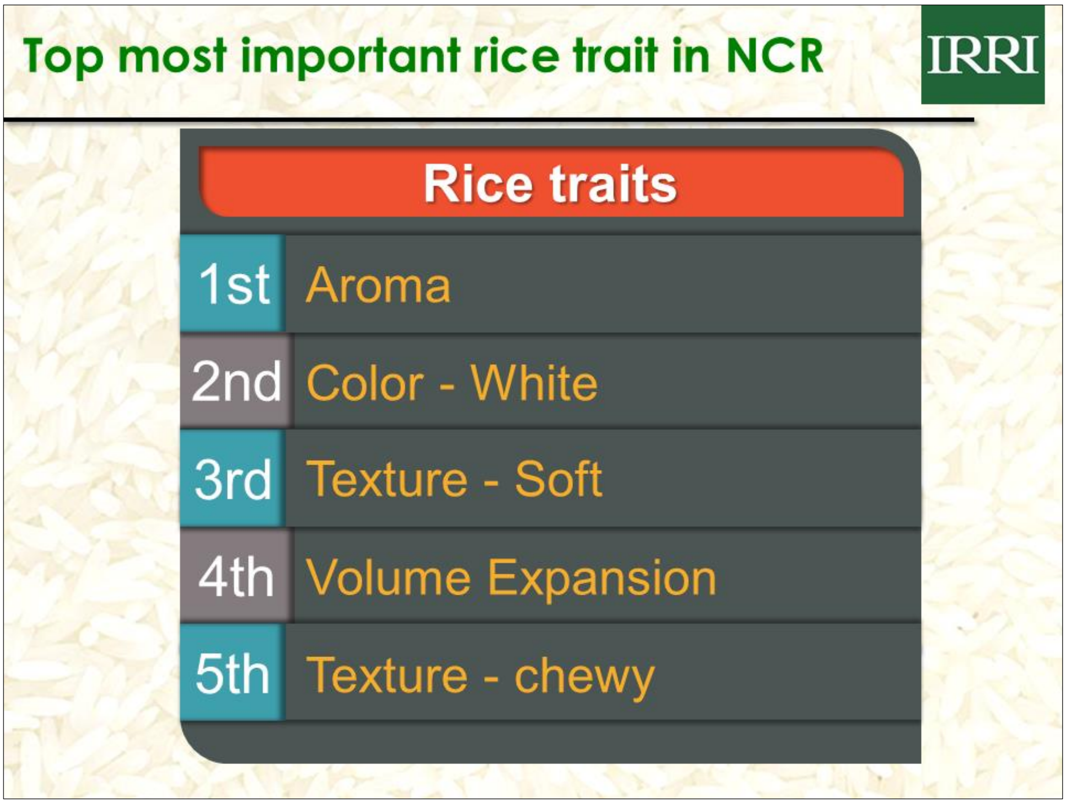
Inilarawan kong mabuti ang katangian ng pag-aaral na ito kay ______________________________
(Pangalan ng mga kalahok)

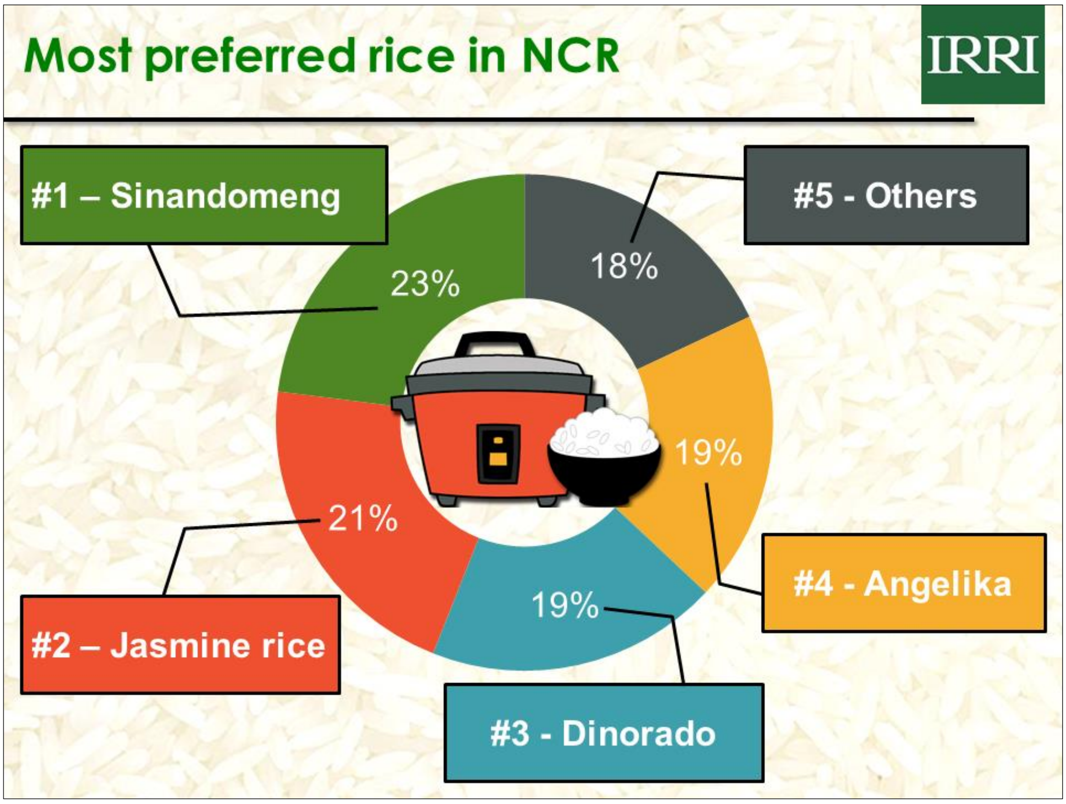
at sa aking paniniwala ay naintidihan nya ang aking mga paliwanag.

Pangalan: ____________________ Lagda: ____________________________ Petsa: ___________

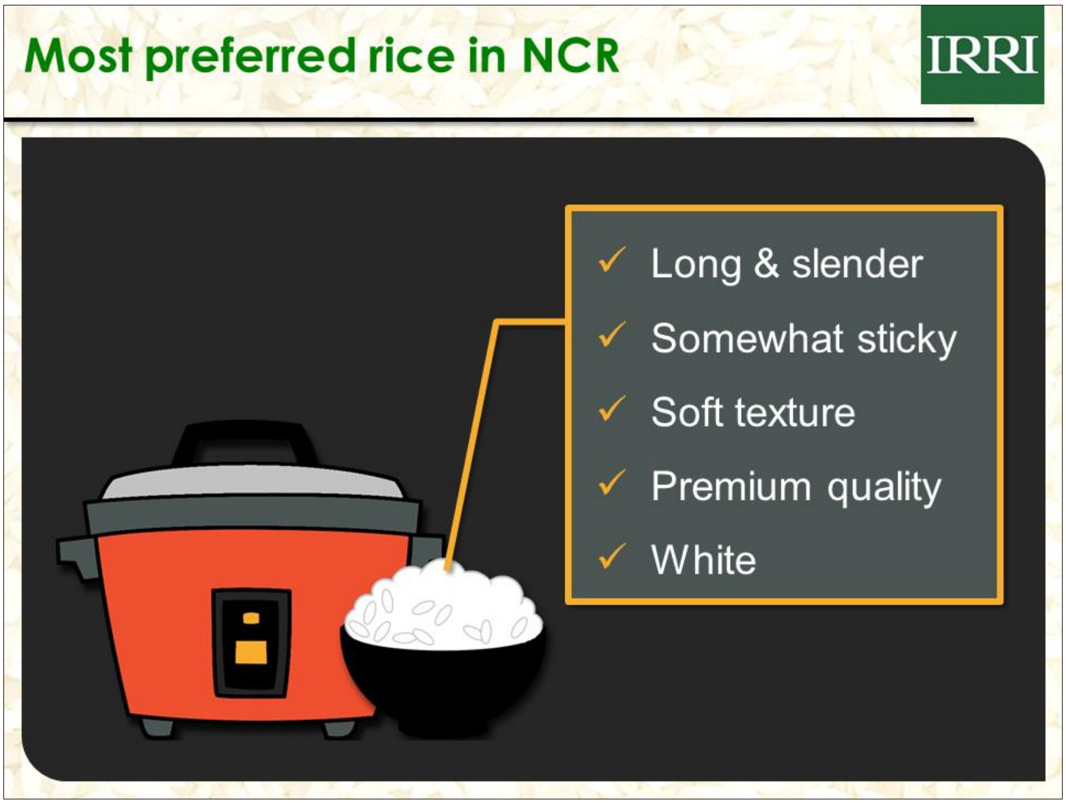
2013_consent_form_for_ participation_non_medicalhealth_research_only.docx

Appendix 9. Information Treatment – Market information





Appendix 9. Information Treatment – Market information (continued)



Appendix 10. Information Treatment – Climate change information