Individual Differences Matter

Personality traits and preferences in smallholders' farm management

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Thesis

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To my family

Contents

Chapter 1 Introduction

1.1 Overview

About 2 billion rural people in the developing world live in small farm households and work on land plots smaller than 2 hectares (Rapsomanikis, 2015). Many of them suffer from low income, insecure food intake, and limited access to markets and services, but they supply food for a substantial proportion of the world's population. In Asia and sub-Saharan Africa, smallholders provide up to 80 percent of the food supply (FAOSTAT, 2018). Successful farm management in smallholder agriculture is therefore vital for food security, rural welfare, and agricultural development in less developed countries.

Managing a farm requires smallholder to make and implement a range of decisions under often varying and uncertain conditions, such as weather and climate changes, pests and diseases, fluctuating prices on output and input markets, changing policies and regulations, and so on. Moreover, smallholder farmers in less-developed countries are often faced with markets for agricultural inputs and outputs that have major imperfections or may even be fully absent (De Janvry et al., 1991). Farm decision making under such pervasive uncertainties and imperfections may have important consequences for the livelihoods of their households as well as rural welfare in a broader sense. Unravelling and understanding what factors underly smallholder farmers' decision-making processes is therefore of crucial importance for designing policies aimed at increasing agricultural production and alleviating rural poverty.

The science of both economics and psychology study human decision making. The conventional economic approach describing production decision making is primarily based on various axioms that assume that producers are rational and selfish. This *Homo Economicus* assumption has been argued to be over-idealized in modelling all kinds of behaviour due to the absence of psychological insights (Frey & Stutzer, 2007). Unlike this neoclassical school of economics, the more recently developed behavioural school of economics has focused on modelling human behaviour as it is. Despite its

findings on a number of so-called behavioural failures that contradict the *Homo Economicus* assumption, the behavioural school of economics has its own limitations by not constructing a convincing unified theory or translating into mathematical formulas (Van Raaij et al., 2013).

Personality theory, that emanated from psychology, has started to be incorporated into economic models to account for individual psychological heterogeneities (Borghans et al., 2008). Personality psychologists claim that personality traits are important sources that can explain people's differences in thoughts, feelings, and behaviours (Roberts, 2006). Taking psychological factors, such as personality traits, into account to offer behavioural insights into the economic behavioural model can be compatible with the overarching utilitarian principle of the neoclassical schools of economics (Almlund et al., 2011; Borghans et al., 2008; Ferguson et al., 2011). There is a growing recognition of the explanatory potential of personality traits for economic outcomes in many empirical realms such as education attainment, energy consumption, and career success (Busic-Sontic et al., 2017; Heckman et al., 2006; Heineck & Anger, 2010; Rustichini et al., 2016).

Nevertheless, a systematic understanding of the role of personality traits in the agricultural production domain is lacking. In essence, smallholder farmers differ from one another in terms of personality traits and attitudes, and these differences can be expected to play a substantial role in the decisions that they make. Literature has stressed that personality traits are crucial factors underpinning an individual's entrepreneurship (e.g., Marcati et al., 2008; Zhao & Seibert, 2006). Agricultural production, in contrast to most salaried employments, naturally involves farm households engaging in multiple activities that might be spatially dispersed, and being able to sensibly adapt their resources (e.g., land, labour, and capital) to micro-variations in market circumstances and climate conditions (Nuthall, 2001; Rosenzweig, 1980). Operating a farm is thus in a way similar to owning a small business and farming requires entrepreneurial drive to some extent to meet challenges and deal with uncertainties (Allen & Lueck, 1998).

The current thesis aims to provide more insights into the contribution of individual differences in personality traits and economic preferences to smallholders' economic decisions in agricultural production and farm management, using available data sets from China. It starts with an investigation

of smallholders' perceived land tenure security from a psychological perspective, where we conceptualize the farmland tenure insecurity perception of a household as having both a cognitive and an affective component. Psychological factors such as personality traits are therefore expected to be crucial in this process. China presents an interesting case in this respect since the government's land policy and farmers' land tenure rights have considerably changed over time. In this respect, farmer decision making in China may also serve as an example of farmer decision making in other countries in which land tenure rights are not firmly established. The subsequent two chapters centre on the roles of personality traits and preferences for two important input use decisions in smallholders' agricultural production: land renting as an example of the quasi-fixed input, and fertilizer as an example of variable input in the agricultural production. And finally, upon finding that certain personality factors are of great importance in explaining variations in smallholders' decision making, this thesis continues to examine the effect of smallholders' personality traits on their overall farm management performance, using technical efficiency as an indicator.

Although each of the chapters 2-5 is envisioned as a stand-alone research article contributing to the economic literature, they all revolve around the topic of the role of personality traits or economic preferences in smallholders' decisions on farm management. Enhancing the understanding of personality traits and preferences in this realm helps to capture heterogenous decisions among rural smallholders and thereby may increase the effectiveness of policies aimed at improving rural welfare and agricultural development, which are often designed according to how individuals behave on average, ignoring the personality heterogeneities.

1.2 Theories and literature review

1.2.1 Personality traits and economic preferences

Personality traits typically refer to the underlying patterns of individual thinking, feelings, and behaving that can help explain the heterogeneity in behaviour across individuals and groups in many circumstances (Roberts, 2006; 2009; Srivastava et al., 2003). A well-validated taxonomy of personality traits, namely the Five Factor Model (FFM), or the Big-Five personality traits, has been commonly acknowledged and used in economic psychology to assess human personality from five major

dimensions (John et al., 2010). It distinguishes five broad dimensions: openness to experiences, conscientiousness, extraversion, agreeableness, and neuroticism (Costa & McCrae, 1992). Table 1.1 summarizes a general definition for each dimension in FFM.

Table 1.1 The Five Factor Model of Personality Traits

Dimension	*Definition*
Openness	The degree to which a person needs intellectual stimulation, change, and variety.
Conscientiousness	The degree to which a person is willing to comply with conventional rules, norms, and standards.
Extraversion	The degree to which a person needs attention and social interaction.
Agreeableness	The degree to which a person needs pleasant and harmonious relations with others.
Neuroticism	The degree to which a person experiences the world as threatening and beyond his/her control.

Source: Costa and McCrae (1992) and Hogan (2007). This table is partially reproduced from Boghans (2008).

The FFM is intended to be a unifying framework underlying a range of psychological variables, including values, preferences, and attitudes, in which each of the five factors can be subdivided into more individual characteristics to provide a more fine-grained description of one's personality. A few important psychometric advantages have made the FFM increasingly popular. The five trait factors are likely to be independent of each other (McCrae & John, 1992), primarily determined by biological maturation rather than life experience (Strivastava et al., 2003), fairly stable during adulthood (Roberts et al., 2006), and uncorrelated with cognitive skills (Stankov, 2005).

In addition, locus of control (*LoC*), originated from Rotter (1966), is a separate personality concept that has widely been used in explaining individual beliefs and decision making (Abay et al., 2017; Caliendo et al., 2015; Cobb-Clark et al., 2014). LoC is defined as a generalized belief about the extent to which people attribute control over their situation to themselves or to the environment. An individual with internal LoC tends to credit achievements to his/her own efforts, while an individual with external LoC is likely to believe that life outcomes are determined by fate.

The concepts of economic preferences, such as risk preference and time preference, are instead proposed by economists as depicting individual differences built on the utility maximization

framework to explain economic decision making. Risk preference is captured by the curvature of the utility function in the standard expected utility function, while time preference refers to how people trade off utility at different points in time (Frederick et al. 2002; Gollier 2001).

Though research of personality traits and preferences has become a blossoming field in the study of human decision making, the relationship between personality traits and economic preferences has not been intensively studied until recently. Several earlier studies suggest that risk preferences may relate to most dimensions of the Big-Five personality traits and time preference correlates to conscientiousness and extraversion (Borghans et al., 2009; Daly et al., 2009). The correlation between personality traits and economic preferences in more recent studies has been found to be rather weak when it comes to explaining important life outcomes and behaviours (Becker et al., 2012; Rustichini et al., 2016; Schröder et al., 2020). Lönnqvist et al. (2015) further find that risk preference obtained from standard choice tasks are less correlated to personality traits than the one obtained from self-assessment questionnaires. Although these findings seem to imply that economic preference measures may capture rather different individual characteristics than personality trait, the possibility that economic preferences mediate the personality–behaviour relationships is not fully excluded (Benischke et al., 2019).

By combining these factors of personality traits and economic preferences, we build up a coherent set of indicators for individual differences in analysing farmers' decision making. Moreover, it further enables us to identify the relationship between economic preferences and psychological measures of personality, so as to shed more light on the relevant literature.

1.2.2 Land tenure security and land rental markets development

The literature on land tenure stresses the importance of land tenure security for land investment and agricultural productivity (Besley, 1995; Holden et al., 2011; Place, 2009). It is argued that higher tenure security contributes to land investments and higher agricultural productivity through three pathways (Besley, 1995). First, under secured tenure, farmers are able to fully reap and harvest the fruits of their investment in the future and thus have more incentives to invest in land. Second, land could be used

as collateral for farmers to access credit that can be utilized for further investments. Third, secure land tenure can stimulate active land market transactions.

When inequalities in land-to-labour ratios exist between farm households, either the land market or the labour market may be used to reduce these inequalities. Whether labour- or land markets are used depends on the relative transaction cost in the two markets (Ray, 1998). When labour supervision costs are high, farmers with higher land-to-labour ratios are expected to rent out additional land. Land rental markets can have positive effects on efficiency and equity through facilitating land transfer from less productive to more productive farm households and allowing less productive farmers to participate in off-farm activities (De Janvry et al., 2001).

1.2.3 Agricultural production theory

Agricultural output in a season depends on the use of (quasi-fixed and variable) inputs and fixed production factors (assets) subject to a technology constraint, and is affected by the technical efficiency of the farm household and external factors such weather conditions and pests and diseases (e.g., Sadoulet & De Janvry, 1995). The technical efficiency of a farm household refers to how effectively it uses variable inputs for generating output, given the available production technology.

Under perfect market conditions where no transaction costs exist, a farm household's production decisions can be considered as independent of its consumption decisions; the two decisions are called 'separable' in farm household economics. However, large market failures (e.g., on the markets for credit, labour, land and/or food) often exist in the rural sector, particularly in developing countries, making that a household's production decisions can no longer be separated from its consumption decisions. The main consequence is that household characteristics that affect consumption decisions (e.g., household's dependency ratio or consumption preferences) may also affect the quantities of inputs that are used (De Janvry & Sadoulet, 2006).

1.2.4 Theoretical framework

Figure 1.1 presents the overall theoretical framework for this thesis. Personality traits and economic preferences will affect a farm household's perceptions. Together with the assets possessed by a

household, they may affect decisions regarding input use for a given farm technology. Technical efficiency reflects the farm households' ability to transform certain amounts of agricultural inputs into final outputs. Personality traits, and risk and time preferences are the central focus of our study and are shown on the left-hand side of the figure. The four bold solid arrows indicate the theoretical relationships to be investigated in four empirical research chapters of the thesis, while other solid arrows indicate those relationships that are relevant to this framework but have been empirically tested in the literature. The dashed arrows reflect other potentially important relationships that are not explicitly examined in this study.

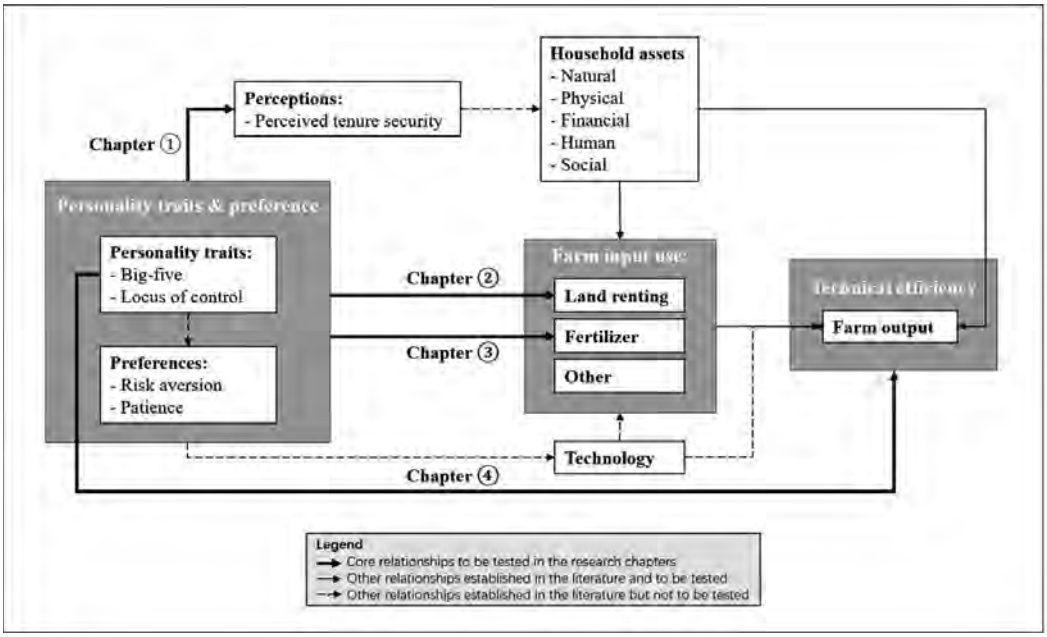

Figure 1.1 Overall theoretical framework of the thesis

1.3 Research objectives

Understanding the roles that personality traits and preferences play in smallholders' decision making is of crucial importance for designing further policies to support and facilitate agricultural and rural development. The overarching objective of this research is to obtain an improved understanding of individual smallholders' decision making, and particularly assess how personality traits and economic preferences affect farm-level management. In particular, the research focuses on four different aspects of farm management: (1) perceived land tenure security; (2) decisions on farm enlargement; (3) decisions on farm inputs uses (i.e., uses of synthetic and organic fertilizers); (4) overall economic performance in farm management, which is evaluated by technical efficiency (i.e., managerial ability to minimize input use given the output level). To achieve this objective, the following research questions will be answered:

- *Chapter 2*: Do smallholders' psychological factors matter when shaping land tenure security perceptions?
- *Chapter 3*: What is the effect of personality traits on smallholders' land rental markets participation? What are the underlying mechanisms through which personality traits exert their effects?
- *Chapter 4*: What are the associations between smallholders' risk and time preferences and their uses of synthetic and organic fertilizers? Do personality traits play a role in these associations?
- *Chapter 5*: What is the impact of personality traits on farm performance? How does the effect of personality traits on technical efficiency compare with the effect of cognitive skills attained through formal education?

Chapter 2 provides an economic-psychological interpretation of farmer's land tenure security perception. As an individual's perception could be an important precondition for his/her decision or behaviour to take place, this chapter serves as a primer for Chapter 3 and 4, where real behaviours of smallholder are investigated. Furthermore, instead of focusing on individual farm-level decisions, Chapter 5 builds upon all the three previous chapters and provides a picture of how smallholders' personality traits as a whole may affect the overall performance of farm.

1.4 Methodology

1.4.1 Study area, sampling, and data collection

The empirical analysis of the thesis is based on two different field surveys that took place in various provinces of China as part of different research projects. The data we used in the chapters 2, 4, and 5 were collected through a large farm household survey carried out in three provinces in eastern China in February 2019. The selected three provinces, Liaoning, Jiangsu, and Jiangxi, are located in the northern, central, and southern parts of eastern China, respectively, to reflect geographical and economic diversity (see Figure 1.2 for their locations). The primary goal of this survey was to assemble information on farmland rentals and resource management. The collected data contain rich information about rural households' family composition, agricultural production of farm households in the year 2018, and a range of other indicators, including individual preferences and personality traits. Other information such as personality traits, and risk and time preferences of the respondent was also obtained in the survey.

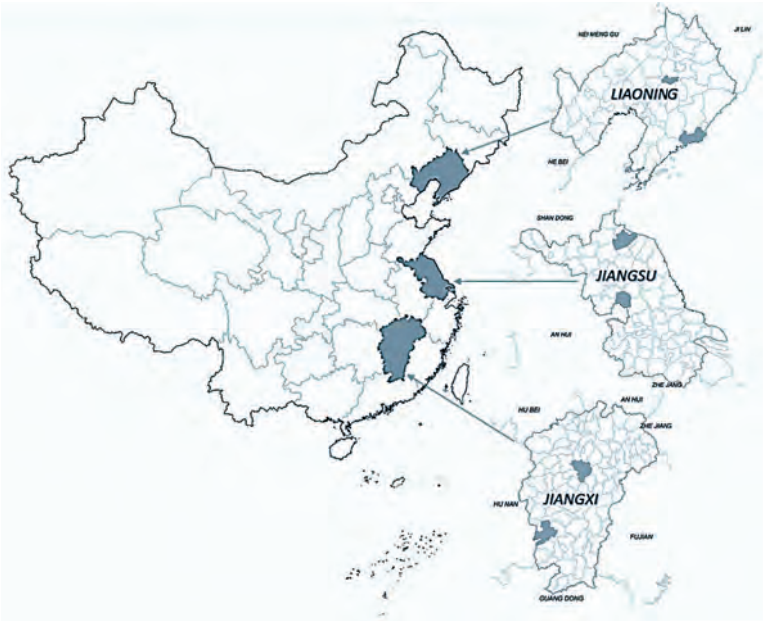

Figure 1.2 Locations of the Liaoning, Jiangsu, and Jiangxi provinces

The sample villages and households were selected through a multistage stratified sampling strategy. Within each province, two counties differing in geographical location and economic development levels were selected by consulting with researchers and local administrative contacts to serve as good representatives of the whole region in terms of their topography, distance to the provincial capitals, and economic development. Within each county, five townships were selected, one from each quintile on the list of townships sorted based on the per capita arable land area. A similar procedure was applied to randomly select four villages within each township. At village level, households were classified into three different stratums, i.e., renting-in, renting-out, and autarkic households, based on their land renting status.[1] Within each stratum, four households were randomly chosen and interviewed. Data of 1420 household observations were collected across 120 villages in total.[2]

The data we used in the research question 2 were collected by in-person interviews with smallholders and village cadres from Handan prefecture in Hebei province in February 2018, as part of a larger survey on the impact of so-called science and technology backyards in Handan prefecture. Handan prefecture is located at the centre of the North China Plain (NCP)—one of China's most important agricultural production regions (see Figure 1.3 for Handan's location).

[1] A small portion of rural households both rented in and rented out farmland at the same time. These households were classified as either renting-in or renting-out households, depending on which type of renting activity dominated in terms of land size.

[2] The total number of households renting in or renting out land was less than four in some of the selected villages. As a result, 1,420 households instead of 1,440 were interviewed in total.

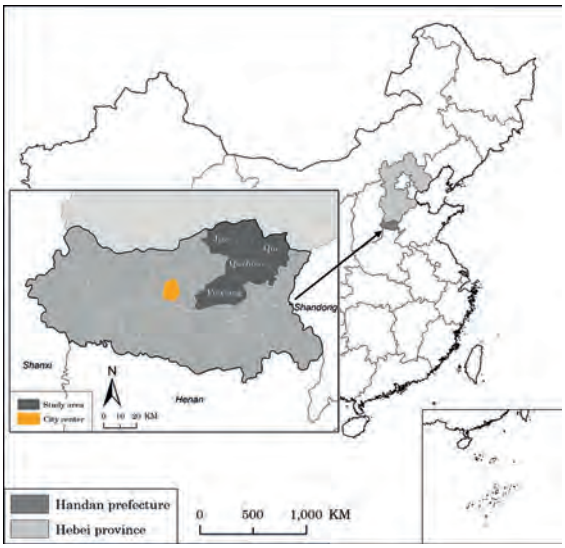

Figure 1.3 Location of the Handan prefecture

The data contain rich information about households' land rental market participations and smallholders' personality characteristics. The field survey was conducted in one county in Handan prefecture (Quzhou), where one of the aforementioned science and technology backyards is located, and three neighbouring counties. To make sure all our sampled villages included mainly maize and wheat producers, townships and villages not producing maize and wheat as their main staple crops were excluded from the sampling list.[3] Then we randomly sampled villages proportional to the size of the township. A list of all registered households was obtained within each village, from which we randomly drew 16 households per village to conduct face-to-face interviews with. In total, we surveyed 2,119 households from 135 rural villages and 22 townships.[4]

The core variables in this thesis, comprising psychological factors (i.e., Big Five personality traits and locus of control) and economic preferences (i.e., risk attitudes and time preference), were elicited using validated survey measures. The Big Five Inventory-10, an internationally recognized measure of

[3] Some villages may specialize in cash crops, such as apple, cotton, and grapes rather than staple food production. We collected information about crop specialization before we conducted interviews in the villages to make sure most smallholders were planting local staple food (wheat and corn) rather than cash crops.

[4] 41 Observations were dropped due to missing or incomplete data. Non-response was about 2 percent.

personality traits and its Chinese version with reasonable measurement validity and reliability (Carciofo et al., 2016; Li, 2013; Rammstedt & John, 2007), was used. Following the standard practice of Rotter (1966), we used the 10-item inventory which has been commonly used in the literature to measure locus of control (Ali et al., 2019; Caliendo et al., 2015; Cobb-Clark et al., 2014). Regarding economic preferences, we measured smallholders' risk and time preferences using measures which combine quantitative and qualitative survey questions that have been shown to be highly correlated with preferences measured in incentivized and more detailed lab experiments (Falk et al., 2018).

To deal with the fact that using psychometric scales among rural populations in developing countries may result in measurement error (Laajaj & Macours, 2017), a few measures were carried out during data collection to mitigate these biases. The acquiescence bias is expected to be reduced by balancing the scale and using both positively and negatively phrased statements (Soto et al., 2008), and the comprehension difficulty of the scales is anticipated to be eased with a few rounds of pre-tests in order to carefully rephrase the scale statements into local dialects.

1.4.2 Empirical strategies

To address the research questions specified in Section 1.3, state-of-the-art econometric models are employed in this thesis to analyse the data set collected in the field.

In Chapter 2, we theoretically decompose perceived tenure insecurity (PTIS) into two components (e.g., cognitive PTIS and affective PTIS) and investigate whether farmers' personality and preferences affected each component of PTIS. The cognitive and affective PTIS are categorical dependent variables, defined as the household's subjective expectation of and worry about the future land reallocations, respectively, on a scale from 1 to 5. An ordered probit model is therefore appropriate for the empirical analysis. A generalized structural equation modelling (GSEM) approach with robust standard errors clustered at village level is further employed to deal with the simultaneous estimation of a recursive structural cognitive-affective model combining two ordered probit regressions. GSEM can not only estimate equations with inter-related variables (Jöreskog et al., 2001), it also allows for the estimation of relations between continuous or categorical variables (Muthén, 1984).

In Chapter 3, we aim to identify personality traits and preferences that affect smallholders' land renting decisions. Decisions on land renting, measured by a series of outcome variables describing smallholders' behaviour and intention to rent in and/or rent out land, are binary variables. Given this dichotomous nature of our dependent variables, the probit model is applied. Moreover, in order to further disentangle the mediation paths through which personality traits affect farmland renting behaviour, we make use of the causal mediation analysis (CMA) proposed by Hicks & Tingley (2012). CMA with bootstrapping estimation of the indirect effect also enables us to test multiple underlying mechanisms at the same time without imposing the assumption of normality of the sampling distribution (Preacher & Hayes, 2008).

In Chapter 4, we investigate the associations between farmers' risk and time preferences, personality traits, and their use of synthetic and organic fertilizers. The intensity of synthetic fertilizer use and the adoption of organic fertilizer of the farm household, representing the two key outcome variables in this study, are a continuous variable and a binary variable, respectively. As a result, the ordinary least squares (OLS) regressions and the probit regressions are correspondingly used to obtain unbiased estimates. A two-stage probit least square (2SPLS) approach is then conducted in the empirical estimation to address the potential concern that farmers' decisions on synthetic and organic fertilizer use may be related to each other.

Finally, in Chapter 5, we focus on examining the impact of personality trait factors on farms' technical efficiency in rice production. Both parametric (e.g., Stochastic Frontier Analysis (SFA)) and nonparametric methods (e.g., Data Envelope Analysis (DEA)) have been commonly applied in assessing technical efficiency, while we select the SFA in our study due to its convenience of being less sensitive to measurement errors and its ability to analyse inefficiency determinants (Coelli et al., 2005). A Cobb-Douglas production function is preferred to Translog, suggested by the result of the specification test, even though Translog is a more flexible functional form (Reinhard, et al., 1999). In addition, a one-step maximum likelihood estimation (MLE) procedure is used to estimate both the stochastic frontier function and the inefficiency function in order to obtain consistent estimates, as suggested by Wang and Schmidt (2002).

1.5 Outline of the thesis

Chapters 2 to 5 are the core parts of the thesis. Each chapter presents an individual academic paper in which empirical answers to the research questions outlined above are presented. Chapter 2 studies the influence of psychological factors, i.e., personality traits and economic preferences, on perceived land tenure insecurity of Chinese rice farmers. We first disentangle the concept of perceived tenure insecurity (PTIS) into its cognitive and affective components, investigate whether and to what extent farmers' psychological factors can explain observed variations in each component of the perceived land tenure insecurity, and then estimate a recursive structural cognitive–affective PTIS model to capture the total effect of personality traits and preferences on the overall perceived tenure insecurity.

Chapter 3 examines the effects of personality traits on smallholders' land rental markets participation in China and investigates the underlying mechanisms through which personality traits exert these effects. A theoretical framework is developed conceptualizing the personality–renting relationship through economic and non-economic factors. We then empirically test the effects of personality traits on both smallholders' land renting behaviour and intention. A casual mediation analysis approach is employed in investigating the mediation mechanism in this personality–land renting relationship.

Chapter 4 focuses on the associations between farmers' risk and time preferences, personality traits, and the use of synthetic and organic fertilizers in China. We use an intertemporal farm household model to describe farm households' fertilizer-use decision under risk and uncertainty in general and then conceptualize how risk and time preferences and personality traits may affect the use of synthetic and organic fertilizer, respectively. The empirical part of this study considers the potential moderation or mediation role of personality traits between risk and time preferences and the fertilizer use decisions.

Chapter 5 investigates the effects of farmers' personality traits on their overall economic performances of farming, that is, technical efficiencies in the agricultural production. We theoretically develop a framework of the relationships between personality traits and farm performance and apply a coherent set of indicators (i.e., the so-called Big Five indicator and locus of control) measuring personality factors in the analysis. By estimating a Cobb-Douglas stochastic production frontier model and an

inefficiency model through a one-step maximum likelihood estimation (MLE) procedure, we empirically analyse if personality traits affect technical efficiency in addition to traditional human capital measures such as education.

Chapter 6 summarizes the chapters to provide a synthesis of the thesis, including a general discussion of the main findings of the previous chapters and the corresponding implications for policy making. The contribution to the literature and the limitation of this thesis are also presented in this chapter.

Chapter 2 An economic-psychological perspective on land tenure insecurity[5]

Abstract: Land tenure security perceived by farmers is generally considered an important precondition for rural development. In this paper, we investigate the influence of psychological factors on farmers' perceived land tenure insecurity. In doing so, we disentangle the concept of perceived tenure insecurity into its cognitive and affective components and examine the relationship between them. We develop a recursive structural cognitive-affective model and present the results of applying structural equation modelling to a dataset collected in 2019 among 1359 rice farmers in three provinces in eastern China. We found that the cognitive component of perceived tenure insecurity shows an inverse "U-shape" relationship with the affective component, which can be interpreted as support for the ''risk-as-feeling'' proposition that feelings do not always correspond with perceived risk estimates in the case of land tenure security. Moreover, some personality traits (i.e., neuroticism and extraversion) were found to significantly affect farmers' perception of land tenure insecurity. We conclude that the perceived tenure security of rural residents may be increased if relevant laws and regulations would be communicated to farmers in such ways that personality heterogeneities are taken into account, paying special attention to farmers with more "vulnerable" traits. Although the research was done for rural China, the findings are also likely to be relevant for other developing countries where formal institution and informal regulations play intertwined roles in rural land tenure.

Keywords: perceived security; land tenure; personality; economic preferences; rural China

[5] This chapter has been submitted to *Land Use Policy* in December 2020 as:
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2.1 Introduction

Secure property rights to land have been widely recognized as an important precondition for farmers to invest in land and therefore boost agricultural productivity (Besley, 1995; De Soto, 2000). Over the past few decades, issuing of rural land documents by governments continues to be the prevailing way to improve tenure security in many developing countries as land titles are expected to reduce or eliminate landowners' uncertainty about their land ownership (Broegaard, 2005; Feder & Feeny, 1991). Despite the acknowledged importance of land tenure security, empirical studies of economic outcomes of land titling programs, such as investments or agricultural productivity, show rather inconsistent results (Abdulai et al., 2011; Brasselle et al., 2002; Fenske, 2011; Ghebru & Holden, 2015; Place, 2009).

One possible explanation for this empirical discrepancy is the lack of consensus about what tenure security means from the perspective of the landowner. Arnot et al. (2011) show that legal title is commonly used as a proxy for tenure security in the available literature. However, whether legal title can guarantee secure rights is a debated question in other authors' opinions (Deacon, 1999; Place & Otsuka, 2000). Recent studies propose to focus on perceived tenure security and suggest it is the factor that most directly affects farmers' land-related decision making and behaviour (Broegaard, 2005; Linkow, 2016).

Perceived tenure security is not an unequivocal concept and lacks a consistent way of measuring in the literature. By definition, it is an individual perception, referring not only to the sense of security that tenure holders associate with their current tenure situation but also with their emotional fears towards future conflicts regarding their property rights (Broegaard, 2005). Similarly, Van Gelder (2007) suggests that perceived tenure security is a two-fold concept, being decomposed into a cognitive ''thinking'' state (perceived probability of risk) and an affective ''feeling'' state (fear of risk). A similar cognition–emotion system has been distinguished in the field of behavioural finance to explain people's investment decision-making process in financial markets (Rapp, 2019; Rick & Loewenstein, 2008; Shiller, 2002). Nonetheless, most existing research on land tenure tends to see perceived tenure security as either a purely cognitive or a purely affective state. For instance, some scholars consider

perceived tenure security from a cognitive perspective, using landholders' perceived risk of conflict and expropriation as indicator, and find it to be strongly associated with gender, migrant status, political connectedness, literacy, and wealth in Africa (Ghebru & Lambrecht, 2017; Linkow, 2016). In China, Ren et al. (2019a) find that the possession of land certificates may positively affect farmers' cognitive expectations of future land reallocations. Alternatively, other studies use affective worry to indicate perceived land tenure security. Rao et al. (2017) find that formal land documents do not contribute to households' worry of losing land in the future, while interpersonal and political trust negatively affects perceived worry.

In addition to tenure security, the importance of individual psychological differences has recently been recognized in studies explaining rural smallholders' agricultural technology adoption and investment decisions (Ali et al., 2020; Bernheim et al., 2015; Duflo et al., 2011; Haushofer & Fehr, 2014). However, despite the recognition of psychological factors such as trust in some of the aforementioned studies, perceived tenure security has not been linked to a common taxonomy of individual psychological differences, including personality traits, locus of control and economic preferences, in the available literature so far. Given that land tenure security perceptions may serve as an important potential bottleneck for investing in new opportunities and risky technologies (Bandiera, 2007; Fenske, 2011; Ma et al., 2013), there is a need to obtain deeper insights into the cognitive and affective components of perceived tenure security and their psychological determinants. In this study we aim to investigate the influence of psychological factors, i.e., personality traits and economic preferences, on farmers' perceived land tenure insecurity. In doing so, we disentangle the concept of perceived tenure insecurity into its cognitive and affective components, examine the relationship between the two components, and investigate whether and to what extent farmers' psychological factors can explain observed variation in perceived land tenure security. We develop a recursive structural cognitive–affective model, and present the results of structural equation modelling to a dataset collected among 1359 rice farmers in 120 villages in Jiangsu, Jiangxi, and Liaoning provinces, P.R. China in 2019. China provides an interesting case to investigate the perceptions of farmland tenure security at the

household level, where tenure security could be threatened by periodical land reallocations in response to demographic changes in the village or by other factors.[6]

The paper is structured as follows. We first review the literature describing the land tenure policy in rural China and the concepts of tenure security in Section 2. Section 3 presents a conceptual framework, operationalizing the relationship between the cognitive and affective components of perceived tenure security, and theorizing about how personality and economic preferences relate to each component. Section 4 describes the data set and empirical strategy. The results of the empirical analysis are presented in Section 5. We end with a conclusion in Section 6.

2.2 Literature review

2.2.1 Land rights reform and tenure policy in rural China

Land property rights in rural China have attracted much attention and concern from researchers since the introduction of the Household Responsibility System (HRS) at the end of the 1970s, under which farmland ownership resides with the collective at the village (or villagers' group) level and farmland use rights were leased out to individual farm households. Thus, land property rights are seen as ''quasi-private'' in China (Deininger & Jin, 2003; Kung, 2002; Ma et al., 2013). Use rights were equally distributed within villages on the basis of household and/or labour force sizes, with periodical land reallocations used to account for demographic changes (Ho, 2010; Lohmar, 2006; Qu et al. 1995).

Multiple rounds of land tenure reforms were implemented since then. The land contract period was extended from originally 15 years to 30 years in 1998 (Jin & Deininger, 2009; Spoor et al., 2010; Wang

[6] Land expropriations by governments for public purposes (e.g., infrastructure, urban expansion) without reasonable compensation may also undermine farmland tenure security in addition to land reallocations (Ma et al., 2015). However, we focus less on the importance of land expropriation and emphasize land reallocation on tenure insecurity in this study mainly for the following two reasons. First, farmland expropriation was less common in our sampling area as most land expropriations occur in sub-urban areas instead of rural villages (except for road constructions). Second, even though minor cases of expropriations (without reasonable compensation) have taken place within our sampling regions in the past, a household is more likely to be protected against inappropriately compensated expropriation in the future given the nationwide distribution of land certificates (Ma et al., 2016) and any farmland expropriation has to be approved by central government according to Article No. 35 in the revised Land Management Law (LML) in 2019.

et al., 2011; Zhu & Prosterman, 2009).[7] The 1998 Land Management Law (LML) required that farmers should receive a written 30-year land use contract from the local collectives to be legally protected (Zhu et al., 2006). The Rural Land Contract Law (RLCL) of 2002 confirms that farmland tenure security should be maintained at least 30 years after the nationwide farmland reallocation and that any further large-scale land reallocations at village level should be prohibited except for some very specific circumstances, such as a natural disaster, or governmental land expropriation (Deininger & Jin, 2003; Wang et al., 2015). The land tenure reform of 2013 initiated a nationwide land certification program and promoted the ''three rights separation system (TRS)'' (Wang & Zhang, 2017). Each rural household should receive a land certificate registered with the Ministry of Land and Resources, specifying the boundaries and areas of contracted land (Ren et al., 2019a).[8] In 2018, the amendment of RLCL further stipulates that the farmland use contract will be extended for another 30 years when the current contract expires (Zhou et al., 2020).

These legal improvements of land tenure through these different rounds of reforms may not be simply equated with effective tenure security at the household level. Available evidence shows that a large number of rural households did not receive land contracts or received contracts that were not fully in line with the LML (Jin & Deininger, 2009; Zhu et al., 2006). Moreover, land reallocations continued to take place in some regions despite the ban on reallocations and the widespread issuance of land certificates (Brandt et al., 2002; Jin & Deininger, 2009; Ren et al. 2019b; Wang et al., 2011). These reallocations may result from ambiguous formulation of relevant laws and prevailing self-governance rules. While the LML and the RLCL of 2002 prohibit land reallocation at the village level, local governments are still given a certain flexibility to apply informal self-governance rules regarding within-village land reallocation as partial land reallocations are allowed to take place if they are accepted by at least two-thirds of villagers' representatives within a village and approved by higher-level (e.g., township) authorities (Ma et al., 2015; Piotrowski, 2009).

[7] This extension of contract period in 1998 is usually referred to as the second round of land contracting (Ren et al., 2019a).
[8] The TRS system separated farmers' use rights of land into a non-transferable farmland contractual right and a transferable farmland operation right, where a farmer's operation right can be used in principle as collateral (Wang & Zhang, 2017).

2.2.2 Land tenure security

The literature on land tenure stresses the importance of land tenure security for agricultural productivity (Besley, 1995; Holden et al., 2011; Place, 2009). Besley (1995) argues that higher tenure security contributes to land investments and higher agricultural productivity through the following three pathways. First, farmers would have more incentives to invest in land as they are able to fully reap and harvest the fruits of their investment in the future under secured tenure. Second, when freehold titles are established, land could be pledged by farmers more easily as collateral to access resources (credit) that can be used for investments. Third, more secure land tenure can stimulate active land market transactions; the option to convert land into liquid assets via land sales or rentals is expected to contribute to investments in land improvements.

Yet, empirical studies examining these three pathways fail to provide consistent results (Ghebru & Holden, 2015; Goldstein & Udry, 2008; Place, 2009). As mentioned above, the lack of consensus on how to define and measure tenure security may play a role (Arnot, et al., 2011; Ghebru & Lambrecht, 2017). A large number of studies define tenure security according to the substance of rights, and measure it by *de jure* indicators of land tenure (e.g., legal title to land) (Abdulai et al., 2011; Holden et al., 2009; Michler & Shively, 2015; Nguyen et al., 2016). Other studies consider it as an assurance concept, and measure it using either the *de facto* probability or the perceived probability of losing some or all rights held through, e.g., eviction or expropriation (Ali et al., 2014; Carter & Olinto 2003; Deininger & Jin, 2006; Linkow, 2016; Ma et al., 2013; Sjaastad & Bromley 1997).

More recent research adopts a tripartite view of tenure security with three constitutive elements: legal tenure *(de jure)* security, actual *(de facto)* tenure security, and perceived tenure security (Ma et al. 2015; Van Gelder, 2010). The *de jure* view of tenure security rests on the classical conception of property rights, suggesting legislative authorized property rights identifying private ownership over a set of valued resources (Singer, 2000). This idea essentially refers to the legal status of property rights and the legal protection in case of infringement (Van Gelder, 2010). The *de facto* view of tenure security emphasizes the actual control of property, regardless of its legal status (Van Gelder, 2010). Though a high level of *de jure* tenure security should theoretically imply effective *de facto* assignment of rights and duties, this is not the case when effective enforcement is lacking as happens in many

developing countries (Ma et al., 2015; Van Gelder, 2010). The concept of perceived tenure security considers tenure security from a dweller-based angle, which may depend on both legal and actual tenure security, but may vary regarding "who perceives it, how much tenure is gained, which actors have been involved" (De Souza, 2001: p.179). Dwellers facing similar legal and/or actual tenure security may still differ in their perceived tenure security due to differences in their subjective understanding of their personal legal and/or tenure situation (Broegaard, 2005; Van Gelder, 2010).

2.3 Conceptual framework

In this section, we first distinguish the cognitive ("thinking") and affective ("feeling") aspects of perceived tenure security and discuss the relationship between the two aspects. Next, we introduce the concepts of the Big-Five personality traits, locus of control, and economic preferences and discuss how they may influence cognitive and affective perceived tenure security. We end the section with presenting the conceptual model that will form the basis for empirical analysis.

2.3.1 Perceived tenure security as a composite concept

Perceived tenure security can be viewed as the closest proxy of land tenure security as farmers themselves are believed to make land-related decisions based on their subjective perceptions of tenure security (Ma et al., 2015; Sjaastad & Bromley, 2000). Given this subjectivity, perceived tenure insecurity is a rather complex concept combining both the general expectation of eviction and the fear of future conflicts from the perspective of the landholder (Broegaard 2005). Nevertheless, most empirical studies merely use landholders' subjective estimates of the likelihood of future eviction, or land reallocation in the case of rural China, to proxy perceived land tenure insecurity (Ghebru & Lambrecht, 2017; Holden & Yohannes, 2002; Ma et al., 2013; Ren et al, 2019a). One exception is the studies by Van Gelder (2007; 2009), which operationalizes perceived tenure insecurity as both a cognitive-based thinking state (the perceived probability of eviction) and an affect-based feeling state (feeling of insecurity regarding the tenure situation).

The underlying reason why most studies of tenure security focus on cognitive factors only is the ''consequentialism'' or economic perspective of decision making (Rick & Loewenstein, 2008). It

presumes that a farmer's utility of his/her tenure situation arises from an expectation-based calculus of land eviction that is associated with his/her emotional feeling in a linear-like way. In other words, cognitive evaluation of a risk, such as its perceived probability and magnitude, is expected to generate corresponding negative feeling states such as worry, fear and insecurity.

Psychologists have long considered the cognitive and affective aspects of mental operation as different determinants of the human decision-making process (Baron, 1994; Schwarz, 2000; Zajonc, 1980).[9] The cognitive aspect involves conscious analysis of sensory information, while the affective aspect refers to the unconscious psychophysiological arousal people experience, associated with, for example, positive or negative affect (Duncan & Barrett, 2007). The ''risk-as-feelings'' approach, opposing the ''consequentialist'' viewpoint, considers risk more as a feeling state than a purely thinking state, arguing that both cognitive assessments and affective feelings may work in concert to guide people's actions, especially under uncertainty (Finucane et al., 2000; Loewenstein et al., 2001; Slovic et al., 2005). Though cognitive evaluation of risk intuitively seems to be linearly correlated with affective feelings,[10] emerging behavioural studies showing the importance of affect-based mental operations in decision making suggest that they may diverge or even flow in opposite directions from each other (Loewenstein, 2001; Nesse & Klaas, 1994; Slovic et al., 2002; Van Gelder, 2007). As a result, cognitive risk perception may not always generate corresponding affective risk feelings.

In this study, we conceptualize the farmland tenure insecurity perception of a household in rural China as having both a cognitive and an affective component. Farm households may cognitively estimate the probability of land reallocations within the village taking place in the future, while affectively responding to the potential land reallocation by showing a degree of worry to it. As explained in the previous section, land reallocation has been prohibited for at least 30 years since 1998 in rural China according to LML and RLCL, resulting in the egalitarian distribution of farmland to be compromised through demographic or employment situation changes. Without reallocating land accordingly, issues

[9] The two aspects are thought to work independently but they can influence and be intercorrelated with each other (Storbeck & Clore, 2007).

[10] Relevant feelings may include negative effects such as stress, worry, anxiety and fear regarding the tenure situation (Van Gelder, 2007).

of inequality in farmland endowment, and therefore in farm income, arise inevitably. In this sense, farmers expecting that a land reallocation will take place may not necessarily experience a high degree of worry to it. In addition, the uncertainty about land reallocation itself may be worrisome, and certainty of land reallocation—either favourable or unfavourable—may diminish the farmer's worry. Therefore, the relationship between farmers' expectation and farmers' worries about rural land reallocations in China, whether it is linear or non-linear, will be explored in the empirical analysis.

2.3.2 Personality, preferences, and perceived tenure insecurity

i. Personality and preferences

Following Abay et al. (2017) and Qian et al. (2020), we include the Big-Five personality traits, locus of control, and economic preferences as indicators of personality and preference factors, respectively. The Big-Five personality model, also named the Five-Factor model (FFM), has become the most comprehensive and widely accepted taxonomy for personality traits (John & Srivastava, 1999; Rustichini et al., 2016). In this model, personality traits are grouped into five factors: openness to experience, conscientiousness, extraversion, agreeableness, and neuroticism (Costa & McCrae, 1992). In general, openness to experience captures the tendency of an individual of being creative and imaginative (Costa & McCrae, 1992). Conscientiousness describes the extent to which a person is hardworking, persistent, and self-controlled (Barrick & Mount, 1991; Zhao & Seibert, 2006). Extraversion is associated with positive affect, enthusiasm, and sociability (Ashton et al., 2002; John et al., 2010). Agreeableness measures how friendly, altruistic, and cooperative a person is (Costa & McCrae, 1992). Neuroticism is basically a negative emotion associated with anxiety, depression, and negative affect (Zhao & Seibert, 2006).

Locus of control (*LoC*) is a separate personality concept that has widely been used in explaining individual beliefs and decision making (Abay et al., 2017; Caliendo et al., 2015; Cobb-Clark et al., 2014). It originates from Rotter (1966), who defines LoC as a generalized belief about the extent to which people attribute control over their situation to themselves or to the environment. People with an internal LoC tend to credit achievements to their own efforts, whereas people with an external LoC

are more likely to believe these were caused by the environment. Recent empirical studies suggest that internal LoC can protect people against negative shocks (Buddelmeyer & Powdthavee, 2016).

While personality psychologists depict individual differences using personality frameworks, economists typically utilize preferences, such as risk preference and time preference, in combination with expectations of future events to explain economic decision making. Some literature considers preferences as facets or aspects of personality (Costa & McCrae, 1988), others argue that preferences and personality traits are rather complementary to each other, and thus preferences are deemed as mediators of personality constructs in determining human behaviour (Becker et al., 2012; Borghans et al., 2008; Ferguson et al., 2011; Roberts, 2009).

The risk preference parameter, also referred to as risk aversion, is an important concept representing the curvature of the utility function in the expected-utility framework (Gollier, 2001). It basically describes to what extent people are prone to taking risk in an uncertain situation. Time preference, or the so-called individual rate of discounting or impatience, refers to the extent to which an individual prefers immediate utility over delayed utility (Frederick et al., 2002). In reality, risk and time preferences are inevitably confounded as postponed rewards always carry a certain extent of risk (Borghans et al., 2008).

ii. Personality, preferences, and cognitive perceived tenure security

Cognitive perceived tenure insecurity, or the perceived probability of future eviction, refers to how people perceive risks related to the land tenure situation. Within the Big-Five personality traits, openness includes facets such as curiosity, intellectuality, and open-mindedness, which are associated with flexible and inclusive cognition (Kaufman et al., 2016; McCrae & Costa, 1997). In other words, people high in openness tend to cognitively explore abstract information (ideas and arguments) through reasoning (Antinori et al., 2017). However, there are no a priori reasons to expect a relationship between openness and cognitive perceived tenure security. Conscientiousness is closely related to rationality and caution (Goldberg, 1999). Hence, following common experience concerning land reallocation, we assume that farmers scoring higher on conscientiousness are more likely to expect a

land reallocation in the future in response to demographic changes taking place within their families and villages. Extraversion is closely associated with interpersonal and social behaviour. Farmers scoring higher on extraversion may be more sensitive to the real land tenure situation within their villages because of more up-to-date information received through their social networks. Whether they are more likely or less likely to expect a land reallocation depends on the situation in their villages. Neuroticism is related to instability and impulsivity (Goldberg, 1999). Neurotic farmers are expected to anticipate a high likelihood of land reallocation as they are more likely to perceive their surroundings to be risky or insecure. Agreeableness is a personality trait which seems less relevant in this context.

Locus of control (LoC) is expected to play an important role in farmers' expectations regarding future land reallocations. People with a higher level of internal LoC believe that their future is determined more by their own actions, whereas people with a higher level of external LoC attribute the occurrence of future events to the external environment (Antonides, 1996). We envisage that people with more internal LoC perceive more personal control over their contracted land and are therefore less likely to expect a land reallocation in the future.

Economic preferences are not expected to affect farmers' cognitive perceived tenure security, or the perceived likelihood of land reallocation occurrence, which is equivalent to the concept of risk perception (Slovic, 1987). Sitkin and Pablo (1992) consider risk perception and risk preference as two distinctive notions. Risk perception could be determined by situational factors, while risk preference is a stable, innate factor, not influenced by the environment. No evidence in the literature suggests a priori expectations of time preference on the risk perception.

iii. Personality, preferences, and affective perceived tenure insecurity

Psychological studies frequently explain negative affect (e.g., worry, fear and anxiety) from personality traits (Beck et al., 1983; Clark & Watson, 1991; Gomez & Francis, 2003; Larsen & Ketelaar, 1991). Both anxiety and fear are defined by high levels of negative affect and/or low levels of positive affect (Clark & Watson, 1991); worry can be defined as anxious apprehension or concern about the uncertain outcome of future events (Macleod et al., 1991). Negative affect refers to subjective

distress and unpleasurable engagement, whereas positive affect reflects the extent to which a person feels enthusiastic, active, and alert (Watson et al., 1988).

Among the Big-Five personality traits, neuroticism and extraversion are known to be associated with anxiety because of their effects on negative and positive affect, respectively (Middeldorp et al., 2008). There is general consensus that individuals scoring high on neuroticism exhibit negative affectivity whereas high extraversion is likely to protect against negative affect (Gershuny & Sher, 1995; Gomez & Francis, 2003; Gramstad et al., 2013). On the one hand, individuals scoring high in neuroticism are likely to experience negative mood states or depressive episodes, and to develop more maladaptive reactions to the environment following stressful life events than those scoring low in neuroticism (Costa & McCrae, 1992; Kendler et al., 2004). Land reallocation in rural China, in essence, could be a stressor for some farmers as it is likely to be perceived as a serious threat to tenure security and may discourage farmland investment (Gong, 2018; Jacoby et al., 2002; Li et al., 1998). Thus, neurotic farmers are expected to be more sensitive to land reallocation as a stressor, which may trigger dread reactions toward its future occurrence. Extraversion, on the other hand, is essentially related to the idea of being pro-social and optimistic (Costa & McCrae, 1992). As a result, extravert people appear to pay more attention to positive and less attention to negative information than introvert people (Noguchi et al., 2006). Extravert farmers are more social and communicative and thus likely to receive a sense of support and relief from others in case of uncertain and worrisome land reallocation situations, preventing them from dread feelings. Therefore, they may weigh positive consequences of land reallocation (i.e., compensation) more than negative ones (i.e., land loss or disputes) as compared with introvert farmers. Hence, we expect neuroticism to be positively and extraversion to be negatively related to the farmer's level of worry regarding future land reallocation, respectively. We found no studies examining relationships between the other dimensions of the Big-Five personality traits and negative or positive affect. Nor did we find a priori reasons to expect a relationship between LoC and negative or positive affect. Therefore, we have no expectations about the impact of openness, conscientiousness, agreeableness, and locus of control in this respect.

People's affective responses to tenure situations may also be subject to their risk or time preferences (Pennings et al., 2002; Pratt, 1964). For instance, Lusk and Coble (2005) found that people's

acceptance of genetically modified food is dependent on the interaction between risk perception and risk preference. In our case, land reallocations that may occur in the near future can be considered an external stimulus associated with uncertainty and risk. Farmers with higher risk preference may feel less worried when they perceive a higher likelihood of future land reallocation. Time preference is associated with anxiety. People with lower discount rates are more likely to suffer from psychological anxiety or worry, because they pay more attention to future events than people with higher discount rates.

2.3.3 Conceptual model

The conceptual framework of our study is graphically summarized in Figure 2.1. Basically, a household's perceived tenure insecurity (PTIS) of farmland may be decomposed into two components: the cognitive PTIS and the affective PTIS; farm households are assumed to cognitively assess the probability of land reallocations taking place, and associate this probability with positive or negative affect, depending on how favourably the land reallocation would turn out to be. Personality and preferences, as well as household characteristics and external factors (i.e., formal enforcement and informal governance) being discussed in Section 4, may affect each PTIS component; these relationships are labelled (1) and (2) in the figure. Furthermore, we explore the relationship between the cognitive and affective components of PTIS, marked as (3) in the figure. The dashed lines in this model are to be tested in our empirical analysis, whereas the solid lines indicate the links with perceived tenure (in)security that were established in the literature so far.

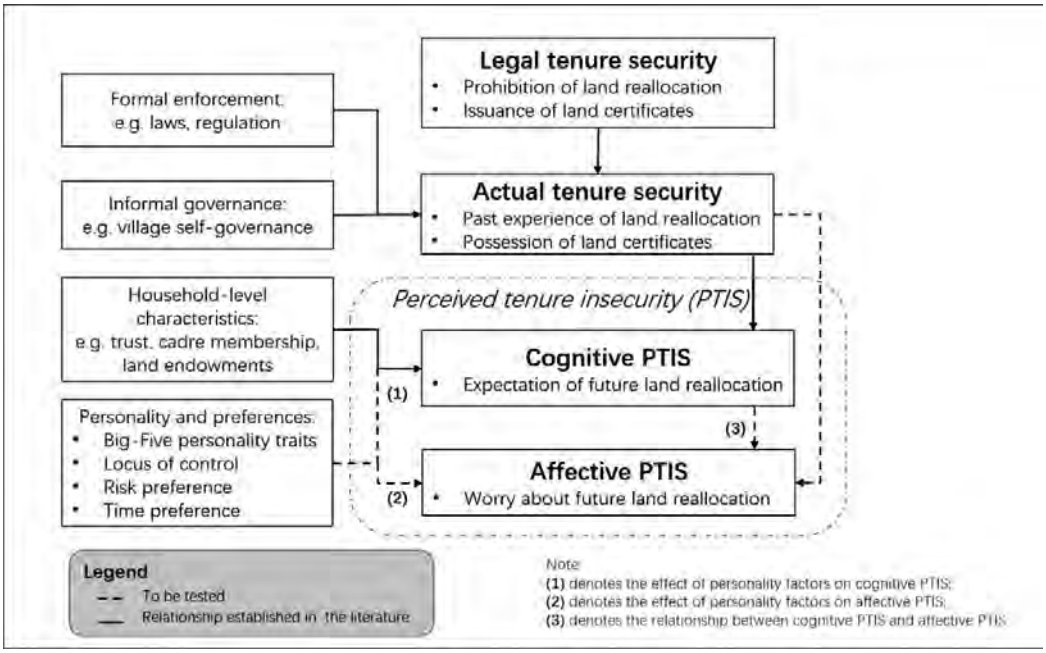

Figure 2.1 Conceptual model of land tenure security

2.4 Data and methods

2.4.1 Data collection

The data set we used in this study was collected from a face-to-face household survey in Jiangsu, Jiangxi, and Liaoning provinces of China in February 2019 as part of a larger survey examining farm-size enlargement in rural China. The three provinces are assumed to be representative of the Southeast, Central-East and Northeast of China, respectively. A multistage sampling strategy was applied to select sample households. Within each province, two counties differing in geographical location and economic development levels were selected.[11] Within each county, we applied stratified random sampling method to select five townships from an ordered list based on average land endowments per rural household. The same approach was applied to randomly select four villages within each township. In each village, all households were then classified into one of three groups: households renting in land

[11] The counties were selected by consulting local policymakers. A more detailed description of sampling procedure is given in Zhou et al (2019).

only, households renting out land only, and households without renting activities.[12] Next, we randomly selected four households per group in each village. In total, 1420 household observations were sampled across 120 villages.[13] In this study, information for 1359 households was used, because 57 households that had no contracted land and 4 households with missing information on major variables were dropped from the sample.[14] We also collected village level information by interviewing 120 village cadres.

2.4.2 Choice of variables and expected effects

The dependent variables that we used in the analysis are indicators of the cognitive and affective PTIS of farmers. Cognitive PTIS was measured by two variables reflecting households' subjective expectations about land reallocation. Specifically, we asked to what extent the household expected that an administrative land reallocation would take place within the next five-year period and after the contract period would end (roughly after ten years), respectively. We adopted a 5-point scale running from 1 (*not expecting land reallocation at all*) to 5 (*expecting land reallocation for sure*) for the answers. Affective PTIS was measured by asking to what extent farmers worried about future land reallocations, on a scale from 1 (*household not worried at all*) to 5 (*household worried badly*).

Personality and preference factors were our focal explanatory variables. They included the farmers' Big-Five personality traits, locus of control, risk preference and time preference. The direction of their expected effects on PTIS has been discussed in Section 3.2. They are also shown in Table 2.1, as are the signs of the expected effects of the other explanatory variables.

We used the Chinese version of the BFI-10 to measure the personality traits on a 5-point Likert-type scale, which has reasonable measurement validity and reliability (Carciofo et al., 2016; Li, 2013). The

[12] A small portion of rural households both rented in and rented out farmland at the same time. These households were classified as either renting-in or renting-out households, depending on which type of renting activity dominated in terms of land size.

[13] In few villages, the total number of households renting in or renting out land was less than four. As a result, we yielded 1420 households instead of 1440 in total.

[14] The household head was invited to be interviewed. However, in case the household head was not available, we interviewed the household member that knew most about agricultural decision making.

BFI-10 scale has been widely used in economic and social-psychological studies (Donato et al., 2017; Oehler et al., 2018; Rammstedt & John, 2007). We elicited LoC following the standard practice of Rotter (1966) using the 10-item inventory with a 5-point Likert-type scale. We followed the suggestions by Collins (1974) and Gatz and Good (1978) that external and internal LoC should be treated as two independent traits, and constructed two separate LoC traits (i.e., internal and external) based on factor analysis. The internal LoC scale consisted of 4 items and the external LoC scale consisted of 4 items; Cronbach's αs were 0.69 and 0.65, respectively, indicating reasonable levels of internal reliability.[15] The average variance extracted (AVE) values were also calculated for all latent personality factors to assess convergent and discriminant validity. All values of AVE were greater than a rule-of-thumb critical value of 0.5, except for the external LoC scale.[16] All items and statements were translated into colloquial expressions and local parlance to ensure comprehensibility and reliability.

Risk and time preferences were measured following the streamlined version of a global preference module developed for eliciting time preference and risk preference among respondents having limited cognitive capacity in time-constraint settings (Falk et al., 2016; 2018).[17] Both preference variables were obtained by combining one qualitative item (one-item self-assessment) and one quantitative item (hypothetical choice experiment). A higher value of the risk preference variable indicated a greater risk-seeking tendency, and a higher value of the time preference variable indicated a greater level of impatience.

Several other variables were expected to affect PTIS, including actual (*de facto)* tenure security and household characteristics like land endowments and trust. Following the relevant literature (Rao et al, 2017; Ren et al., 2019a), actual tenure security was measured by three indicators, namely the

[15] The external LoC scale originally had 6 items, 2 items were dropped after the factor analysis given validity and reliability concerns.

[16] The AVE value of external LoC equaled 0.463, which was still acceptable since the composite reliability (CR) was higher than 0.6 (CR (external LoC) =0.774), according to Fornell and Larcker (1981).

[17] Each of the risk and time preferences was obtained by combining one qualitative item and one quantitative item. For most preferences the optimization procedure resulted in a combination of two survey items, involving one qualitative item, which is more abstract, and one quantitative item, which puts the respondent into a precisely defined hypothetical choice scenario.

possession of an old land contract issued after the second-round land contracting, the possession of a new land certificate issued after the recent nationwide land certification program (that started in 2013), and the household's land reallocation experience in the past. Possession of old contracts and new certificates were measured as dummy variables at the household level with values equal to 1 (*yes*) or 0 (*otherwise*). Without possessing land documents, farmers were expected to perceive themselves more insecure as being not provided a legal protection against potential rights infringement. Nevertheless, farmers having a new land certificate were expected to perceive land reallocation after the contract period would end because the certificate contained detailed information of the contract period. Land reallocation experience was defined as a dummy variable at the village level obtained by asking village cadre if the village had reallocated contracted farmland since the second round of land contracting. Farmers residing in the village where at least one land reallocation occurred since 1997, on the one hand, might expect land reallocation to occur again in the future as it happened before; on the other hand, might expect another round of land reallocation not likely to take place within a short period of time. The effect of past land reallocations on future PTIS thus was expected to be either positive or negative.

Land endowments were measured both by the imbalance of land endowments and by land fragmentation. The former was measured by the difference between a household's contracted farmland per capita and the village-level average. The larger the absolute difference, the more likely the household was to expect a future land reallocation. If the land endowment exceeded the village average, the household was expected to worry more about land reallocations because land reallocations are meant to equalize per capita land resources in a village. If the household's per capita land endowment was below the village average, the household was expected to worry much less because it would gain land from a land reallocation. Land fragmentation was measured by the number of contracted farmland plots. Households with a larger number of plots were more likely to expect their plots to be reallocated and consolidated into fewer and larger plots. They were therefore expected to worry less about land reallocations.

Household trust was measured by a 5-point scale of the respondent's trust in other villagers, running from 1 (*totally distrust*) to 5 (*totally trust*). As described in Section 2.1, local governments may use

ambiguous formulations of relevant laws and prevailing self-governance rules to implement land reallocations provided a large majority (at least two-thirds) of the villagers agree with it. Trust among villagers may be essential to reach such a consensus. Hence, households with a high level of trust in other villagers were more likely to expect a land reallocation in the short term.

Household characteristics, including age, gender, education of household head, household migration, and cadre membership, may also affect perceived tenure (in)security. An elderly farmer may either worry more about land reallocation because his/her influence or social power within the village is deteriorating over time, or worry less due to their shorter time horizons of working on farm. A female household head was expected to be associated with lower perceived tenure security as she tended to have a weaker social and economic position than a male head (Ghebru & Lambrecht, 2017). A farm household head working off-farm as a migrant was expected to perceive a higher likelihood of land reallocation but not necessarily to worry about it. A farm household with a more educated head and a household with a member belonging to the village cadre both were assumed to be more likely to perceive a secure land tenure given the better chance of accessing policy information and other income opportunities (Holden & Yohannes, 2002). We had no a priori expectation about household size, as there was no direct evidence of its effect on perceived land tenure security in the literature.

2.4.3 Model specification and estimation strategy

We start by investigating whether farmers' personality and preferences affected each component of perceived tenure insecurity. We also aim to examine the ''consequentialist'' viewpoint that whether a respondent's affective feeling of tenure insecurity is a linear consequence of his/her cognitive future land reallocation perception or not. We therefore specify the following structural equation system:

$$y_{ij}^{C} = \alpha_0 + \alpha_1 P_{ij} + \alpha_2 X_{ij} + \delta_p + \varepsilon_{ij}, \quad (1)$$

$$y_{ij}^{A} = \beta_0 + \beta_1 y_{ij}^{C} + \beta_2 \left(y_{ij}^{C}\right)^2 + \beta_3 P_{ij} + \beta_4 Pr_{ij} + \beta_5 X'_{ij} + \delta_p + \rho_{ij}, \quad (2)$$

where y_{ij}^{C} and y_{ij}^{A} denote cognitive and affective perceived tenure insecurity for farm household i residing in village j, respectively. P_{ij} is a vector of personality variables representing the Big-Five personality traits and locus of control. Pr_{ij} is a vector of preference variables including risk and time preferences. X_{ij} and X'_{ij} represent two sets of control variables for Equation (1) and Equation (2), respectively. Both sets of control variables comprise actual tenure security, land endowments, trust, and household socio-demographic characteristics, but they are slightly different in terms of land endowment variables. In X_{ij}, we include the absolute value of difference between per capita land endowment and the village average, while the normal value of it was included in X'_{ij}. δ_p represents the province dummy variable. ε_{ij} and ρ_{ij} are village-clustered robust standard error terms following the standard normal distribution. In Equation (2), the affective tenure insecurity perception y_{ij}^{A} is assumed to be influenced through the cognitive perceived tenure insecurity y_{ij}^{C}. A quadratic term of y_{ij}^{C} is also included in Equation (2) to test for nonlinearity. This structural equation system estimates both the direct effects on affective PTS and the indirect effects of psychological factors working through cognitive PTS.

Structural equation modelling (SEM) is well-recognized to simultaneously estimate equations with inter-related variables (Jöreskog et al., 2001), and has extensively been used in psychometric studies and more recently in economics.[18] Equations (1) and (2) reflect a recursive structural cognitive–affective model combining two ordered probit regressions, for dependent variables measures using ordinal scales, which is simultaneously (instead of sequentially) estimated using a generalized structural equation model (GSEM) with robust standard errors clustered at village level. As an extension of SEM, GSEM allows for the estimation of relations between continuous or categorial variables (Muthén, 1984). In addition, the GSEM framework enables us to simultaneously examine the direct and indirect effects of psychological factors (Pearl et al., 2016; Preacher & Hayes, 2008).[19]

[18] It is worth noting that SEM is valid for estimation of equation systems with observed variables only, simply by specifying identity relationships between observed and latent variables in the measurement model.

[19] Note that our ordered probit GSEM model could not take the covariance of error terms in the two equations into account. No statistical method has been developed to address this potential correlation yet.

According to previous studies, personality and preference factors are largely genetically determined and are partially inherited (Bouchard & Loehlin, 2001; Jang et al., 1996). Albeit recent studies argue that personality may evolve over the life cycle as a result of age-related maturation (Borghans et al., 2008; Cobb-Clark & Schurer, 2013; Specht et al., 2014), personality and preferences are assumed to be exogenous in this study as they appear to be stable among working-age adults over a few years and the mean-level changes are small and constant across age groups (Cobb-Clark & Schurer, 2012; Schildberg-Hörisch, 2018). One of the control variables, trust, may be endogenous since a household not worrying about land reallocations may tend to show a high level of social trust. Following Ma et al. (2019), we apply the average trust of other interviewed villagers within the same village as a proxy of individual farmers' trust, assuming that one's trust is strongly related to the trust of fellow villagers through behaviour over time.

2.5 Results

2.5.1 Descriptive analysis

Table 2.1 shows the descriptive statistics of the variables used in the PTIS model. We observed that farmers were on average more likely to expect land reallocation to happen after the end of the current second-round land contracting period than during the contracting period. However, regarding the future land reallocation, farmers in general were less worried about it given their expectations.

Regarding the actual tenure security variables, we observed that more than 45% of the villages in the sample had reallocated their farmland since 1998. On the possession of land documents, 49.5% of the interviewed households reported that the new land certificate had been distributed and 69.4% reported that the old land contract had been distributed to them by their village collectives.

Table 2.1 Descriptive statistics and expected signs of model variables

	N	M				SD	Min	Max	Expected sign w.r.t. PTIS[a]	
		Liaoning	Jiangsu	Jiangxi	Full sample				Expectation	Worry
Dependent variables										
Perceived tenure insecurity										
Worry or fear to land reallocations	1359	2.058	2.218	2.009	2.096	1.207	1	5	n.a.	n.a.
Expect land reallocations within next five years	1359	2.459	2.959	2.968	2.792	1.174	1	5	n.a.	n.a.
Expect land reallocations after contract period ends	1359	2.954	3.479	3.345	3.258	1.177	1	5	n.a.	n.a.
Explanatory variables										
Personality traits & preferences										
Openness to experience	1359	2.912	3.072	2.947	2.977	1.045	1	5	+/−	
Conscientiousness	1359	4.100	4.230	4.020	4.144	0.789	1	5	+	
Extraversion	1359	3.731	4.060	3.898	3.898	0.921	1	5	+/−	−
Agreeableness	1359	3.878	3.924	3.871	3.893	0.747	1	5		
Neuroticism	1359	2.376	2.180	2.457	2.334	0.889	1	5	+	+
Internal locus of control	1359	4.190	4.166	4.027	4.130	0.666	1	5	−	
External locus of control	1359	3.057	2.862	3.251	3.054	0.804	1	5	+	
Risk preference	1359	-0.096	-0.019	0.122	0.000	0.818	-0.97	2.16	n.a.	−
Time preference	1359	-0.113	0.051	0.066	0.000	0.846	-1.14	1.39	n.a.	+
Actual tenure security										
Past land reallocation in village since 1997 (1=yes)	120	0.550	0.300	0.525	0.458	0.500	0	1	+/−	+
Land certificate (1=yes)	1359	0.160	0.789	0.541	0.495	0.500	0	1	+/− [b]	−
Land contract (1=yes)	1359	0.814	0.721	0.539	0.694	0.461	0	1	−	−
Control variables										
Imbalance of land (mu)	1359	0.808	0.884	0.304	0.673	2.089	-3.36	17.57	n.a.	+
Absolute value of imbalance of land (mu)	1359	1.664	1.453	0.804	1.315	1.757	0	17.57	+	n.a.
Number of contracted land plots (pieces)	1359	3.006	3.769	5.884	4.188	3.662	1	40	+	−
Trust in villagers	1359	3.748	3.645	3.563	3.562	0.836	2.778	4.273	+ [c]	
Age of head (years)	1359	60.615	60.871	57.977	59.843	9.570	27	89	+/−	+/−
Gender of head (1=female)	1359	0.084	0.048	0.070	0.068	0.251	0	1	+	+
Education of head (years)	1359	7.494	6.431	5.855	6.605	3.221	0	18		−
Household size (people)	1359	3.214	3.998	4.683	3.950	1.918	1	14		+
Off-farm work (1=yes)	1359	0.104	0.172	0.138	0.138	0.345	0	1	+	+/−
Cadre membership (1=yes)	1359	0.071	0.131	0.109	0.104	0.305	0	1	+	−

Note: [a] n.a. indicates the expected effects are not available; + and − indicate positive and negative effects; variables without formulating an expected effect are left blank. [b] We expect different effects of land certificates on the two expectation variables. Having a land certificate would negatively affect land reallocation expectation in 5 years, but positively affects the expectation after the contract period ends because it contains detailed information of contract period. [c] The effect of trust on expectation of land reallocation only applies to short-term land reallocations.

2.5.2 Estimation results

Table 2.2 presents the GSEM estimation results. We discuss the results for the cognitive PTIS equation first, followed by a discussion of affective PTIS equation including the relationship between the two components.

i. Factors influencing affective PTIS

Columns (1) and (3) of Table 2.2 report the regression results for cognitive PTIS as measured by expected land reallocation within five years and after the current contract period ends, respectively. We found that extraversion had a significant positive impact. This finding suggests that farmers with more social contacts and more up-to-date information tend to be more aware of upcoming land reallocations; when no land reallocations are foreseen in a village, the expectations of relatively extravert farmers are similar to those of other farmers in the same village. The average marginal effects shown in Table 2.3 suggest that on average one additional point on the extraversion scale corresponded with 2.4% higher likelihood of expecting land reallocation to happen in the near future (adding the marginal effects associated with the two highest values of the expectation scale, i.e., 0.014 and 0.010). The other four personality traits did not significantly affect cognitive PTIS, except for neuroticism in the equation for land reallocation within the coming 5-year period. This finding provides support for the presumption that neurotic people tend to perceive their environment as unstable and are therefore more likely to expect that a land reallocation will occur. On average one additional point on the neuroticism scale corresponded to 2.7% higher likelihood of expecting land reallocation. We further found a marginal negative effect ($p<.10$) of internal LoC on the perceived likelihood that a land reallocation will take place in the coming years.

We also obtained some interesting results for the other explanatory variables that were included in the cognitive PTIS equation. As expected, actual tenure security as measured by past land reallocations and possession of land documents significantly affected cognitive tenure (in)security. Farmers residing in villages where at least one land reallocation occurred since 1997 were more likely to expect that further land reallocations would occur, whereas farmers possessing old land contracts issued by the village administration were significantly less likely to expect a land reallocation. The estimated effects

are modest. Farmers living in villages that experienced at least one land reallocation were 6.7% more likely to expect land reallocation within the coming five years, as compared to farmers living in villages that did not experience a land reallocation since 1997. Farmers possessing a land contract were 8% more likely to expect short-term land reallocation, as compared to farmers not possessing such contracts. It was also noteworthy to observe that possession of new land certificates did not significantly affect farmers' land reallocation expectations. A potential explanation is that the added value of the land certificates might have been unclear because they had only just been issued.

Only few control variables were found to exert significant effects on cognitive PTIS. Trust in other villagers was found to be positively related to the perceived likelihood that land would be reallocated within five years. This finding supports the argument that trust among villagers contributes to the consensus that is needed for implementing land reallocations through village self-governance rules. With regard to land reallocations after the contract period ends, we found some evidence ($p<.10$) that farmers' expectations might depend positively on the number of contracted plots and on the household's village cadre membership. These findings are both consistent with our a priori expectations (see Table 2.1). The results also indicate that gender may play a role, with females somewhat less likely ($p<.10$) to expect a land reallocation after the end of the contract period.

Table 2.2 Estimation results for cognitive–affective tenure insecurity perception, generalized structural equation model (GSEM) [a]

	Within 5 years				After contracting period ends (2027–2029)			
	Land reallocation expectation		Land reallocation worry		Land reallocation expectation		Land reallocation worry	
Variables	Coefficients [b]	S.E.[c]	Coefficients	S.E.	Coefficients	S.E.	Coefficients	S.E.
	(1)		(2)		(3)		(4)	
Expectation	-	-	0.671***	0.141	-	-	1.060***	0.156
Square of Expectation	-	-	-0.119***	0.025	-	-	-0.167***	0.024
Openness to experience	0.044	0.031	-0.005	0.035	0.021	0.031	-0.005	0.035
Conscientiousness	0.020	0.036	0.022	0.029	0.013	0.034	0.026	0.028
Extraversion	0.069**	0.034	-0.048	0.034	0.074**	0.032	-0.045	0.034
Agreeableness	0.010	0.032	0.004	0.033	-0.036	0.032	0.007	0.033
Neuroticism	0.079**	0.035	0.087**	0.035	0.051	0.033	0.100***	0.037
Internal locus of control	-0.059*	0.032	0.014	0.031	0.007	0.032	0.018	0.031
External locus of control	-0.040	0.032	0.056	0.039	-0.040	0.034	0.054	0.039
Risk preference	-	-	0.064	0.044	-	-	0.071	0.046
Time preference	-	-	0.001	0.041	-	-	0.001	0.042
Past reallocation	0.198***	0.077	0.120*	0.070	0.125*	0.070	0.110	0.073
Land contract	-0.241***	0.067	0.026	0.072	-0.179**	0.069	0.045	0.071
Land certificate	-0.087	0.076	0.069	0.095	0.037	0.079	-0.012	0.100
Imbalance of land (abs)	0.015	0.019	-	-	0.027	0.020	-	-
Imbalance of land	-	-	0.038**	0.016	-	-	0.040**	0.016
Plot number	0.001	0.009	-0.001	0.009	0.013*	0.008	-0.002	0.010
Trust in villagers	0.073**	0.034	-0.033	0.037	0.033	0.031	-0.032	0.039
Age of head	-0.003	0.003	-0.011***	0.004	-0.004	0.003	-0.011***	0.004
Gender of head	-0.154	0.114	-0.018	0.125	-0.223*	0.117	-0.048	0.122
Education of head	0.001	0.011	-0.013	0.011	0.006	0.011	-0.013	0.012
Household size	0.009	0.019	0.051***	0.018	-0.001	0.019	0.046**	0.018
Off-farm work	0.123	0.087	-0.073	0.094	0.033	0.089	-0.053	0.094
Cadre membership	0.107	0.106	-0.313***	0.105	0.199*	0.111	-0.293***	0.106
Obs.	1359		1359		1359		1359	
Pseudo R^2	0.024		0.028		0.024		0.032	
Province dummy	YES		YES		YES		YES	

Note: [a] The mean value of VIF was 1.29, with a maximum value of 2.39. We therefore concluded that multicollinearity was low; [b] * $p<.10$; ** $p<.05$; *** $p<.01$; [c] Standard errors clustered at village level.

Table 2.3 Marginal effects of the ordered probit models [a, b, c]

	Cognitive PTIS: Prob (y_{ij}^{C}) [d]					Affective PTIS: Prob (y_{ij}^{A}) [d]				
	Pr (y_{ij}^{C}=1)	Pr (y_{ij}^{C}=2)	Pr (y_{ij}^{C}=3)	Pr (y_{ij}^{C}=4)	Pr (y_{ij}^{C}=5)	Pr (y_{ij}^{A}=1)	Pr (y_{ij}^{A}=2)	Pr (y_{ij}^{A}=3)	Pr (y_{ij}^{A}=4)	Pr (y_{ij}^{A}=5)
Expectation	-	-	-	-	-	0.045***	-0.003***	-0.015***	-0.015***	-0.012***
	-	-	-	-	-	(0.009)	(0.001)	(0.003)	(0.003)	(0.003)
Square of Expectation	-	-	-	-	-	-0.254***	0.019***	0.086***	0.083***	0.066***
	-	-	-	-	-	(0.052)	(0.006)	(0.019)	(0.018)	(0.015)
Extraversion	-0.016**	-0.010**	0.003*	0.014**	0.010**	-	-	-	-	-
	(0.008)	(0.005)	(0.002)	(0.007)	(0.005)	-	-	-	-	-
Neuroticism	-0.018**	-0.012**	0.003**	0.016**	0.011**	-0.033**	0.002**	0.011**	0.011**	0.009**
	(0.008)	(0.005)	(0.002)	(0.007)	(0.005)	(0.013)	(0.001)	(0.005)	(0.005)	(0.004)
Internal locus of control	0.013*	0.009*	-0.002	-0.012*	-0.008*	-	-	-	-	-
	(0.008)	(0.005)	(0.002)	(0.007)	(0.004)	-	-	-	-	-
Past reallocation	-0.045***	-0.030***	0.008**	0.039***	0.028**	-0.045*	0.003	0.015*	0.015*	0.012*
	(0.017)	(0.011)	(0.004)	(0.014)	(0.011)	(0.026)	(0.002)	(0.009)	(0.009)	(0.007)
Land contract	0.054***	0.036***	-0.010***	-0.048***	-0.032***	-	-	-	-	-
	(0.015)	(0.010)	(0.003)	(0.013)	(0.010)	-	-	-	-	-
Imbalance of land	-	-	-	-	-	-0.015**	0.001**	0.005**	0.005**	0.004**
	-	-	-	-	-	(0.006)	(0.000)	(0.002)	(0.002)	(0.002)
Trust in villagers	-0.017**	-0.011**	0.003*	0.015**	0.010**	-	-	-	-	-
	(0.008)	(0.005)	(0.002)	(0.007)	(0.005)	-	-	-	-	-
Age of head	-	-	-	-	-	0.004***	-0.001**	-0.002***	-0.002***	-0.001***
	-	-	-	-	-	(0.002)	(0.000)	(0.001)	(0.001)	(0.000)
Household size	-	-	-	-	-	-0.019***	0.002**	0.007***	0.006***	0.005***
	-	-	-	-	-	(0.007)	(0.001)	(0.002)	(0.002)	(0.002)
Cadre membership	-	-	-	-	-	0.119***	-0.009**	-0.040***	-0.039***	-0.031***
	-	-	-	-	-	(0.040)	(0.004)	(0.014)	(0.013)	(0.011)

Note: [a] Only variables with significant estimated coefficients are shown in the table; [b] * p<.10; ** p<.05; *** p<.01; [c] Standard errors clustered at village level are shown in parentheses; [d] We only present the marginal effects of cognitive and affective PTIS within 5 years. Marginal effects for PTIS after the contracting period ends are very similar.

ii. Factors influencing affective PTIS

Columns (2) and (4) of Table 2.2 show the simultaneously estimated coefficients of factors influencing farmers' affective worry about land reallocations within five years and after the contract period expires, respectively. The results show a highly significant inverse U-shaped relationship between cognitive expectation and affective feelings of worry. The coefficient estimates indicate that farmers' worries are highest on average at a level of 2.82 for land reallocations within five years and 3.17 for land reallocations after the contract period expires (on a 5-point scale), respectively. In other words, when a farmer expressed that a land reallocation was either very likely or very unlikely, (s)he tended to worry less about it. When a farmer did not expect a land reallocation, there was evidently not much to worry about. And when a farmer considered the occurrence of a land reallocation in the future as very likely, (s)he may simply accept it and not worry much about it whether or not it would be in the self-interest of the farmer. When farmers were less sure about whether land reallocations could be expected they would worry more about such land reallocations. Hence, our findings provide strong support for the ''risk-as-feelings'' approach and show that the linear ''consequentialist'' viewpoint was rejected in this context.

With regard to personality and preferences, the main focus of our paper, we found that neuroticism had a significant positive impact on farmers' worries about land reallocations in the short run (within five years) as well as in the long run (after the contract expires), controlling for the perceived likelihood that a land reallocation would occur. This finding is consistent with a priori expectations. One additional point on the neuroticism scale was associated with 2% higher likelihood of being worried or very worried about future land reallocations (adding the marginal effects associated with the two highest values of the worry scale, i.e., 0.011 and 0.009). On the other hand, we did not find any significant effects for the other Big-Five personality traits. Nor did we find significant effects for internal and external LoC and for risk and time preferences on affective PTIS of farmers. Hence, neuroticism seems to be the main personality factor driving worries about future land reallocations among the interviewed farmers. Its estimated effect, however, is again modest.

We further found that actual tenure security played a much smaller role in affective PTIS than in cognitive PTIS. The impact of land documents on farmers' worry about land reallocations was found to be not significantly different from zero. This result is consistent with the finding by Rao et al. (2017) that official land documents do not reduce farmers' worry about losing land. We did find some

evidence (p<.10) that past land reallocation experience increased farmers' worries about land reallocations in the short run.

Estimation results for the control variables also provided several interesting insights. As expected, the land endowment imbalance was found to have a significant positive effect on farmers' worries regarding land reallocations. This finding means that farm households with above-average per capita land endowments were more worried about land reallocations, which usually aim at restoring the balance in per capita land resources, whereas those with below-average land endowments worried much less. The age of the household head was found to have a significant negative impact on worries about land reallocations. This finding does not reflect the fact that elderly farmers may have a higher rate of time preference, because time preference is another explanatory variable in the model. Instead, it may imply that more experienced farmers are less worried in general about conditions affecting their farm resources. Larger households expressed significantly higher levels of worry as compared to smaller ones. A potential explanation for this finding is that larger households usually have more members involved in migration (e.g., Hu et al., 2011; Shi et al. 2007), and therefore may be allocated less land per capita in new rounds of reallocation. Finally, we found that having a member of the village cadre in the household had a significant negative influence on worries about land reallocations. Household having at least one member of village cadre were 7% less likely to be worried or to be very worried about future land reallocation. This finding provides support for the presumption that households with close links to the village government have better chances of accessing policy information and/or better access to resources that can be used for other income generating activities opportunities, and therefore are less worried about land reallocations.

Table 2.4 presents the standardized indirect and total effects of key psychological factors and covariates on the affective feelings of worry. The indirect effect, in this case, was the effect of a variable on affective perceived security via cognitive perceived security. Notably, the total effect of neuroticism on worry was significantly positive, implying that farmers scoring high in neuroticism experienced significant negative affect, particularly in a situation of high uncertainty about future land reallocation. The total effect of extraversion on worry was found to be insignificant. Although the indirect effect of extraversion through cognitive PTIS was positive and significant (according to Table 2.3), the direct effect on affective PTIS was negative and not significant (according to Table 2.2), and thus the sum of these two effects turned out to be not significant.

Two of the other explanatory variables included in the model were found to have significant total effects on affective PTIS. The impact of village-level land reallocation in the past on insecure feelings was significantly positive, indicating that past land reallocation not only increased farmers' expectation of future land reallocation, but also weakened the affective sense of security. Having village cadres in the household had a significant and negative total effect on the worry regarding short-term land reallocations, because of the increased indirect effect, suggesting that they perceived a higher likelihood of land reallocations after the current contracting period ends. The total effect of official land documents on reducing farmers' affective worry was insignificant, further suggesting that even though some of the land documents may reduce farmers' perception land future land reallocation taking place, holding them cannot provide farmer with a sense of security once land reallocation happens.

Table 2.4 Standardized indirect and total effects [a b]

	Within 5 years				After contracting period ends			
	Indirect effect		Total effect		Indirect effect		Total effect	
Variables	Coefficients	S.E.	Coefficients	S.E.	Coefficients	S.E.	Coefficients	S.E.
Extraversion	0.047*	0.025	-0.002	0.043	0.079**	0.035	0.033	0.049
Neuroticism	0.053**	0.027	0.139***	0.048	0.055	0.036	0.155***	0.053
Internal LoC	-0.040*	0.024	-0.026	0.040	0.008	0.034	0.026	0.047
External LoC	-0.027	0.022	-0.029	0.042	-0.042	0.036	0.012	0.050
Past reallocation	0.133**	0.060	0.247***	0.085	0.133*	0.077	0.240**	0.098
Land contract	-0.162***	0.060	-0.135	0.102	-0.190**	0.081	-0.150	0.118
Land certificate	-0.059	0.053	-0.057	0.092	0.039	0.083	0.027	0.110
Cadre membership	0.072	0.070	-0.242**	0.120	0.211*	0.117	-0.089	0.150

Note: [a] * $p<.10$; ** $p<.05$; *** $p<.01$; [b] Direct effects are shown in Table 2.2.

As a final note, we would like to point out that most post-estimation tests and indices were unavailable in GSEM due to the assumption of joint normality of the observed variables. We also estimated a bootstrapped SEM, run on the same dataset, as a way to overcome the limitation in the post-estimation indices. The estimated coefficients and their significance in SEM were similar to those in GSEM. In SEM, the goodness of fit of the structural model can be calculated. In this model, the standardized root mean squared residual (SRMR) equalled 0.065 and the coefficient of determination (CD) equalled 0.39. An acceptable range for the SRMR index is between 0 and 0.08 (Hu and Bentler, 1999). This means our result is acceptable.

2.6 Conclusion

The present study analysed the influence of personality and economic preferences of farmers on their perceived land tenure security. We decomposed the concept of perceived tenure insecurity (PTIS) of land into two theoretically different components: cognitive PTIS and affective PTIS. We developed a recursive structural cognitive–affective model and estimated the link between these components using an ordered probit GSEM model based on a dataset of 1359 rice farmers in three provinces in China. The main findings and their policy implications are as follows.

First, we did not find that the cognitive PTIS and the affective PTIS are linearly related. In contrast, we found a non-linear (inverse "U-shape") relationship, showing that these two components can diverge. This finding empirically substantiates the ''risk-as-feeling'' proposition that feelings may not always correspond with perceived risk estimates in the case of land tenure security. One underlying reason for this finding is that farmers may simply accept the fact and feel less worry about it when the land reallocations are very likely to happen. As a result, cognitive expectation of land reallocations in China may not necessarily be equivalent to farmers' feelings of anxiety or worry, but only partially reflect farmers' overall perception of tenure security. This insight corroborates the claims by Van Gelder (2007) that the notion of perceived tenure security should go beyond the traditional concept as a merely cognitive probability assessment and should incorporate with psychological components.

Another notable insight from the inverse U-shaped cognitive–affective PTIS relationship is that it is the uncertainty about the likelihood of future within-village administrative land reallocation that undermines farmers' affective sense of security. This uncertainty may be a consequence of weak legal enforcement in rural China and an ambiguous comprehension of farmers about the legal validity of land documents (Zhu & Prosterman, 2009). For instance, as shown in this study, land contracts may significantly mitigate farmers' cognitively perceived likelihood of land reallocation, but they fail to provide farmers with a sense of affective security for the given expectations regarding the occurrence of land reallocations. This suggests that farmers do believe that land contracts protect against land reallocations, but we find that contracts do not affect their worries about land reallocations.

Furthermore, some personality factors were found to significantly affect farmers' perceived tenure insecurity beyond external factors. Our results indicate that neuroticism is the internal psychological factor that naturally undermines overall perceived tenure security, though the estimated impact was relatively modest. Farmers scoring high on neuroticism not only cognitively anticipated unstable land

tenure within the contracting period, but also affectively worried about it. This finding is consistent with the literature in the field of personality and psychopathology, suggesting that neuroticism is closely associated with experienced negative affect and uncertainty intolerance (Rosen et al., 2014; Yang et al., 2015). Other personality and preference factors (openness, conscientiousness, agreeableness, LoC, economic preferences) did not significantly affect PTIS, with one exception that farmers scoring high on extraversion perceived a higher likelihood of future land reallocations.

Our findings have important implications for policy making. The recent land reforms in China as well as the newly-revised RLCL in 2019 have prioritized stabilization of rural land property rights and strengthening tenure security. However, several supporting measures may be taken into consideration to achieve the policy goals in a more efficient way. First, one important finding of our research is that worries about land reallocations (i.e., affective PTIS) are the largest when there is much uncertainty regarding future land reallocations. Local governments may reduce this uncertainty by ensuring that all rural households possess land documents, as evidenced by our regression results for land contracts in the cognitive PTIS equations. Moreover, in case village governments decide to reallocate land despite the existing ban on reallocations, making concrete information on such land reallocations (i.e., the expected time and the boundaries of land being reallocated) available beforehand would further reduce the uncertainty among affected households.

Second, efforts at strengthening the comprehension of rural land tenure policies are likely to be more effective if they take personality heterogeneities among rural farmers into consideration. In our study we found that neurotic farmers worry significantly more about upcoming land reallocations than other farmers. We therefore suggest that policy makers or local administrative officials provide clearer guidance regarding the implementation of future land reallocations, rather than formulate relevant laws in an ambiguous way (Ma et al., 2015). This would especially be beneficial for farmers with more affective ‘‘vulnerable’’ traits (e.g., neuroticism), and thereby make policy communication more inclusive. This is because individuals high in neuroticism have more difficulties to react to uncertain or immediate information (Hirsh & Inzlicht, 2008). Moreover, individuals being high in neuroticism may need information continuously provided to them as a result of higher perceived social costs (Morrison, 1993). Personality traits are expected to play similar roles in perceived tenure insecurity of farmers living in other developing countries with formal and informal institutional arrangements playing intertwined roles in rural land tenure. Similar policy conclusions may be derived for those countries.

Our study also intends to contribute to the academic debate about the accurate measurement of perceived land tenure security in developing countries. Empirical studies equating farmers' subjective estimates of future land reallocation probabilities to perceived land tenure (in)security generally are based on the premise that rural land reallocations are as threatening as land evictions in other cases. However, without taking the farmer's affective component into account, measuring cognitive expectations alone may not comprehensively reflect farmer's overall perceived land tenure (in)security.

Future research may further test the robustness of the non-linear cognitive–affective perceived tenure security relationship, especially applying latent variable methods to measure the two psychologically related components. Our results are also relevant for empirical studies of the tenure security–investment relationship, where current findings in the literature are inconclusive about the extent to which farmers' land-related investments are affected by perceived tenure security.

Chapter 3 Effect of personality traits on smallholders' land renting behaviour: Theory and evidence from the North China Plain[20]

Abstract: This study investigates the effect of smallholders' personality traits on their land rental market decisions. We develop a conceptual framework and show that these internal factors could affect smallholders' land rental market participation beyond institutional and socio-demographic factors. Our empirical analysis is based on a survey of 2119 rural households collected in the North China Plain. We find that smallholders with a higher level of openness are more active in participating in the farmland rental market. Moreover, internal locus of control plays a significant role in explaining smallholders' land renting behaviour. We further show that need for achievement mediates the link between internal locus of control and smallholder's intention to rent land, indicating that fostering a higher level of internal locus of control—and subsequently achievement desire—could play an important role in promoting smallholders' land-renting behaviour. More generally, our results imply that taking rural smallholders' personality traits into account in designing land rental policies may increase the effectiveness of policies aimed at promoting land rental market participation among smallholders and incubating crop farm scale enlargement in rural China.

Keywords: land rental market; personality traits; locus of control; mediation analysis; rural China

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3.1 Introduction

Agricultural production in rural China has long been constrained by small-scale and fragmented land holdings (Nguyen et al., 1996; Tan et al., 2006). More than 60 percent of farms were cultivated by smallholders with farms of less than 0.5 hectares by 2013 (Ji et al., 2016; Yao, 2000). The Chinese central and local governments have been promoting land consolidation and larger-scale farm operations through land rental market development (MoA, 2016), but the progress has been rather uneven across regions (Luo, 2016; Ma et al., 2019; Wang et al., 2017). For example, recent data show that about 33.8 percent of the farmland was rented out at the national level nationwide by 2017 (MARA, 2018), while it was less than 30 percent in the North China Plain regions, compared to more than 30 percent–50 percent in the middle and lower reaches of the Yangtze River (Wang et al., 2018).[21]

Previous research on rural households' land rental market participation in China and elsewhere has mostly stressed the impact of external constraints. For instance, Carter and Salgado (2001) found that credit constraints were central factors that limited smallholders' access to land rental markets in Latin America. Other studies found evidence that labour market imperfections (Mullan et al., 2011; Yao, 2000), prohibitive land transaction costs (Huy et al., 2016; Skoufias, 1995), and incomplete property rights and land tenure insecurities (Feng et al., 2010; Holden et al., 2011; Ma et al., 2019) are important factors prohibiting rural households' participation in land rental markets.

Several recent studies on rural households' agricultural production decisions argued that, despite the presence of various external constraints, internal or psychological characteristics might be fundamental factors affecting rural smallholders' agricultural production and investment decisions (Bernheim et al., 2015; Bertrand et al., 2004; Duflo et al., 2011; Haushofer & Fehr, 2014). Specifically, Bernard et al. (2014) argued that low aspirations among poor people can lead to underinvestment even when returns are high. Furthermore, Abay et al. (2017) showed that internal locus of control can play an important role in explaining smallholders' behaviour towards on-farm technology adoption. Ali et al. (2019) found that noncognitive skills (polychronicity, work centrality, and optimism) significantly affect adoption decisions and technical efficiency in rice production in Ghana.

[21] The higher land rental market development in some south coastal provinces of China has been credited to the higher economic development, smaller land endowment, and more institutional innovations than in the northern provinces (Ito et al., 2016; Wang et al., 2017).

Despite the growing awareness of the role of psychological factors in smallholders' decision making, to our knowledge their potential role in farmland renting decisions has not been examined so far. We believe it is of major importance for policymakers (or other stakeholders) in developing countries to obtain more insight into the link between smallholders' personality traits and farmland renting behaviour. First, well-functioning rural land rental markets facilitate the rural structural transformation in China and other developing countries, as they contribute to efficiency and equity by allowing more-able producers to gain access to additional land and permitting off-farm employment for households with less-able producers (Chamberlin & Ricker-Gilbert, 2016; Jin & Deininger, 2009; Ma et al., 2019). Personality traits may affect smallholders' actual and perceived profitability of land rentals, just like other production and investment decisions. Second, current public policies regarding land rental market development have mainly focused on releasing external constraints (Deininger & Feder, 2009; Ma et al., 2015). However, certain personality traits may predispose or intrinsically drive individuals to (not) engage in land renting activities. A better understanding of smallholders' psychological characteristics and their subsequent roles in land rental market participation might contribute to more effective land market development policies.

The current rural farmland liberalization in China lays a good foundation for investigating the role of personality traits in smallholders' land rental market participation. Since 1978, farmland in China has been managed under the so-called "household responsibility system (HRS)," which divides the property rights of rural farmland into two layers: the ownership right is owned by the village collectives and the use right is held by individual households that contract farmland from the village. In the early stages of the HRS, farmland used to be distributed according to a completely egalitarian principle in which all households in a village received land use rights based on the number on persons and/or laborers in a household (Qu et al., 1995), and was only allowed to be rented by households with permission from village leaders (Lin, 1989). The Chinese government then gradually relaxed restrictions on farmland transfer among rural smallholders since the 1990s as a way to promote agricultural modernization. The "Rural Land Contract Law (RLCL)" of 2002 fixed the contract duration for the use of arable land at 30 years, and almost entirely prohibited land reallocations (Ye, 2015). In other words, smallholders' family size was no longer related to their farm(land) size after 2002, though minor reallocations still took place within some villages (Long et al., 2012; Luo, 2016; Ma et al., 2015). Since 2009, rural land reforms in China aimed at stimulating rural land rental markets and land investments by measures to improve tenure security (Luo, 2016; Ma et al., 2015; Wang et al., 2015; Wang & Zhang, 2017).

This study focuses on addressing two research questions: First, what is the relationship between personality traits and smallholders' land rental markets participation in China? Second, if there is a relationship, what are the underlying mechanisms through which personality traits exert their effects? We specifically develop a conceptual framework of the effects of personality traits on smallholders' land rental market participation through economic and non-economic factors, and use a cross-sectional survey of 2119 rural households collected in the North China Plain to estimate the impact of personality traits on land rental decisions. This dataset contains rich information about smallholders' land renting behaviour and intention, personality traits, and preferences. The findings indicate that smallholders with a relatively high level of openness participated more in the farmland rental market. Internal locus of control was found to play a significant role in explaining smallholders' land renting-in decisions. We further show that the effect of internal locus of control is mediated through the smallholders' need for achievement, indicating that fostering higher levels of internal locus of control—and subsequently achievement desire—could play a significant positive role in promoting smallholders' land renting behaviour. This study can shed light on the extant literature of land rental market development by showing that personality traits can influence smallholders' participation in land markets, beyond institutional and socio-demographic factors.

The remainder of the paper is organized as follows. In Section 2 we develop a conceptual framework of the impact of personality traits and preferences on land renting decisions. Section 3 provides a description of the context of our study and data collection. In Section 4 we present our empirical estimation strategy; Section 5 reports on the descriptive analysis and estimation results. Section 6 presents the conclusion.

3.2 Conceptual framework

Both economists and psychologists' endeavour to identify determinants of heterogeneity in human behaviour. In conventional economic analysis, decision problems are typically depicted in the framework of utility maximization, where an individual's utility is shaped by various types of preferences concerning risk, time and formal or informal institutions. Psychologists who study individual personality characteristics generally predict human behaviour using the framework of personality traits, which can be defined as the most fundamental psychological constructs underlying the regularities in people's thinking, feeling, and behaviour (Roberts, 2009).

These psychological constructs have been integrated in behavioural economics into the economic decision-making framework (Almlund et al., 2011; Becker et al., 2012; Borghans et al., 2008; Heckman & Kautz, 2012). A growing number of empirical studies have started focusing on the roles of personality traits in investment and technology adoption behaviour (Ali et al., 2019; Busic-Sontic et al., 2017; He & Veronesi, 2017). However, knowledge about the effects of personality traits on land rental market participation is still lacking.

In the following sub-sections, we first describe the relevant personality variables and then develop a framework conceptualizing how personality traits may be associated with land renting decisions of smallholders in China.

3.2.1 Personality traits

Personality traits (or noncognitive skills) are typically defined as patterns of thoughts, feelings and behaviours that persist from one decision situation to another (Roberts, 2006). An individual's personality traits are often formed in his/her early stages of childhood through biological maturation, i.e., gene expression and hormonal processes, and learning (Roberts, 2009; Specht et al., 2014), and are rather stable over time after adulthood (Srivastava et al., 2003). Previous studies show that personality traits affect almost every aspect of an individual's decision making and behaviour (Cobb-Clark & Schurer, 2012; Jones et al., 2006).

Although the concept of personality traits is rather broad, in practice it is generally acknowledged that individual personality traits can be derived primarily from five dimensions (Mount et al., 2005). The literature shows consensus in using the Five Factor Model (FFM, or *Big-Five Model*) to measure an individual's personality traits (Borghans et al., 2008). The five factors, specifically labelled as *openness to experience*, *conscientiousness*, *extraversion*, *agreeableness*, and *neuroticism* (OCEAN), categorize personality traits at the broadest level of abstraction (Costa & McCrae, 1992). Openness to experience [*O*] characterizes people who are intellectually curious, tend to seek new experiences and explore novel ideas. Conscientiousness [*C*] describes an individual's degree of organization, persistence, hard work and motivation to pursue long-term goals. Extraversion [*E*] describes the degree of being confident, dominant, energetic, active, and enthusiastic. Agreeableness [*A*] is an indication of an individual's trust, altruism, and cooperation within interpersonal relationships. Neuroticism [*N*] represents the individual's degree of emotional instability, distress, anger and frustration (John & Srivastava, 1999).

Another personality trait, which has been frequently studied in behavioural science, is *locus of control* [LoC].[22] LoC is described as the degree to which people attribute success or failure to themselves or the external circumstances (Rotter, 1966). People with a strong internal LoC believe that their future is determined more by their own actions, whereas people with a strong external LoC believe that the external environment has more power in controlling their lives (Antonides, 1996). People who are more internally controlled are also known to seek information, take initiatives, and engage in entrepreneurial activities (Antonides, 1996; Caliendo et al., 2014; Hansemark, 2003).

3.2.2 Personality traits and land renting behaviour

Previous studies regard smallholders' participation in land rental markets essentially as an economic decision (De Janvry et al., 2001; Deininger & Feder, 2001). On the notion that smallholders are "poor but rational" profit-maximizing decision-makers, smallholders with favourable farm-operating skills can access land resources offered by households with less-developed skills through land rental markets. Land, in this way, is regarded as a fundamental economic factor of production, with profit maximization driving land renting decisions. Personality traits may affect farmland renting behaviour, just like affecting other agricultural production and investment decisions. However, farmland is not only an essential factor in agricultural production but may also possess non-economic values like emotional attachment, status, or social security (Kuehne, 2013; Quinn & Halfacre, 2014; Wang & Zhang, 2017; Zhang & Donaldson, 2010). These non-economic values may depend to a certain extent on specific personality traits. In this study we therefore assume that smallholders' land renting decisions depend on economic as well as non-economic factors, and that personality traits may affect both types of factors.

i. Economic factors

There are generally two strands of literature relating personality traits with economic decisions made by rural smallholders. First, considerable literature exists on the role of personality traits (e.g., LoC and Big Five) in agricultural technology adoption and investment. For example, Crase and Maybery (2004) found that smallholders' openness to experience is a significant explanatory factor of farm management practices in Australia. Empirical evidence from Africa shows that other personality facets,

[22] The exact relationship between LoC and the Big-Five in personality trait studies is rather unclear. Some studies argue that LoC can be an additional personality trait apart from the Big Five, while other studies have shown that LoC and the Big Five had additional predictive power in understanding individual behaviours (Judge et al. , 2002; Morrison, 1997). In our study, we assume that LoC is an additional personality trait, which might be related to some Big-Five characteristics, but is different in nature.

such as LoC, tenacity, and impulsiveness, play important roles in explaining heterogeneous decision-making regarding adoption of improved seeds, chemical fertilizers, and irrigation practices (Abay et al., 2017; Ali et al. 2019). Smallholders in Tanzania and Mozambique with more external locus of control are found significantly less likely to adopt improved maize varieties (Malacarne, 2019).

The second strand of literature focuses on the role of personality traits in rural households' livelihood strategies, especially migration decisions. Caliendo et al. (2015) found evidence that internal LoC is associated with a higher propensity to migrate across regions in Germany. Ayhan et al. (2019) explored the effects of the Big-Five factors on migration in Ukraine and found that openness to new experiences is positively associated with the probability of an individual to migrate from rural to urban areas.

Personality traits may also play a role in the economic considerations that drive rural smallholders' land rental decisions in China. Given existing land and labour market imperfections, many Chinese smallholders are making decisions on land and off-farm labour market participation simultaneously rather than in isolation (Feng et al., 2010). Decisions to rent out land are closely related to decisions to migrate to urban areas and to explore new income earning opportunities, whereas farm expansion through land rentals often requires novel managerial ideas and adoption of innovative technologies. Openness to experience, i.e., an individual's propensity to try new experiences and explore novel ideas (Costa & McCrae, 1992), is likely to play a crucial role in such land rental markets participation decisions. Whether they expand their farms through renting additional land or give up (part of) their land and migrate to urban areas depends on their own land–labour endowment and their comparative advantages in agricultural production.

Hypothesis 1: Openness to experience has a positive effect on overall participation in land rental markets.

Locus of control may also affect land rental market participation. Smallholders with a strong internal LoC may believe they are responsible for taking actions to change their fate, while those with a high level of external LoC may believe their life is to a large extent determined by their external environment. Though there is no direct and clear evidence about the role locus of control plays in the land rental market participation in the literature, our interest in studying locus of control is motivated by studies examining its importance in other factor markets. For example, Caliendo et al. (2015) found that locus of control affected people's labour market participation decision via their job seeking behaviour. Individuals having a high level of internal locus of control were more likely to take extra

effort to search for a job. Caliendo et al. (2019) further found that people with high level of internal locus of control were more oriented to search for job opportunities across larger geographic areas, and also migrated more often. Given these findings, we would expect that smallholders with strong internal LoC are more likely to participate in land rental markets, either by renting-in land or by renting-out land, as a result of exerting more efforts in searching on-farm or off-farm income earning opportunities.

Hypothesis 2: Internal locus of control has positive effects on overall participation in land rental markets.

ii. Non-economic factors

Non-economic values of land may also determine how smallholders view and deal with their land (Fairhead & Leach, 1996; Leach & Mearns, 1996; Lokhorst et al., 2014). Personality traits are likely to affect these non-economic values, and hence to affect land rental decisions.

First, farmland holdings are considered as an important source of social security for rural smallholders in China; rural households faced with unemployment or other risks and uncertainties can still rely on the farmland assigned to them for earning a living (Ma et al., 2015; Wang et al., 2013; Yu et al., 2010). Renting out farmland may put smallholders at a risk of losing this important source of social security until the rental contract expires (Qu et al., 2018). Neurotic persons, i.e. individuals characterized by getting stressed easily, avoiding negative factors, and being prone to interpret ordinary situations as threatening or stressful (Paunonen & Ashton, 2001), may be less inclined to rent out land because they see this as a loss of protection against unemployment, bad health and other misfortune. Alternatively, when farming is considered as stressful as compared to wage employment, neurotic smallholders may prefer to rent out their arable land and earn a wage income elsewhere. Because of the opposite directions of the two processes regarding neuroticism, we can only estimate the net impact of neuroticism on land renting out and we thus do not state a hypothesis about it.

Arable land may also be a status symbol. Empirical evidence suggests that land-renting (and labour-hiring) entrepreneurial farmers in China not only tend to expand their scale of agricultural production, but also frequently occupy superior positions in authority relations and have greater social power (Zhang & Donaldson, 2010). This suggests that conscientiousness plays a role in land rental decisions. This would be consistent with evidence that conscientiousness is related to life goals of having a high-status career and an influential and prestigious occupation (Roberts & Robins, 2000). We thus expect

that smallholders who score high in conscientiousness will pursue superior within-village social status by renting more land.

Hypothesis 3: Conscientiousness has a positive effect on renting in land.

Smallholders may also experience a strong emotional attachment (i.e., belonging or connection) towards their land, as was found in some African communities (Koot et al., 2019a; Koot et al., 2019b; Mujere, 2011). Personality traits may affect such emotional attachments, and thereby play a role in land rental decisions. But in the case of China, it may be assumed that emotional attachment to the land is rather weak given the system of allocation of land to households under the HRS.

3.2.3 Preferences and motivations

Besides personality traits, we also consider preferences and motivational factors in our analysis. Motivations and preferences are less likely to be intrinsic components of personality traits (Roberts, 2009; Ferguson et al., 2011). Instead, they may mediate the effects of the fundamental psychological constructs (i.e., personality traits) on behaviour (Mooradian et al., 2006). Hence, we extend our conceptual model of land rental market participation by including the potential mediating roles of risk attitudes, social trust, and achievement motivation.

Risk-averse households are less likely to participate in the land rental market (Ma, 2013), whereas non-kinship trust can reduce transaction costs and thereby stimulate land rental transactions (Ma et al., 2019). A person high in *need for achievement* [nAch] aims at rivalling and surpassing others at tasks in which she or he engages (McClelland, 1961). Farm expansion, being able to stimulate entrepreneurship and higher within-village social status, can be an important way to fulfil the achievement desire of a smallholder.

Hypothesis 4: Personality traits affect land renting behaviours through risk preference, need for achievements, and (or) interpersonal trust.

3.2.4 Graphical representation

The conceptual model presented in Sections 2.1–2.3 is graphically represented in Figure 3.1. It shows that decisions to rent in or rent out land depend on external as well as internal factors. The most fundamental internal factors, i.e., personality traits, affect these rental decisions directly and/or indirectly through preferences and motivations, which are considered as mediating factors. These preferences and motivations affect economic and non-economic factors in land rental decisions. Due to data limitations, we do not examine the role of these intermediate economic and non-economic factors in the empirical analysis but estimate reduced-form equations of personality traits, preferences and motivations, and land rental market participation. Economic and non-economic factors are therefore not shown in the graph.

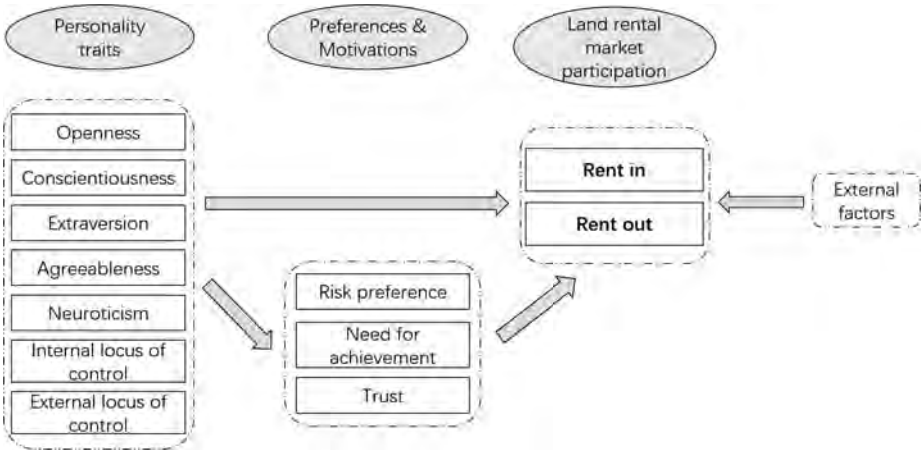


Figure 3.1 Conceptual model

3.3 Context and data

To study the role of personality traits in rural smallholders' farmland renting behaviour, we used data from a large-scale rural household survey conducted in the North China Plain in 2018. In the following sub-sections, we first explain our sampling and data collection procedures, followed by a detailed illustration of the measurement of personality traits and preferences.

3.3.1 Sampling and data collection

The data of our study was collected by in-person interviews with smallholders and village cadres from Handan prefecture in Hebei province, China in February, 2018. Handan prefecture is located at the

centre of the North China Plain (NCP)—one of China's most important agricultural production regions. The agricultural sector accounted for 12.5 percent of Handan Prefecture's total GDP in 2016, which is significantly higher than the national average of 8.6 percent (CNBS, 2017).

Data collection took place as part of a larger survey on the impact of so-called science and technology backyards in Handan prefecture. Among others, the survey contained rich information about households' land rental market participation. For the purpose of our study, we added a separate module on rural smallholders' personality characteristics to it. This allowed us to gain deeper insights into the effect of personality traits on smallholders' land renting behaviour, which cannot be gained by using available secondary data sets collected for larger regions or China as a whole.

To collect the household data, the field survey was conducted in four counties in Handan prefecture. After one round of pre-tests, we first listed all townships and villages within these four sampled counties, comprising 23 townships and 649 villages. We further restricted our sample to staple food production areas. To make sure all our sampled villages included mainly maize and wheat producers, we excluded villages where maize and wheat were not the main crops produced.[23] Then we randomly sampled villages proportional to the size of the township. In total, a sample of 135 villages from 22 townships was obtained. A list of all registered households was obtained within each village, from which we randomly drew 16 households per village to conduct *face-to-face* interviews with. In each household we interviewed the main farming member within each family. In total, we have surveyed 2,119 households from 135 rural villages.[24]

3.3.2 Measures

We measured a series of outcome variables to describe households' land renting behaviour. Specifically, we asked, at the time of survey, if: (1) the household was participating in the land rental market (renting-in or renting-out at least one piece of land); (2) the household was renting at least one piece of farmland; (3) the household was renting out at least one piece of farmland; (4) the respondent was intending to rent (in) more farmland; (5) the respondent was intending to rent out more farmland.[25] Moreover, for households who rented-in land, we calculated the household's average plot size of the

[23] Some villages may specialize in cash crops, such as apple, cotton, and grapes rather than staple food production. We collected information about crop specialization before we conducted interviews in the villages to make sure most smallholders were planting local staple food (wheat and corn) rather than cash crops.
[24] 41 Observations were dropped due to missing or incomplete data. Non-response was about 2 percent.
[25] To avoid unclear definition among surveyed households, we clarified to all the respondents that farmland inherited from their predecessors should not be reported as land rental transactions.

rented-in land by dividing the total size of the rented land by the rented plot numbers; for households who rented out land, we calculated the percentage of household farmland that was rented out, which ranged from 0 (indicating none of their farmland had been rented out) to 1 (indicating that all contracted land had been rented out).

The key variables in our study were the measured smallholders' Big-Five personality traits, LoC, risk preference, trust, and nAch. To measure personality traits in a reliable way, we adopted an internationally recognized Big-Five personality scale (BFI-10) and applied its Chinese version (see Carciofo et al., 2016; Rammstedt & John, 2007). The BFI-10 scale has been widely used in economic and behavioural studies (Donato et al., 2017; Oehler et al., 2018; Soliño & Farizo, 2014). In the BFI-10, each of the five personality dimensions was captured by two items, for which respondents rated their level of agreement on a 5-point Likert-type scale. We elicited LoC following the standard practice of Rotter (1966) but used the 10-item inventory with a 6-point Likert-type scale (see Table 3.A1 in the Appendix), which has been widely used in other studies (Ali et al., 2019; Caliendo et al., 2015; Cobb-Clark et al., 2014; Coleman & Deleire, 2003). We constructed two separate LoC traits (i.e., internal and external) based on factor analysis.[26] Each of the internal and external LoC traits corresponded to 5 items.

We measured smallholders' general risk preferences by using an 11-point rating scale running from 0 (*I see myself as a person who always tries to avoid risks*) to 10 (*I see myself as a person who always positively takes risks*). Moreover, the Need for Achievement inventory with 5-point Likert-type scale consisted of three items adapted from Namayengo (2017) (see Table 3.A1 in the Appendix). Interpersonal trust was a dichotomous measure using a standard question originating from the World Value Survey (WVS) valued 0 (*In general, I believe most people are trustworthy*) or 1 (*I believe most people need to be treated with caution*).

Control variables measured in the survey were the aforementioned external factors (see Figure 3.1), including land tenure security variables, land characteristics, and household and village characteristics. Tenure security was measured by whether smallholders had obtained the land certificate after the new-round land certification program, and if smallholder's farmland was not periodically reallocated within

[26] Some studies, such as Collins (1974), Gatz and Good (1978) have suggested that external and internal locus of control should be treated as two independent traits. We follow the same practice in our study.

village in the second-round land contracting period.[27] Higher tenure security was expected to increase the probability of participation in the land rental market. Contracted farmland size and number of plots were introduced as indicators of a household's land endowment, which were expected to have impact on the household's renting additional land. Household demographic information was used as an indicator of labour endowment. A larger number of household labour was expected to positively affect the decision to rent in land. Households' access to credit and off-farm opportunities were also considered as participation in land rental markets is closely associated with households' exposure to off-farm labour market and credit. Village characteristics contained information about village-level land endowments, geographical location, and within-village kin relationships. We used a group of location variables indicating the degree to which (village) households were connected to the larger economy and markets (Renkow et al., 2004), and we used the number of family clans to indicate the kinship structure within a village.[28] A detailed list of these covariates and their definitions can be found in Table 3.A2 in the Appendix.

3.3.3 Reliability and validity considerations

Concerning the potential problems in using psychometric scales among rural populations in developing countries (Laajaj & Macours, 2017), we have taken a few measures to account for potential biases due to measurement error. As the acquiescence bias is likely to happen in rural low-income settings, we tried to mitigate it following common practice in the psychometrics literature by balancing the scale (e.g., locus of control) and using both positively and negatively phrased statements (Soto et al., 2008). Furthermore, as the relatively low educational level of respondents may have affected their understanding of the questions, we undertook a few rounds of pre-tests for the personality scales prior to the official interview with the respondents. The pre-test was carried out with smallholders residing in two out-of-sample villages in Handan prefecture. We asked them to repeat their understanding of each scale item using their own wordings, then we rephrased the items which were difficult to understand and re-tested again. In this way, we found that smallholders in this sample region could understand the scales well and only one item of the BFI-10 was reworded slightly into local dialect after the pre-test.

[27] The launch of Document No. 1 in 1984 marked the beginning of the 1st round of land contracting, in which the central government stated that the land-use rights of farmers should be granted for at least 15 years in their land contracts. The central government then extended land contracts to another 30 years upon expiry (since 1999), referring to the start of the 2nd round of land contracting. (Feng et al., 2014)

[28] A Chinese clan is defined as a patrilineal and patrilocal group of related people sharing a common surname or ancestor.

We also addressed the reliability and validity concerns of measuring personality traits. First, the BFI-10 scale has been shown to be an appropriate measure retaining significant levels of reliability and validity both in China and in other countries (Carciofo et al., 2016; Rammstedt & John, 2007). Second, the reliabilities of scales measuring locus of control and need for achievement were tested using Cronbach's α, which were 0.76 (internal LoC), 0.69 (external LoC), and 0.73 (nAch), indicating these scales had reasonable internal consistency.[29] Moreover, average variance extracted (AVE) comparisons were applied to all latent personality traits to assess convergent and discriminant validity. Convergent validity was verified as all AVE values were greater than a rule-of-thumb critical value of 0.5, except for the external LoC scale.[30] Discriminant validity was used to test whether latent constructs were inter-correlated due to measurement error. The square root of AVE values for each latent construct are reported in Table 3.A3 in the Appendix, indicating discriminant validity because the values on the diagonals were the highest in any column or row.

3.4 Empirical strategy

3.4.1 Multivariate regression analysis

We were primarily interested in households' actual land renting-in and renting-out behaviours. As long as a household was renting or renting out a piece of farmland at the time of survey, they were categorized as participating in the land rental market. We further asked respondents to report their intention (or willingness) to rent in and/or rent out more land in the near future than the household currently did. We included this question because the actual land renting decision might have been taken (partly) by the household, regardless of the respondent's personality, whereas intention to rent in or out (more) land was primarily determined by the respondent's personality and preferences (Ajzen, 1991). In total, we have six outcome variables.

Given the dichotomous nature of our dependent variables, to analyse the effects of personality traits on the land rental market participation, we first ran a series of *Probit* regressions. Specifically, we estimated three sets of equations, each time adding more variables:

$$y_{ij} = \Phi\left(\alpha_{0j} + \alpha'_{1j}x_i + \alpha'_{2j}w_i + \varepsilon_{ij}\right), \quad (1)$$

[29] According to a rule of thumb, alpha higher than 0.60 indicates an acceptable reliability.
[30] Fornell & Larcker (1981) suggest that an AVE value being no smaller than 0.4 can still be acceptable if the composite reliability (CR) is larger than 0.6. In our case, the AVE of external LoC was 0.450, and CR of external LoC was 0.796.

where y_{ij} is the land renting outcome variable j (running from 1 to 6, including behaviors and intentions) for smallholder i (running from 1 to I, being the number of observations). x_i is a vector of the household decision-maker's personality traits (both the Big-Five and LoC variables). w_i is a vector of county dummy variables, ε_{ij} is the village-clustered robust standard error term, and Φ is the standard normal distribution function. The as are coefficients to be estimated for the first set of equations.

To control for potential confounding factors, which might bias our estimation of the impact of personality traits, we took into account the respondent's basic demographic and family characteristics and the households' land tenure situation factors (i.e., land certificate possession, past land adjustments) (the vector z_i), as well as the household's village characteristics (the vector v_i). In the land renting intention equations, we also included the actual land renting-in and renting-out variables as explanatory variables (the vector z_i). The βs are coefficients to be estimated for the second set of equations. This gave us as a next step:

$$y_{ij} = \Phi\left(\beta_{0j} + \beta'_{1j}x_i + \beta'_{2j}w_i + \beta'_{3j}z_i + \beta'_{4j}v_i + \varepsilon_{ij}\right), \quad (2)$$

To examine whether an individual's preferences play a role in land renting behaviour, we included m_i, the vector of the respondent's personal preferences. Specifically, m_i included the respondent's measured general risk preference, need for achievement, and interpersonal trust. The γ s are coefficients to be estimated in the third set of equations. Thus, we have:

$$y_{ij} = \Phi(\gamma_{0j} + \gamma'_{1j}x_i + \gamma'_{2j}w_i + \gamma'_{3j}z_i + \gamma'_{4j}v_i + \gamma'_{5j}m_i + \varepsilon_{ij}), \quad (3)$$

Personality traits are assumed to be rather stable over time and exogenous after adulthood, according to previous literature suggesting that personality traits are partially genetically inherited and fostered mostly in the early childhood of an individual (Bouchard & Loehlin, 2001; Cobb-Clark & Schurer, 2012; Costa & McCrae, 1992; Jones et al., 2006; Srivastava et al., 2003). Although there is mixed evidence of the stability of preferences over time (Chuang & Schechter, 2015; Schildberg-Hörisch, 2018), we assume that preferences are relatively stable at least over the short periods of time. We can therefore interpret the estimation results for those variables as causal effects on land rental behaviour. The same holds for the household and village characteristics included in Eq. (2) and Eq. (3), because

they were determined before land rental market participation decisions were taken (e.g., age, gender, education).

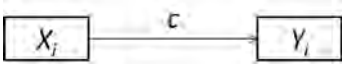
3.4.2 Causal mediation analysis

Since a mediator mediates, or carries over, the effect of the independent variable on dependent variables (Mackinnon, 2008), the size of the direct effects of independent variables may diminish in the presence of mediating variables. Hence, we assume that the preference variables mediate the effect of personality traits on land rental participation if the coefficients of personality traits in Eq. (2) diminish compared to those in Eq. (1). To further disentangle the paths through which personality traits and preferences affect farmland renting behaviour, we conducted Causal Mediation Analysis (CMA) (Hicks & Tingley, 2012). This analysis enabled us to understand to what extent preferences, achievement desire, and trust mediated the effects of personality traits on land renting behaviour.

Specifically, we employed the (multiple) mediation model proposed by Preacher and Hayes (2008) (Figure 3.2). In this model, M_i depicts potential mediators. Path *c* in Panel A of Figure 3.2 is the total effect of X_i on Y_i, which is decomposed into a direct effect c' and indirect effects of X_i on Y_i via mediators M_1 and M_2 in Panel B. a_1 and a_2 depict the effects of X_i on the mediators, and b_1 and b_2 depict the effects of the mediators on Y_i. Hence, the total indirect effect of X_i on Y_i is the sum of $a_1 b_1$ and $a_2 b_2$. Figure 3.2 also applies to the case of one mediator or more than two mediators analogously.

Complications arise when either the mediator or the outcome is a dichotomous variable and when using the standard normal distribution for deriving a *p*-value for the indirect effect (Preacher & Hayes, 2008). In this case, the calculation of indirect effects requires a combination of OLS regression along with either Probit or Logit models (Mackinnon & Dwyer, 1993). We adopted the method of bootstrapping for non-parametric estimation of the indirect effect without imposing the assumption of normality of the sampling distribution, as suggested by Preacher and Hayes (2008).

Panel A. Total effect



Panel B. Decomposing the total effect into a direct effect and indirect effects

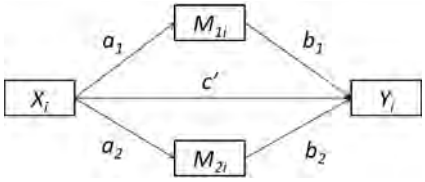


Figure 3.2 Mediation of personality traits (X_i) on land renting behaviours (Y_i)

3.5 Results

3.5.1 Descriptive analysis

Table 3.1 presents summary statistics for key variables; summary statistics of the control variables can be found in Table 3.A2 in the Appendix. In the sample, 26.1 percent of smallholders participated in the land rental market; 12.6 percent rented farmland and 14.8 percent rented out farmland (see Table 3.1). However, 25.5 percent and 24.2 percent of households intended to rent and rent out more land, respectively, indicating that the land rental market had the potential for future development in our survey area.

Table 3.2 shows the Pearson correlation coefficients among all psychological characteristics. Most of the correlation coefficients were well below 0.3 in absolute terms but statistically significant, suggesting that the majority of the psychological constructs used in this study were correlated, but substantially distinct from each other. The descriptive results in Table 3.2 for the Big-Five personality traits showed construct validity, because the correlations between neuroticism and the other four dimensions (openness, conscientiousness, extraversion, agreeableness) were negative, as expected, and are consistent with previous psychometric research (Gosling et al., 2003). We found that internal LoC was significantly correlated with conscientiousness (0.263), extraversion (0.144), agreeableness (0.290), and particularly nAch (0.381). This suggests that if an individual's internal LoC was positively associated with his or her land renting behaviour (or intention to join the land rental market), then this effect might be mediated through an individual's nAch, if nAch would also be correlated with land renting behaviour. We further found that risk preference was negatively correlated with openness and extraversion, and positively correlated with neuroticism, which is in line with previous observations by Dohmen et al. (2010).

Table 3.1 Definition of (key) variables and descriptive statistics

	n	M	SD	Min	Max	VIF
	(1)	(2)	(3)	(4)	(5)	(6)
Outcome variables						
Land rental market participation						
Household was either renting or renting out land	2119	0.261	0.439	0	1	
Household was renting land	2119	0.126	0.332	0	1	
Household was renting land out	2119	0.148	0.355	0	1	
Land rental market participation intention						
Respondent was intending to either renting or renting out land	2119	0.445	0.497	0	1	
Respondent was intending to rent farmland	2119	0.255	0.436	0	1	
Respondent was intending to rent out farmland	2119	0.242	0.428	0	1	
Key personality variables						
Respondent's personality traits						
Openness to experience [O]	2119	2.830	0.982	1	5	1.07
Conscientiousness [C]	2119	3.894	0.896	1	5	1.16
Extraversion [E]	2119	3.278	1.005	1	5	1.09
Agreeableness [A]	2119	4.144	0.803	1	5	1.18
Neuroticism [N]	2119	2.538	0.942	1	5	1.20
Internal locus of control	2119	4.839	0.759	1	6	1.40
External locus of control	2119	2.836	0.979	1	6	1.13
Respondent's preferences and trust						
Risk preference	2119	4.342	3.203	0	10	1.06
Need for achievement	2119	4.104	0.833	1	5	1.35
Interpersonal trust	2119	0.371	0.483	0	1	1.03

Table 3.2 Correlations among respondent's personality traits, preferences, and trust

	O	C	E	A	N	Internal LoC	External LoC	Risk preference	Need for achievement	Trust
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Openness to experiences [O]	1									
Conscientiousness [C]	0.034	1								
Extraversion [E]	0.098***	0.096***	1							
Agreeableness [A]	-0.084***	0.230***	0.025	1						
Neuroticism [N]	-0.025	-0.172***	-0.220***	-0.209***	1					
Internal LoC	0.011	0.263***	0.144***	0.290***	-0.275***	1				
External LoC	0.026	-0.131***	-0.089***	-0.187***	0.218***	-0.259***	1			
Risk preference	0.093***	0.023	0.082***	-0.037*	-0.045**	0.003	0.021	1		
Need for achievement	0.172***	0.263***	0.162***	0.141***	-0.127***	0.381***	-0.114***	0.138***	1	
Interpersonal trust	0.030	-0.016	-0.065	0.002	0.079***	-0.025	-0.009	-0.035	-0.019	1

Note: * $p<0.1$. ** $p<0.05$. *** $p<0.01$.

3.5.2 Farmland rental market participation

Table 3.3 reports the estimated effects of smallholders' personality traits and preferences on their household's overall participation in the farmland rental market (either renting or renting out land). We first included personality variables only, then adding control variables to the models, and finally included motivation and preferences variables as well.

We found that openness to experience positively affected smallholders' participation in land rental markets in all three equations, providing support for Hypothesis 1. A one standard deviation increase in smallholders' openness to experiences corresponded to a 2.0 percentage points increase in the probability of land rental market participation in equation (3) ($p<0.05$). It indicates that more open smallholders were more likely to change their livelihoods by utilizing the land rental market, either by increasing farm size to be more specialized in agricultural production, or by renting out land and getting involved in migration or for some local off-farm employment. We further found no significant effects on land rental market participation for the other four of the Big-Five personality traits.

Regarding LoC, we found that both internal LoC and external LoC of smallholders had significant effects on their households' overall land renting participation. A one standard deviation increase in internal LoC (external LoC) was associated with a 2.4 (2.1) percentage point increase in the probability of land rental market participation ($p<0.05$) in equation (3). For internal LoC this finding provides support for Hypothesis 2, and suggests that smallholders with relatively high internal LoC exert more effort in searching for either on-farm or off-farm opportunities. The positive effect that we estimated for external LoC was not postulated in the conceptual framework (Section 2.2). Further research may explain this unexpected finding.

The last three columns in Table 3.3 report the regression results for respondents' intention to participate in the land rental markets. We found that internal LoC also had a strong positive effect on intention to participate more in the land rental market ($p<0.05$). A one standard deviation increase in internal LoC increased the intention to participate more in the land rental market by 2.6 percentage points. Internal LoC thus had consistent effects on both actual participation and on intention to participate more. We did not find significant effects of external LoC on the respondents' intentions to participate more in land rental markets, even though it had a significant positive effect on overall land rental market participation. The same holds for openness to experience.

Table 3.3 Impact of personality on overall participation in farmland rental market (*probit*)

Outcome variables	*Household participated in the land rental market*			*Respondent intended to participate more in the land rental market*		
	(1)	(2)	(3)	(4)	(5)	(6)
Respondent's personality traits						
Openness to experience [O]	0.018**	0.019**	0.020**	0.003	-0.004	-0.007
	(0.009)	(0.010)	(0.010)	(0.010)	(0.011)	(0.012)
Conscientiousness [C]	0.003	0.005	0.005	0.011	0.010	0.007
	(0.009)	(0.010)	(0.010)	(0.011)	(0.012)	(0.012)
Extraversion [E]	0.012	0.006	0.008	0.008	0.003	-0.001
	(0.010)	(0.011)	(0.011)	(0.010)	(0.010)	(0.011)
Agreeableness [A]	-0.000	0.004	0.004	0.000	0.006	0.007
	(0.010)	(0.010)	(0.010)	(0.009)	(0.010)	(0.010)
Neuroticism [N]	-0.008	-0.003	-0.004	0.012	0.016	0.017
	(0.010)	(0.011)	(0.011)	(0.011)	(0.012)	(0.012)
Internal locus of control	0.023**	0.023**	0.024**	0.034***	0.031**	0.026**
	(0.010)	(0.011)	(0.011)	(0.011)	(0.012)	(0.012)
External locus of control	0.021**	0.020*	0.021**	-0.006	-0.003	-0.005
	(0.009)	(0.011)	(0.011)	(0.010)	(0.011)	(0.011)
Respondent's personal preferences and trust						
Risk preference			-0.009			0.016
			(0.010)			(0.011)
Need for achievement			-0.003			0.018
			(0.012)			(0.014)
Interpersonal trust			0.042*			-0.044**
			(0.024)			(0.020)
Respondent's social-demographic characteristics						
Age (year)		0.001	0.001		-0.004***	-0.004**
		(0.001)	(0.001)		(0.001)	(0.001)
Gender (1=male)		0.006	0.008		0.060	0.057
		(0.042)	(0.042)		(0.039)	(0.039)
Education (year)		0.000	0.001		0.001	-0.000
		(0.003)	(0.003)		(0.003)	(0.003)
Household head (1=yes)		0.042	0.045		0.079*	0.076*
		(0.036)	(0.036)		(0.041)	(0.041)
Household and land characteristics						
Land reallocated before (1=yes)		0.082**	0.088**		0.025	0.019
		(0.035)	(0.035)		(0.028)	(0.028)
Land certificate possession (1=yes)		-0.031	-0.030		-0.004	-0.005
		(0.022)	(0.022)		(0.018)	(0.018)
Contract farmland size (mu)		-0.005	-0.005		0.001	0.001
		(0.003)	(0.003)		(0.003)	(0.003)
Number of contracted land plots		-0.021***	-0.021***		-0.010	-0.010
		(0.007)	(0.007)		(0.007)	(0.007)
Number of laborers		0.014*	0.014*		0.016*	0.015*
		(0.008)	(0.008)		(0.009)	(0.009)
Number of elders		0.011	0.010		0.007	0.007
		(0.017)	(0.017)		(0.018)	(0.018)
Number of students		-0.012	-0.011		0.018**	0.016*
		(0.009)	(0.009)		(0.009)	(0.009)
Family laborers work off-farm (%)		0.086*	0.092*		-0.035	-0.047
		(0.047)	(0.048)		(0.052)	(0.052)
Credit accessibility (1=yes)		0.021	0.025		0.093***	0.086***
		(0.025)	(0.025)		(0.029)	(0.029)
Household rented land (1=yes)	-	-	-		0.170***	0.170***
					(0.037)	(0.037)
Household rented-out land (1=yes)	-	-	-		0.066**	0.073**
					(0.029)	(0.029)
Village characteristics						
Distance to county centre (km)		0.001	0.001		-0.001	-0.001

		(0.002)	(0.002)		(0.001)	(0.001)
Distance to township centre (km)		-0.008	-0.008		0.001	0.001
		(0.007)	(0.007)		(0.004)	(0.004)
Distance to highway (km)		-0.002	-0.002		0.002	0.001
		(0.003)	(0.003)		(0.001)	(0.001)
Distance to food market (km)		0.002	0.002		0.000	0.000
		(0.003)	(0.003)		(0.002)	(0.002)
Township government (1=yes)		0.020	0.022		-0.004	-0.005
		(0.050)	(0.049)		(0.039)	(0.040)
Village merged before (1=yes)		-0.072	-0.071		-0.037	-0.033
		(0.062)	(0.060)		(0.072)	(0.069)
Farmland size per capita (mu)		0.067**	0.067**		-0.004	-0.004
		(0.029)	(0.028)		(0.023)	(0.023)
Number of family clans in the village		-0.003	-0.004		0.021**	0.022**
		(0.012)	(0.012)		(0.009)	(0.009)
County dummies	Yes	Yes	Yes	Yes	Yes	Yes
Observations	2,119	1,912	1,912	2,087	2,087	2,087

Notes:
- Robust-clustered standard errors in parentheses, * p<0.1. ** p<0.05. *** p<0.01.
- Number of observations varies as data on village characteristics are missing for some villages
- Average marginal effects are reported.

3.5.3 Farmland renting-in and renting-out behaviour

This section presents and discusses the regressions results for smallholders' land renting-in and renting-out behaviour separately (see Table 3.4). We found that internal LoC had a consistently significant positive effect on the households actual renting-in of land ($p<0.05$) and on smallholders' intention to rent more land ($p<0.01$), except when we controlled for respondents' preferences and interpersonal trust (columns (3) and (6)). One standard deviation increase in internal LoC corresponded to a 1.6 (2.4) percentage points higher probability of renting-in behaviour (intention) (columns (2) and (5)). The significant positive effect on the renting-in of land and the insignificant effect on the renting-out of land implies that smallholders with a relatively strong internal LoC were more likely to seize opportunity through renting land instead of migrating to urban areas. Interestingly, when we added preferences and trust to the equations, the respondents' nAch had a significant positive effect on the households actual renting behaviour ($p<0.10$) and intention to rent more land ($p<0.05$), while internal LoC was no longer significant. This finding suggests a possible mediation effect of nAch (and possibly also risk preference, which had a significant effect in the intention equation at $p<0.10$) for internal LoC. In Section 5.4, we will examine these potential mediation effects of nAch and risk preference in more detail. We also found some tentative evidence ($p<0.10$) that internal LoC affected the respondents' intention to rent-out more land. But the impact on actual land renting-out was not statistically significant.

Regarding the other personality traits, we found some tentative evidence that external LoC had positive effects on land renting out ($p<0.10$). But the impact of external LoC on intention to rent out more land was not statistically significant. These findings imply that smallholders who believe that their lives are controlled by their external environment seemed to accept that others were interested in renting (part of) their land and actually rented it out. Interpersonal trust played an important role in such decisions, as indicated by its significantly positive effect ($p<0.05$) in the renting out land equation (see column (9)).

We did not find significant effects of smallholders' conscientiousness on land renting (or renting out), thus rejecting Hypothesis 3. This finding supports the presumption that emotional attachment to the land is rather weak in China given the system of allocation of land to households under the HRS.

We also did not find significant effects of neuroticism on renting out (or renting) of land, except for a slightly significant positive effect ($p<0.10$) on intention to rent out more land in the equation that includes personal preferences and trust. These findings might suggest that neuroticism affects

smallholders' intention to rent out more via the process of perceived stress reduction than via the process of perceived loss of protection against adverse events.

The estimated coefficients for the other three personality traits—openness to experience, extraversion and agreeableness—were all not statistically significant in the land renting equations nor in the land renting out equations. For openness, this result contrasts with the significant positive effects on overall land renting participation reported in Table 3.3. A possible explanation is that smallholders with a high level of openness are more likely to try new experiences by either enlarging their farms or renting-out all their land and migrating (see motivation of Hypothesis 1 in subsection 2.2.1).

In the Probit analysis that was applied for Table 3.4, smallholders that rented land are compared with the group that rented-out land or did not participate in the rental market; and those that rented-out land are compared with the group that rented land or did not participate. As an alternative we also applied multinomial probit to a categorized participation variable with three outcomes: (1) household rented land, (2) autarkic household (as a base outcome), and (3) household rented-out land. The regression results are presented in Table 3.A4 in the Appendix. The main findings are similar to those of the probit model estimations. The positive coefficient estimates for openness are significant (at $p<0.10$) in one of the three land rent-in participation regressions and one of the three land rent-out participation regressions. These additional findings provide some tentative support for the proposition that smallholders with a high level of openness are more likely to try new experiences by enlarging their farms or by migrating.

Table 3.4 Impact of personality traits on household farmland renting-in and renting-out behaviour and intention (*probit*)

Outcome variables	*Household rented land*			*Intention to rent more land*			*Household rented out land*			*Intention to rent out more land*		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Respondent's personality traits												
Openness to experience [O]	0.007	0.010	0.008	0.003	-0.004	-0.008	0.010	0.007	0.009	-0.001	-0.003	-0.002
	(0.006)	(0.006)	(0.006)	(0.008)	(0.009)	(0.009)	(0.008)	(0.008)	(0.008)	(0.007)	(0.007)	(0.007)
Conscientiousness [C]	0.001	0.009	0.007	0.003	-0.000	-0.004	0.007	0.002	0.004	0.004	0.004	0.004
	(0.007)	(0.007)	(0.007)	(0.009)	(0.009)	(0.009)	(0.008)	(0.008)	(0.008)	(0.008)	(0.008)	(0.008)
Extraversion [E]	0.010	0.004	0.003	0.008	-0.001	-0.005	0.006	0.006	0.009	0.005	0.008	0.008
	(0.007)	(0.006)	(0.006)	(0.010)	(0.009)	(0.010)	(0.008)	(0.008)	(0.008)	(0.007)	(0.007)	(0.007)
Agreeableness [A]	-0.009	-0.003	-0.004	-0.001	0.012	0.011	0.004	0.003	0.003	-0.002	-0.006	-0.006
	(0.008)	(0.007)	(0.007)	(0.008)	(0.009)	(0.009)	(0.008)	(0.008)	(0.008)	(0.008)	(0.007)	(0.007)
Neuroticism [N]	0.004	0.006	0.005	0.002	0.003	0.003	-0.011	-0.009	-0.010	0.008	0.013	0.014*
	(0.007)	(0.006)	(0.006)	(0.010)	(0.010)	(0.010)	(0.009)	(0.009)	(0.009)	(0.008)	(0.008)	(0.008)
Internal locus of control	0.017**	0.016**	0.012	0.027***	0.024***	0.014	0.010	0.008	0.011	0.012	0.014*	0.015*
	(0.007)	(0.008)	(0.008)	(0.009)	(0.009)	(0.010)	(0.009)	(0.008)	(0.008)	(0.008)	(0.008)	(0.008)
External locus of control	0.009	0.008	0.008	-0.002	0.003	0.002	0.014*	0.013	0.014*	-0.005	-0.009	-0.010
	(0.007)	(0.006)	(0.006)	(0.008)	(0.008)	(0.008)	(0.008)	(0.008)	(0.008)	(0.008)	(0.008)	(0.008)
Respondent's personal preferences and trust												
Risk preference			-0.001			0.014*			-0.010			0.005
			(0.007)			(0.008)			(0.008)			(0.008)
Need for achievement			0.013*			0.030**			-0.011			-0.005
			(0.007)			(0.012)			(0.009)			(0.010)
Interpersonal trust			0.007			-0.026			0.038**			-0.022
			(0.015)			(0.016)			(0.016)			(0.015)
Respondent's social-demographic characteristics												
Age (year)		-0.002**	-0.002**		-0.005***	-0.005***		0.003***	0.003***		0.001	0.001
		(0.001)	(0.001)		(0.001)	(0.001)		(0.001)	(0.001)		(0.001)	(0.001)
Gender (male)		0.024	0.024		0.059**	0.058**		-0.008	-0.007		0.017	0.017
		(0.025)	(0.025)		(0.027)	(0.026)		(0.035)	(0.035)		(0.027)	(0.027)
Education (year)		-0.003	-0.003		-0.004	-0.005*		0.003	0.003		0.004*	0.004*
		(0.002)	(0.002)		(0.003)	(0.002)		(0.002)	(0.002)		(0.002)	(0.002)
Household head (1=yes)		0.026	0.027		0.053*	0.048*		0.006	0.009		0.019	0.018
		(0.024)	(0.023)		(0.028)	(0.028)		(0.028)	(0.028)		(0.026)	(0.026)
Household and land characteristics												
Land reallocated before (1=yes)		-0.021	-0.022		0.032	0.025		0.084***	0.090***		0.006	0.003
		(0.017)	(0.017)		(0.024)	(0.024)		(0.030)	(0.031)		(0.021)	(0.021)
Land certificate possession (1=yes)		-0.009	-0.008		0.001	-0.000		-0.018	-0.018		-0.002	-0.002

		(0.014)	(0.014)		(0.016)	(0.016)		(0.019)	(0.019)	(0.014)	(0.014)
Contract farmland size (mu)		-0.005**	-0.005**		-0.002	-0.002		-0.000	-0.000	0.004	0.004
		(0.002)	(0.002)		(0.003)	(0.003)		(0.002)	(0.002)	(0.002)	(0.002)
Number of contracted land plots		0.000	0.000		-0.010*	-0.010*		-0.022***	-0.022***	-0.002	-0.002
		(0.005)	(0.005)		(0.005)	(0.005)		(0.005)	(0.005)	(0.005)	(0.005)
Number of laborers		0.016***	0.015***		0.021***	0.020***		0.004	0.004	0.000	0.000
		(0.005)	(0.005)		(0.007)	(0.007)		(0.006)	(0.006)	(0.006)	(0.006)
Number of elders		-0.022	-0.022*		-0.000	-0.002		0.025**	0.024**	-0.004	-0.003
		(0.013)	(0.013)		(0.015)	(0.015)		(0.012)	(0.012)	(0.012)	(0.012)
Number of students		-0.007	-0.007		0.019***	0.017**		-0.005	-0.003	-0.002	-0.002
		(0.005)	(0.005)		(0.007)	(0.007)		(0.008)	(0.008)	(0.007)	(0.007)
Family laborers work off-farm (%)		-0.006	-0.008		-0.035	-0.046		0.091***	0.100***	0.017	0.016
		(0.032)	(0.033)		(0.041)	(0.041)		(0.035)	(0.034)	(0.041)	(0.041)
Credit accessibility (1=yes)		0.012	0.012		0.058**	0.052**		0.008	0.013	0.029	0.028
		(0.018)	(0.018)		(0.023)	(0.022)		(0.019)	(0.019)	(0.020)	(0.020)
Household rented land (1=yes)	-	-	-		0.175***	0.172***	-	-	-	-0.012	-0.012
					(0.034)	(0.034)				(0.022)	(0.022)
Household rented-out land (1=yes)	-	-	-		-0.064***	-0.061***	-	-	-	0.114***	0.117***
					(0.021)	(0.021)				(0.026)	(0.025)
Village characteristics											
Distance to county centre (km)		-0.001	-0.001		0.001	0.001		0.002	0.002	-0.002**	-0.002**
		(0.001)	(0.001)		(0.001)	(0.001)		(0.001)	(0.001)	(0.001)	(0.001)
Distance to township centre (km)		-0.005	-0.005		0.002	0.002		-0.004	-0.004	-0.001	-0.001
		(0.003)	(0.003)		(0.003)	(0.003)		(0.005)	(0.005)	(0.003)	(0.003)
Distance to highway (km)		-0.001	-0.001		0.003**	0.002**		-0.002	-0.001	-0.001	-0.001
		(0.001)	(0.001)		(0.001)	(0.001)		(0.002)	(0.002)	(0.001)	(0.001)
Distance to food market (km)		0.005***	0.005***		0.002	0.002		-0.004	-0.004	-0.001	-0.001
		(0.002)	(0.002)		(0.001)	(0.001)		(0.003)	(0.003)	(0.002)	(0.002)
Township government (1=yes)		-0.028	-0.027		-0.031	-0.031		0.047	0.047	0.010	0.009
		(0.020)	(0.020)		(0.025)	(0.025)		(0.040)	(0.040)	(0.029)	(0.028)
Village merged before (1=yes)		-0.047	-0.045		-0.050	-0.042		-0.024	-0.024	-0.002	-0.004
		(0.030)	(0.031)		(0.061)	(0.057)		(0.048)	(0.045)	(0.026)	(0.027)
Farmland size per capita (mu)		0.011	0.011		0.017	0.016		0.061**	0.061**	-0.018	-0.019
		(0.015)	(0.015)		(0.020)	(0.020)		(0.029)	(0.028)	(0.017)	(0.017)
Number of family clans in the village		0.002	0.002		0.014**	0.014*		-0.005	-0.005	0.012*	0.012**
		(0.008)	(0.008)		(0.007)	(0.007)		(0.009)	(0.009)	(0.006)	(0.006)

County dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
	2,119	1,912	1,912	2,119	1,912	1,912	2,119	1,912	1,912	2,119	1,912	1,912

Notes:
- Robust-clustered standard errors in parentheses, * p<0.1. ** p<0.05. *** p<0.01.
- Number of observations varies as data on village characteristics are missing for some villages
- Average marginal effects are reported.

3.5.4 Mediation analysis

To examine the potential mediation effects, suggested by the regression results, we applied Baron and Kenny's (1986) causal mediation analysis (CMA). Table 3.5 reports the results of this mediation analysis for internal LoC and land renting-in behaviour (top panel) and intention (bottom panel), where nAch and risk preference are potential mediators to be investigated.

For actual land renting-in by households, the mediation effect was found to be insignificant. A possible explanation is the prevalence of informal land rentals, characterized by informal contracts and zero rent payments, which are still popular in rural China (Ma et al., 2018; Ye et al., 2018). These usually happen when a household migrates to the city and relatives or acquaintances in the same village feel responsibility for cultivating the land that would otherwise remain idle or be reallocated by the village government. As a result, households that rent land may not be self-motivated to do so, and nAch and risk preference do not significantly affect actual land renting.

We did find significant mediation effects for the respondent's land renting-in intention. Specifically, we found that internal LoC strongly influenced the smallholder's nAch (p<0.05, Row 12), and nAch was strongly correlated with the smallholders' land renting-in intention (p<0.05, Row 13). The indirect effect of internal LoC through nAch and the total indirect effect were both significant at 5% level (Rows 14 and 18), while the direct effect of internal LoC turned out to be insignificant (Row 19). For risk preference we did not find significant mediation effects, as both its correlation with internal LoC and with land renting intention were not significant. Combined with the finding that the effect of internal LoC on intention to rent more land became insignificant when nAch was controlled for (column 6, Table 3.4), these findings suggest that internal LoC does not directly affect land renting-in intention, but has an indirect effect through smallholders' need for achievement. Hence, we found partial support, namely for internal LoC, for the hypothesis that personality traits affect land renting behaviours through risk preference, need for achievements, and (or) interpersonal trust (Hypothesis 4).

Table 3.5 Mediation analysis results for impact of internal LoC on land renting-in

		Y= Household rented land			
		Coefficient	**Bootstrapped std. error**	**CI lower**	**CI upper**
		(1)	(2)	(3)	(4)
1.	**Total effect [c]**	0.091**	0.044	[0.000	0.176]
2.	Effect of X on M1 [a_1]	0.374**	0.020	[0.333	0.414]
3.	Effect of M_1 on Y [b_1]	0.074	0.041	[-0.007	0.155]
4.	**Indirect effect with M_1[#] [$a_1 \times b_1$]**	0.020	0.015	[-0.007	0.054]
5.	Effect of X on M2 [a_2]	0.003	0.022	[-0.039	0.046]
6.	Effect of M_2 on Y [b_2]	-0.006	0.038	[-0.081	0.069]
7.	**Indirect effect with M_2[#] [$a_2 \times b_2$]**	0.000	0.001	[-0.002	0.004]
8.	**Total indirect effect[#]**	0.020	0.016	[-0.008	0.055]
9.	**Direct effect [c'][#]**	0.070	0.044	[-0.016	0.159]
10.	Proportion of total effect mediated		21.978%		
		Y= Respondent intended to rent more land			
		Coefficient	**Bootstrapped std. error**	**CI lower**	**CI upper**
11.	**Total effect [c]**	0.106**	0.042	[0.022	0.182]
12.	Effect of X on M_1 [a_1]	0.374**	0.020	[0.333	0.414]
13.	Effect of M_1 on Y [b_1]	0.141**	0.052	[0.040	0.242]
14.	**Indirect effect with M_1[$a_1 \times b_1$]**	0.042**	0.015	[0.013	0.072]
15.	Effect of X on M_2 [a_2]	0.003	0.022	[-0.039	0.046]
16.	Effect of M_2 on Y [b_2]	0.064	0.036	[0.007	0.134]
17.	**Indirect effect with M_2[$a_2 \times b_2$]**	-0.001	0.002	[-0.008	0.002]
18.	**Total indirect effect**	0.041**	0.016	[0.010	0.071]
19.	**Direct effect [c']**	0.065	0.044	[-0.017	0.154]
20.	Proportion of total effect mediated		38.679%		

Notes:
- X=Internal LoC, M_1=nAch, M_2=risk preference, Y= Household rented land, resp. Respondent intended to rent land.
- See Section 4.2 for definition of a_1, a_2, b_1, b_2, c and c'.
- Indirect effects (in columns 4, 7, 8, 14 17 and 18) were calculated with 1000 re-sampling bootstrapped standard errors.
- Bias-corrected 95% confidence intervals (CI) were reported.
- ** p<.05

3.6 Conclusion

Based on a rural survey of 2119 households from the North China Plain, we tested our conceptual framework and found that personality traits of smallholders significantly affect their farmland renting behaviour, beyond external factors such as socio-demographic and institutional factors. Specifically, first, estimates from a probit model showed that the main personality traits affecting smallholders' overall land rental market participation are openness to experience and locus of control [LoC]. Second, our results provided evidence that smallholders with strong internal LoC generally tend to seize opportunities to rent in land rather than rent out land and focus on off-farm opportunities. We further found that need for achievement [nAch] is the plausible channel through which internal LoC affects smallholders' land renting behaviour.

Given the heterogeneous personality traits among rural smallholders, these findings show that certain traits may predispose or intrinsically motivate individuals to participate in land renting activities, which may have important implications for policy makers. First, policy makers aiming to identify or screen appropriate rural households to promote the scale farming operations may take their personality traits into consideration. For example, providing more extensive rural entrepreneurial programs and corresponding subsidy policies—particularly targeting smallholders who have high-level of internal LoC—may be more efficient in fostering self-motivated family farms than the simple scaled-farm subsidies given to all rural smallholders. Moreover, as people who are more internally controlled, by nature, tend to be more resistant to external manipulation or control if they are aware of that (Rotter, 1982) and more open to information, taking initiatives, and exerting effort when tasks are thought to be skill-demanding (Antonides, 1996), policies promoting the scale farming operations that involve mandatory compliance need be developed with caution.

Taken as a whole, although our analysis is based on the premise that reducing external transaction costs has a central role for facilitating land rental participation, we showed that there are also "psychological hurdles" of entering into land rental markets. This suggests that reducing external constraints alone, such as market transaction costs, may not translate into straightforward and immediate land rental market participation. Instead, adapting policy measures according to smallholders' personality traits may improve the effectiveness of rural policy and projects in China.

Despite the extensive analysis we have conducted, there are several limitations in this study we have to acknowledge. First, though changes in personality traits are seen as stable after adulthood (Cobb-

Clark & Schurer, 2012; Jones et al., 2006; Srivastava et al., 2003), there is some evidence that traits can change across the lifespan due to age-related maturation and degeneration processes, or environmental influences (Borghans et al., 2008; Specht et al., 2011; Specht et al., 2014). We could not completely exclude the concern of endogeneity of personality traits. Second, the dataset we used in this study was collected in a specific region (the North China Plain), where the land rental incidence was relatively low, and the external conditions of the sampled smallholders (i.e., farming structure, off-farm employment situation, and climate) were relatively homogeneous across counties and villages. The rich information that we collected for this relatively small area can provide useful new insights that cannot be obtained from available secondary data sets for larger areas or China as a whole. To examine the external validity of our main findings, similar information will need to be collected in regions with different geographic and socioeconomic characteristics. Last, although we conceptualized several economic and non-economic values of land as underlying factors through which personality traits and preferences may affect smallholders' participation, we did not explicitly estimate these economic and non-economic effects due to lacking data on these variables. This is unlikely to bias our estimation results for personality traits, given that such traits are relatively constant and are unlikely to be affected by land rental decisions. It may, however, affect our findings for the mediating roles of preferences and motivations to some extent because the estimates of b_1 and b_2 in Table 3.5 may suffer from omitted variables bias (see also Figure 3.2). It also means that we cannot disentangle the intermediate roles played by economic and non-economic motivations in shaping the relationship between personality traits and land market participation. Future research may try to shed more light on the impact of these limitations.

Appendix

Table 3.A1 Questions related to locus of control and need for achievement in the survey

Scale	Items
Locus of control *(10-item, 6-point Likert-type scale)*	My life is determined by my own actions. When I get what I want, it is usually because I worked hard for it. I am usually able to protect my personal interests. I can mostly determine what will happen in my life. When I make plans. I am almost certain/guaranteed to make them work. To a great extent, my life is controlled by accidental/chance happenings. I feel that what happens in my life is determined by others. It is not always wise for me to plan too far ahead because many things turn out to be a matter of good or bad fortune. My life is chiefly controlled by other powerful people. I have little chance of protecting my personal interests.
Need for achievement *(3-item, 5-point Likert-type scale)*	I always look for opportunities to improve my situation. I have many aspirations. I work hard to be among the best.

Note: Items of locus of control scale are adapted from the scale developed by the German Socio-Economic Panel (SOEP) study and items of need for achievement scale are adapted from the scale developed by Namayengo (2017).

Table 3.A2 Descriptive statistics of control variables

Variables	n	M	SD	Min	Max	VIF
	(1)	(2)	(3)	(4)	(5)	(6)
Respondent's characteristics						
Age (year)	2119	56.854	10.976	20	86	1.76
Gender (1=male)	2119	0.801	0.399	0	1	2.35
Education (year)	2119	6.591	3.793	0	16	1.31
Household head (1=yes)	2119	0.784	0.411	0	1	2.33
Household characteristics						
Land reallocated before (1=yes)	2119	0.127	0.334	0	1	1.01
Land certificate possession (1=yes)	2119	0.442	0.497	0	1	1.02
Contracted farmland size (mu)	2119	7.047	4.146	0	32	1.48
Number of contracted farmland plots	2119	3.259	1.940	0	15	1.38
Number of laborers (between 16 and 65 years old)	2119	3.042	1.605	0	8	1.91
Number of elders within the household	2119	0.509	0.772	0	3	1.68
Number of students within the household	2119	1.059	1.154	0	7	1.33
Family laborers with off-farm income (%)	2119	0.235	0.222	0	1	1.27
Credit accessibility (1=yes)	2119	0.194	0.396	0	1	1.10
Village characteristics						
Distance to county centre (km)	2119	12.683	7.371	1	45	1.26
Distance to township centre (km)	2119	3.819	2.470	1	12.5	1.13
Distance to highway (km)	1944	3.762	7.103	0	60	1.09
Distance to food market (km)	1960	4.756	4.051	0	30	1.06
Township government (1=yes)	2119	0.010	0.030	0	1	1.04
Village merged before (1=yes)	2119	0.015	0.173	0	1	1.04
Farmland size per capita (mu)	2119	1.590	0.522	0.7	4	1.03
Number of family clans in the village	2119	2.065	1.159	1	6	1.03

Note: VIF of key variables are presented in Table 1. A VIF below 10 indicates no serious multicollinearity problem.

Table 3.A3 Discriminant validity of personality traits constructs (Fornell-Larcker Criterion)

	O (1)	C (2)	E (3)	A (4)	N (5)	In_LoC (6)	Ex_LoC (7)	nAch (8)
Openness [O]	**0.699**							
Conscientiousness [C]	0.154	**0.720**						
Extraversion [E]	0.143	0.129	**0.689**					
Agreeableness [A]	-0.024	0.174	0.133	**0.755**				
Neuroticism [N]	-0.091	-0.193	-0.197	-0.220	**0.745**			
Internal LoC [In_LoC]	0.070	0.292	0.209	0.331	-0.329	**0.722**		
External LoC [Ex_LoC]	0.063	-0.121	-0.064	-0.188	0.205	-0.303	**0.671**	
Need for achievement [nAch]	0.255	0.325	0.283	0.177	-0.191	0.434	-0.148	**0.809**

Note: The diagonal reports the square root of the average variance extracted (AVE) for each latent construct, which indicates discriminant validity because the diagonal values are the highest in any column or row.

Table 3.A4 Impact of personality traits on household farmland renting-in and renting-out behaviour and intention (multinomial *probit*)

Outcome variables	*Behaviour*						*Intention*					
	(1)		(2)		(3)		(4)		(5)		(6)	
	Rent-in	Rent-out	Rent-in	Rent-out	Rent-in	Rent-out	Rent-in	Rent-out	Rent-in	Rent-out	Rent-in	Rent-out
Respondent's personality traits												
Openness to experience [O]	0.069	0.079*	0.092*	0.075	0.080	0.084	0.024	-0.002	-0.022	-0.022	-0.045	-0.024
	(0.043)	(0.047)	(0.050)	(0.054)	(0.051)	(0.055)	(0.046)	(0.048)	(0.055)	(0.052)	(0.055)	(0.053)
Conscientiousness [C]	-0.003	0.027	0.052	0.005	0.041	0.016	0.048	0.039	0.044	0.035	0.022	0.032
	(0.048)	(0.050)	(0.054)	(0.053)	(0.054)	(0.056)	(0.052)	(0.052)	(0.057)	(0.055)	(0.058)	(0.058)
Extraversion [E]	0.075	0.030	0.040	0.017	0.037	0.033	0.025	0.037	-0.025	0.053	-0.045	0.047
	(0.047)	(0.050)	(0.051)	(0.056)	(0.051)	(0.055)	(0.052)	(0.045)	(0.056)	(0.048)	(0.056)	(0.048)
Agreeableness [A]	-0.028	0.023	0.012	0.032	0.007	0.028	0.007	-0.009	0.069	-0.026	0.067	-0.023
	(0.053)	(0.049)	(0.057)	(0.053)	(0.057)	(0.054)	(0.045)	(0.049)	(0.052)	(0.049)	(0.053)	(0.049)
Neuroticism [N]	0.021	-0.076	0.048	-0.062	0.040	-0.068	0.032	0.059	0.037	0.093	0.039	0.102*
	(0.049)	(0.052)	(0.051)	(0.062)	(0.051)	(0.062)	(0.053)	(0.053)	(0.058)	(0.059)	(0.059)	(0.059)
Internal locus of control	0.122**	0.065	0.136**	0.066	0.111*	0.085	0.148***	0.110**	0.134**	0.121**	0.087	0.122**
	(0.053)	(0.053)	(0.066)	(0.058)	(0.063)	(0.058)	(0.054)	(0.052)	(0.060)	(0.058)	(0.062)	(0.058)
External locus of control	0.087*	0.081	0.092*	0.086	0.096*	0.095	-0.013	-0.037	0.026	-0.056	0.019	-0.065
	(0.045)	(0.049)	(0.052)	(0.061)	(0.052)	(0.060)	(0.046)	(0.051)	(0.051)	(0.058)	(0.051)	(0.057)
Respondent's personal preferences and trust												
Risk preference					-0.021	-0.045					0.087	0.055
					(0.053)	(0.060)					(0.053)	(0.054)
Need for achievement					0.073	-0.064					0.146**	0.000
					(0.057)	(0.067)					(0.073)	(0.067)
Interpersonal trust					0.103	0.255**					-0.176*	-0.183*
					(0.124)	(0.109)					(0.105)	(0.105)
Respondent's social-demographic characteristics												
Age (year)			-0.009	0.020***	-0.008	0.019***			-0.029***	0.002	-0.027***	0.002
			(0.006)	(0.006)	(0.006)	(0.006)			(0.006)	(0.007)	(0.006)	(0.007)
Gender (male)			0.142	-0.084	0.144	-0.078			0.321*	0.189	0.310	0.181
			(0.227)	(0.233)	(0.226)	(0.235)			(0.194)	(0.208)	(0.193)	(0.208)
Education (year)			-0.016	0.015	-0.015	0.018			-0.019	0.024	-0.023	0.022
			(0.017)	(0.016)	(0.017)	(0.016)			(0.016)	(0.016)	(0.016)	(0.016)
Household head (1=yes)			0.249	0.118	0.254	0.138			0.402*	0.220	0.377*	0.214
			(0.214)	(0.196)	(0.211)	(0.196)			(0.208)	(0.207)	(0.206)	(0.206)
Household and land characteristics												
Land reallocated before (1=yes)			0.011	0.533***	0.012	0.566***			0.102	0.072	0.065	0.051
			(0.157)	(0.160)	(0.155)	(0.161)			(0.140)	(0.138)	(0.141)	(0.138)
Land certificate possession (1=yes)			-0.145	-0.103	-0.138	-0.102			-0.007	-0.020	-0.012	-0.027
			(0.112)	(0.123)	(0.113)	(0.122)			(0.095)	(0.093)	(0.096)	(0.094)

Contract farmland size (mu)			-0.040**	-0.008	-0.040**	-0.009			-0.014	0.020	-0.014	0.021
			(0.019)	(0.017)	(0.019)	(0.016)			(0.016)	(0.016)	(0.017)	(0.017)
Number of contracted land plots			-0.023	-0.158***	-0.022	-0.157***			-0.043	-0.024	-0.042	-0.026
			(0.041)	(0.037)	(0.041)	(0.037)			(0.030)	(0.033)	(0.031)	(0.033)
Number of laborers			0.127***	0.021	0.125***	0.022			0.110***	0.027	0.107**	0.027
			(0.044)	(0.041)	(0.043)	(0.041)			(0.041)	(0.043)	(0.042)	(0.043)
Number of elders			-0.133	0.131*	-0.136	0.128			0.023	-0.003	0.016	0.003
			(0.108)	(0.077)	(0.107)	(0.079)			(0.096)	(0.083)	(0.096)	(0.083)
Number of students			-0.061	-0.057	-0.060	-0.045			0.107***	0.021	0.098**	0.016
			(0.044)	(0.054)	(0.045)	(0.054)			(0.041)	(0.047)	(0.042)	(0.047)
Family laborers work off-farm (%)			0.109	0.629**	0.104	0.682***			-0.247	0.042	-0.313	0.018
			(0.268)	(0.246)	(0.271)	(0.248)			(0.253)	(0.276)	(0.254)	(0.280)
Credit accessibility (1=yes)			0.110	0.068	0.113	0.096			0.399***	0.293**	0.371***	0.275**
			(0.141)	(0.129)	(0.141)	(0.129)			(0.129)	(0.128)	(0.127)	(0.128)
Household rented land (1=yes)	-	-	-	-	-	-			0.866***	0.277	0.866***	0.283
									(0.139)	(0.175)	(0.140)	(0.174)
Household rented-out land (1=yes)	-	-	-	-	-	-			-0.061	0.587***	-0.038	0.605***
									(0.161)	(0.133)	(0.161)	(0.132)
Village characteristics												
Distance to county centre (km)			-0.004	0.011	-0.004	0.011			0.004	-0.014**	0.004	-0.014**
			(0.009)	(0.010)	(0.009)	(0.010)			(0.006)	(0.006)	(0.006)	(0.007)
Distance to township centre (km)			-0.042	-0.026	-0.042	-0.027			0.011	-0.002	0.009	-0.002
			(0.029)	(0.037)	(0.029)	(0.036)			(0.020)	(0.021)	(0.020)	(0.021)
Distance to highway (km)			-0.010	-0.009	-0.011	-0.009			0.013	-0.004	0.012	-0.003
			(0.012)	(0.015)	(0.012)	(0.014)			(0.008)	(0.005)	(0.008)	(0.006)
Distance to food market (km)			0.034**	-0.019	0.035**	-0.019			0.004	-0.005	0.005	-0.006
			(0.015)	(0.020)	(0.015)	(0.020)			(0.009)	(0.013)	(0.009)	(0.013)
Township government (1=yes)			-0.133	0.222	-0.125	0.223			-0.115	0.057	-0.118	0.049
			(0.214)	(0.234)	(0.212)	(0.233)			(0.169)	(0.196)	(0.169)	(0.196)
Village merged before (1=yes)			-0.417	-0.207	-0.401	-0.208			-0.228	-0.062	-0.192	-0.068
			(0.265)	(0.340)	(0.268)	(0.323)			(0.382)	(0.221)	(0.366)	(0.220)
Farmland size per capita (mu)			0.150	0.418**	0.151	0.420**			0.081	-0.091	0.076	-0.097
			(0.130)	(0.178)	(0.129)	(0.175)			(0.116)	(0.118)	(0.117)	(0.119)
Number of family clans in the village			0.017	-0.043	0.014	-0.045			0.080*	0.098**	0.080*	0.100**
			(0.064)	(0.062)	(0.064)	(0.061)			(0.043)	(0.045)	(0.044)	(0.045)
County dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	2,119	1,912	1,912	2,119	1,912	1,912	2,119	1,912	1,912	2,119	1,912	1,912

Notes: (1) Robust-clustered standard errors in parentheses, * p<0.1. ** p<0.05. *** p<0.01. (2) Number of observations varies as data on village characteristics are missing for some villages.
(3) Autarkic households are set as the base outcome.

Chapter 4 Economic preferences, personality traits, and fertilizer application: Evidence from rice farmers in eastern China[31]

Abstract: Negative externalities associated with the inappropriate use of fertilizers by rural smallholders are a growing concern in many countries. This paper contributes to the literature by examining factors that influence farmers' fertilizer use decisions. We test testing whether risk and time preferences and personality traits are associated with Chinese rice farmers' use of synthetic and organic fertilizers. We rely on survey data collected from 815 farm households in three rice-producing provinces in eastern China to empirically estimate a reduced-form and a two-stage probit least squares model. We find that risk seeking and patience are positively associated with the application of organic fertilizer in rice production, while the use of synthetic fertilizer is not significantly associated with the economic preference measures. There is no significant association between personality traits and (synthetic or organic) fertilizer use. The insights gained by this study can provide important inputs for designing policies aimed at promoting sustainable agricultural intensification in China and elsewhere.

Keywords: fertilizer use; risk preference; time preference; personality traits; farmers; China

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4.1 Introduction

Agricultural production in Asian countries grew dramatically in the last few decades to fulfill the rising domestic and global demand (Huang et al., 2017; FAOSTAT, 2018). This development, however, has also brought obstacles to countries like China that pursue a transition towards a more sustainable agricultural system. For example, China is the largest user of synthetic nitrogen fertilizer in the world, but its efficiency of nitrogen fertilizer use is relatively low (Wang et al., 2018; Wu et al., 2019). Much of the applied nutrients is not absorbed by the soil but discharged into the water system, which generates serious adverse externalities to the environment (NBSC, 2015; Carter et al., 2012). This low nitrogen use efficiency is also detrimental to farmers' economic profit (Huang et al., 2012). An additional cause of environmental pollution in China is the inadequate management of organic waste from livestock farms (Chadwick et al., 2015). The average manure-recycling ratio is lower than 40% in China, indicating that more than half of the manure nutrients are lost (Gu et al. 2017; Jin et al., 2020). Although manure and other types of organic fertilizers, like crop residues or compost, help to preserve the quality of the soil and thus maintain a profitable production over the mid- or long-term (Chadwick et al., 2015), in China organic fertilizer is used rather infrequently, which is partly explained by the relatively low share of crop farmers who also produce livestock (Smith & Siciliano, 2015; Zhang et al., 2019).[32]

Given the environmental concerns related to high and inefficient fertilizer use, the central government of China has initiated a series of policies, such as the "Zero-growth of Synthetic Fertilizer Application" policy from 2015 and the "Livestock and Poultry Manure Utilization" policy from 2017. These policies aim to encourage the recycling of animal waste for land fertilization (MARA, 2015; 2017). However, despite some progress, the fertilizer use intensity in China is still almost three times that of high-income countries on average (World Bank, 2021). Additionally, organic fertilizer use in Chinese crop production remains low (Jin et al., 2020). These facts suggest two puzzling questions: Why do Chinese farmers rely so heavily on synthetic fertilizer? And why do they use organic fertilizer so infrequently?

The extant literature suggests that farm characteristics (Tan et al., 2008; Zhou et al., 2010), household and farmer characteristics (Han & Zhao, 2009; Smith & Siciliano, 2015), and markets and policies

[32] The share of rural households that both plant crop and raise livestock declined from 71% in 1986 to only 12% in 2017 (Jin et al., 2020). There is some limited evidence that manure markets have developed at a small scale between particular animal and arable farm types in specific regions, while more broad-based development of markets for processed and unprocessed animal manure is needed to stimulate farm use of organic fertilizer (Yan et al., 2017).

(Li et al., 2012; Ni, 2013) can explain farmers' fertilizer-use decisions. Recent research also suggests that individual-specific characteristics, such as economic risk and time preferences, may explain the adoption or use of fertilizer (Khor et al, 2018; Knight et al., 2003; Le Cotty et al., 2018).

Farmers' risk attitudes may play a role because fertilizer-use is commonly associated with a variety of uncertainties, such as unclear quality and effectiveness of synthetic fertilizer. Time preference may influence farmers' fertilizer-use decisions as fertilizer can be considered an investment good for which farmers need to spend money or time, or both, before reaping benefits at a later point in time. However, the results of studies on the associations between fertilizer use and risk and time preferences are inconclusive, and most research is conducted in countries where the uptake of synthetic fertilizer is relatively low, such as Burkina Faso and Ethiopia (Knight et al., 2003; Le Cotty et al., 2018). Little evidence is documented on the associations between fertilizer use and risk and time preferences in countries where synthetic fertilizer has been widely adopted and even excessively used by farmers for years such as China. One exception is the study by Khor et al. (2018), which finds that risk-aversion may lead to a lower fertilizer use intensity among low-wealth farmers in Vietnam.

Furthermore, personality characteristics, such as polychronicity,[33] passion, and optimism, have been linked to farmers' adoption decisions and efficiency of input use in Ghana (Ali et al., 2019). Behavioral economists and economic psychologists suggest that personality traits can complement economic preference measures in explaining behavior or decisions of economic agents (Almlund et al., 2011; Becker et al., 2011; Borghans et al., 2008). This implies that considering personality traits in addition to economic preferences can enrich the analysis of farmers' use of fertilizer.

This study adds to the literature on the determinants of fertilizer use decisions by investigating the associations between farmers' risk and time preferences, personality traits, and the use of synthetic and organic fertilizers in China. We build a theoretical framework based on household utility maximization and test it on a survey data set of 815 farmers from three important rice-producing provinces in Eastern China. The data set contains rich information about farm fertilizer applications, including the intensity of synthetic fertilizer use and whether the farm uses organic fertilizer. The data set also contains measures of farmers' risk and time preferences and personality measures. We first conduct a reduced-form analysis to test whether risk and time preferences are associated with the

[33] Polychronicity is a psychological characteristic, referring to people's preference to work on multiple tasks at the same time rather than doing one thing at a time.

amount of synthetic fertilizer use and whether a farmer uses organic fertilizer. We then explore whether personality traits moderate associations between risk and time preferences and (synthetic and organic) fertilizers use. Next, we consider that synthetic and organic fertilizers may to a certain extent be substitutes in crop production and use a two-stage probit least squares model to examine the same associations considering that the two forms of fertilizer may be substitutes.

The remainder of the paper is structured as follows. Section 2 presents the conceptual framework. The data set and the empirical methods are described in Section 3. Section 4 presents the results and Section 5 presents a discussion and conclusion.

4.2 Theoretical framework

In this section, we present a theoretical framework for the relationships of risk and time preferences and personality traits with farmers' fertilizer use behaviour. We first consider an intertemporal farm household model to describe farmers' fertilizer-use decisions under risk in general. Then, we further conceptualize how risk and time preferences and personality traits may affect the use of synthetic and organic fertilizers in China with more details, summarized in an integrated framework.

4.2.1 The role of risk and time preferences for fertilizer use decisions

To conceptualize the roles of risk and time preferences in farmers' fertilizer use decisions, we consider an intertemporal farm household model (Le Cotty et al., 2018). In the model, a representative farmer maximizes the sum of the discounted utility over two periods within a single season of crop production. Period 1 is the planting period, in which the farmer allocates all initial wealth to either fertilizer investment F, or a composite good c_1 which reflects "everything else". Investments in fertilizer in period 1 are necessary to obtain an agricultural profit in the harvest period 2. In other words, the cost of purchasing the fertilizer precedes its benefits in time. Following Le Cotty et al. (2018), credit access and savings are not taken into consideration for simplicity. We further assume that the farmer consumes all agricultural production c_2 in the second period, and maximizes the following isoelastic utility function:

$$Max\ U = \frac{c_1^{1-\gamma}}{1-\gamma} + \frac{1}{1+r}\frac{c_2^{1-\gamma}}{1-\gamma}, \tag{2.1}$$

where U is the expected discounted utility of the farmer which is assumed to be time separable with a constant relative risk aversion (CRRA) parameter γ ($\gamma \neq 1$). Discounting is represented by the discount rate r. Given the assumptions mentioned above, utility is maximized subject to the following constraints:

$$c_1 + p_f F = W_0, \tag{2.2}$$

$$c_2 = AF^{\alpha}, \tag{2.3}$$

where W_0 is the initial wealth of the farm and p_f is the price of fertilizer input. c_1 is the farmers' consumption in the planting period (period 1) and c_2 denotes the farmers' consumption in the harvest season (period 2), which is equivalent to the agricultural produce of the farm. We assume agricultural produce to be the numéraire good with a price of 1 and that the production function satisfies a Cobb-Douglas specification with decreasing returns to scale. For reasons of simplicity, we consider only fertilizer use F as the input factor (with other inputs fixed), A is the total factor productivity, and α is the output elasticity of fertilizer use ($\alpha < 1$).

Substituting c_1 and c_2 into equation (2.1), and taking the setting the first derivative of the utility function with respect to F to zero gives the following first order condition:

$$\frac{\partial U}{\partial F} = \left(-p_f\right)\left(W_0 - p_f F\right)^{-\gamma} + \frac{1}{1+r}\left(AF^{\alpha}\right)^{-\gamma}\left(\alpha AF^{\alpha-1}\right) = 0. \tag{2.4}$$

By rearranging equation (2.4), we obtain the following equation:

$$\frac{p_f(1+r)}{\alpha A^{1-\gamma}} = \frac{\left(W_0 - p_f F\right)^{\gamma}}{F^{1+\alpha\gamma-\alpha}}. \tag{2.5}$$

In equation (2.5), the left-hand side increases with the time preference parameter r, while the right-hand side decreases with respect to fertilizer use F, holding other parameters constant.[34] In other words, equation (2.5) implies that fertilizer input F is monotonically decreasing with respect to the discount rate r:

[34] If the left-hand side increases due to the increase of r, holding all other parameters constant, the right-hand side also has to increase, which is only possible if F decreases.

$$\frac{\partial F}{\partial r} < 0. \tag{2.6}$$

This suggests that more patient farmers use more fertilizers in period 1. The available empirical literature supports this presumption. Duflo et al. (2011) find that the lack of synthetic fertilizer application in Kenya may be partly driven by farmers' time-inconsistency and procrastination. Le Cotty et al. (2018) find that farmers with higher patience in Burkina Faso tend to use more fertilizer in the planting period. Time preferences may affect in particular the use of organic fertilizer, because organic fertilizer generally requires 3 to 5 years to produce its positive effects on crop yields and soil quality improvements (Jacoby et al., 2002). This suggests that more patient farmers apply more fertilizer, and particularly more organic fertilizer, as compared to less patient farmers.

The relationship between risk preference and fertilizer use in equation (2.5) is non-trivial and the empirical literature on this relationship produces mixed findings as well (Khor et al., 2018; Roosen & Hennessy, 2003; Sheriff, 2005; Stuart et al., 2014). Some studies find that a higher level of risk seeking is positively associated with farmers' intensity of synthetic fertilizer use when the fertilizer is seen as a risk-increasing input for farm incomes, in particular when the quality of fertilizers is uncertain (Khor et al., 2018; Roosen & Hennessy, 2003). Other research, however, suggests that risk averse farmers tend to use more synthetic fertilizer to secure yields (Sheriff, 2005; Stuart et al., 2014). Generally, farmers are usually not able to forecast their future income with high precision due to risk factors such as market price volatility, weather variability, and soil erosion (Babcock, 1992; Dercon & Chiristiaensen, 2011). Risk preference may be relevant for the decision to use organic fertilizer as well. Applying organic fertilizer may introduce weeds and pests (Zhang et al., 2020), resulting in volatile yield (Khaliq et al., 2006; Moe et al., 2019). The benefits of combining synthetic and organic fertilizers, such as the increased organic carbon content in the soil which increases crop yields in the long run (Dick & Gregorich, 2004), may be unclear and considered as uncertain by a farmer. In addition, adopting organic fertilizer may involve the risks arising from potential losses during transportation and storage of organic manure (Zhang et al., 2019).[35] This would suggest that risk averse farmers are less likely to use organic fertilizer.

4.2.2 Personality traits and fertilizer use

[35] Organic fertilizer can either be obtained by purchasing from the input markets or produced by farm households themselves using labor, which is valued at the prevailing (shadow) wage rate (Shi et al., 2011).

While risk and time preferences are key components in the economic analysis of economic actors, personality traits are crucial concepts in personality psychology (Goldberg, 1990; Golsteyn & Schildberg-Hörisch, 2017). Personality traits typically refer to the underlying patterns of individual thinking, feelings, and behaving, which are partly biologically determined and relatively stable for people in adulthood. Personality traits can help explain the heterogeneity in behaviour across individuals and groups in many circumstances (Roberts, 2006; 2009; Srivastava et al., 2003). The most prominent model of personality traits is the *Big Five Model*, which distinguishes five broad dimensions: openness to experiences, conscientiousness, extraversion, agreeableness, and neuroticism (Costa & McCrae, 1992).[36]

In theory, individual differences in personality traits can also explain variation in the behaviour of farmers in areas such as technology adoption, rural-urban migration, land rentals, and fertilizer use decisions (Ali et al., 2019; Ayhan et al., 2020; Fouarge et al., 2019; Qian et al., 2020). For example, farmers with low levels of openness to experience may prefer conventional over innovative agricultural production methods (Qian et al., 2020). Conscientious farmers may be more likely to apply organic fertilizer in combination with synthetic fertilizer to improve the growing conditions of crops. Farmers with higher levels of agreeableness have been observed to care more about the environment and consume more pesticide-free products (Westjohn et al., 2012). Similarly, they may also apply less synthetic fertilizer to reduce the pollution it generates or be more likely to use organic fertilizer. To our knowledge, there is no empirical evidence so far on the associations between personality traits and fertilizer use neither in China nor in other parts of the world.

The relationship between personality traits and economic preferences has not been intensively studied until recently. Some studies such as Borghans et al. (2009) find that risk preferences relate to most dimensions of the Big Five model; other studies, such as Daly et al. (2009), find that time preferences are associated with conscientiousness and extraversion. These findings imply the possibility that personality traits may mediate the relationships between risk and time preferences and fertilizer use decisions. But other studies find no significant evidence that economic preferences and personality traits are strongly related to each other (Becker et al., 2012; Rustichini et al., 2016). Becker et al. (2012) suggest that personality traits may be used as a complement to economic preferences in the analysis

[36] Openness to experience is a trait that describes a person's degree of being creative, imaginative, and original. Conscientiousness characterizes a person's degree of organization, persistency, and responsibility. Extraversion reflects an individual's tendency to be positive, enthusiastic, and social. Agreeableness links to the friendliness, altruism, and cooperation. Neuroticism is associated with negative emotions such as anxiety, depression, and negative affect (John & Srivastava, 1999).

of inter-individual differences, while Benischke et al. (2019) find that certain personality traits may moderate the effect of risk preference on behaviour. All these studies suggest that the potential role of personality traits in the relationship between risk and time preferences on the one hand and fertilizer use on the other hand should not be neglected.

4.2.3 An integrated framework

Although we focus on risk and time preferences and personality traits in this paper, various other factors influence fertilizer decisions of farmers. These factors can be organized in four domains: household possessions of assets, household characteristics, inputs and output prices, and other external factors. Following the Sustainable Livelihood Strategies Approach, five main types of assets determine how rural households operate farms: natural, physical, financial, human, and social assets (DFID, 2000; Ellis, 2000). Natural assets (e.g., size of arable land) have been associated with fertilizer use efficiency (Coady, 1995; Tan et al., 2008); physical assets (e.g., possession of machinery) and financial assets (e.g., access to credit or savings) have been linked with fertilizer adoption in low-income countries (Dercon & Christiaensen, 2011; Liverpool & Winter-Nelson, 2010); social assets (e.g., social networks of a household) and human assets (e.g., number, age, and education of laborers in the household) are also important factors affecting fertilizer use decisions (Huffman, 2001). In this paper's empirical analysis, we view these assets as exogenous to fertilizer-use decisions as they are likely to remain unchanged or change at a very slow rate over time. Hence, we include these factors as control variables in the regressions.

Second, some characteristics of rural households (e.g., how many children and elderly members live in a household) can influence the decisions farmer households make. If markets were perfect, we would expect that these characteristics only affect the household's consumption decisions. However, if major market imperfections exist, also agricultural production decisions are influenced by household characteristics (de Janvry & Sadoulet, 1995; 2006). We therefore control for the household dependency ratio (i.e., the share of children and elderly members in a household).

Third, production theory suggests that output prices and variable input prices affect fertilizer use decisions in different ways. Higher prices of outputs and (non-complementary) variable inputs are expected to have positive effects on fertilizer use, whereas a higher price of fertilizer itself is expected to have a negative impact. As such, we include input and output prices in our statistical analysis.

Last, besides farm assets, household characteristics, and inputs and output prices, we also control for other prevailing external factors (e.g., agro-ecological conditions, rural institutions, and policies) that have been shown to be relevant in previous research (Kuiper, 2005; Hong et al., 2020).

Figure 4.1 graphically presents the variables that we include in our empirical analysis. Farmers' synthetic and organic fertilizer use decisions, presented in the centre of the framework and marked in grey, are the key outcome variables. Risk and time preferences and personality traits are the central focus of our study and are shown at the left-hand side of the figure. The solid arrows indicate potential relationships between each box. The dashed arrow indicates potential moderation or mediation effects.[37] Exogenous factors are shown in the box on the right-hand side of the figure. We do not include household decisions that are made jointly with fertilizer use decisions, such as land rentals, labor hiring, use of machinery services, off-farm employment, or food consumption, in the model. Instead, we only include variables that are unlikely to be influenced by the fertilizer use decisions and focus our analysis on the reduced-form relationships. Hence the estimated effects represent the total effects, i.e., the direct effects plus the indirect effects going through other household decisions, of the exogenous variables on fertilizer use decisions.

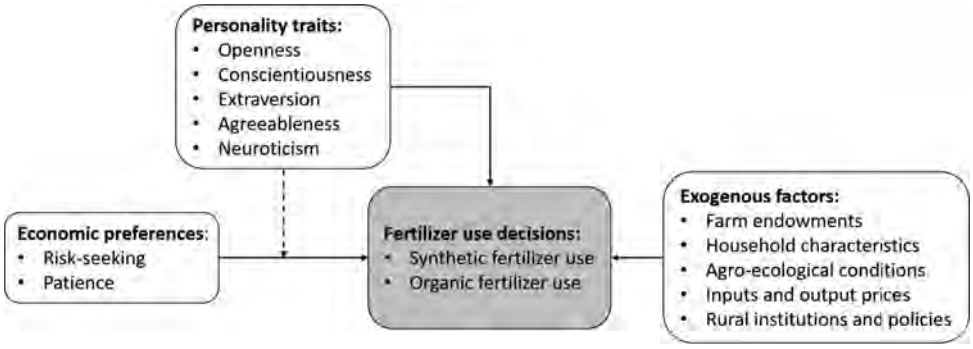

Figure 4.1. Graphic presentation of the conceptual framework for fertilizer-use decisions

[37] In this study, we assume that economic preferences are the core deep measures concerning individual differences and empirically test the potential moderating role of personality traits. However, we acknowledge that one could alternatively view personality traits as the deepest measure (Borghans et al., 2009; Daly et al., 2009).

4.3 Data

4.3.1 Data set

This study uses data collected through a large farm household survey that was conducted in three important rice-producing provinces in eastern China in February 2019. The primary goal of the survey was to assemble information on farmland rentals and resource management among rice farmers. The three provinces were chosen to represent northern (Liaoning), central (Jiangsu), and southern (Jiangxi) parts of eastern China. The collected data contains rich information about rural households' family composition, agricultural production in the 2018 crop season, and a range of other indicators including individual preferences and personality traits.

A multi-stage stratified sampling strategy was applied to yield the sample of households participating in the study. By consulting local policy makers, 2 counties differing in geographical location and economic development levels were selected within each province. Within each county, all townships were sorted based on their per capita arable land and 5 counties were determined using the systematic sampling method. Similarly, 4 villages were chosen in each township. Within each selected village, households were classified into three groups (stratums): renting-in, renting-out, and autarkic households. In each stratum, 4 households were randomly selected for the interviews.[38] A total of 1,420 rural households living in 120 villages were thus included.[39] Within each household, the household head was invited to answer the survey. If the household head was absent, the household member being responsible for agricultural decision making was interviewed instead.[40] For the purpose of this study, we focus on households primarily producing rice and exclude 389 households who did not produce agricultural output, 195 households who did not grow rice as their major agricultural output, and 21 observations with missing information. Thus, our analysis is based on 815 rice-producing farm households.

4.3.2 Measures

The survey measured synthetic fertilizer-use (in kg/mu) as the total amount of active chemical ingredients per unit land, obtained by adding up pure nitrogen, phosphate, and potassium (NPK) (in

[38] A small portion of households both rented in and rented out farmland at the same time. These households were classified as either renting-in or renting-out, depending on which type of renting activity dominated in terms of land size.
[39] The total number of households renting in or renting out land was less than four in some of the selected villages. As a result, 1,420 households instead of 1,440 were interviewed in total.
[40] For 90.8% of these households, the household head responded to the survey.

kilogram) and dividing it by the sown area (i.e., total area that farmer grows rice on) (in mu).[41] The survey includes a dichotomous variable for organic fertilizer use, equalling 1 if a farmer used any type of organic input (purchased organic fertilizer, animal manure, compost, green manure, etc.) and equalling 0 otherwise. The data set does not differentiate between the different types of organic fertilizer.

Following Falk et al. (2018), participants' risk and time preferences were elicited using survey measures which combine quantitative and qualitative survey questions that are highly correlated with preferences measured in incentivized and more detailed lab-experiments. The main benefit of this approach is that the survey measures can be used in the field to robustly measure economic preferences even when time constraints and other resource constraints do not allow conducting detailed, incentivized experiments (Falk et al., 2016; 2018). Moreover, using these measures allows us to compare of the preferences across studies (e.g., Fuhrmann-Riebel et al., 2020; Lades et al., 2021). For instance, the time-preference measure combines hypothetical choices between receiving an early payment and five different larger delayed payments with a (qualitative) question about the willingness to delay the benefit of consuming something today until someday in the future (using a 10-point scale). For each preference measure, we first calculated the z-scores of the quantitative and qualitative survey items at the individual level and then weighted the quantitative and qualitative items based on the weights obtained from an experimental validation procedure presented by Falk et al. (2016). We finally standardized this weighted average score to obtain preference variables with zero means and standard deviations equal to one. A higher value of the risk preference variable indicates a greater level of risk-seeking tendency, and a higher value of the time preference variable indicates a greater level of patience.

Respondents' personality traits were measured using the Chinese version of the BFI-10 on a 5-point Likert-type scale. The BFI-10 shows acceptable psychometric properties (measurement validity and reliability) and thus is a suitable instrument to assess respondents' personality traits for economic analysis when data collection time is limited (Carciofo et al., 2016; Rammstedt & John, 2007). The BFI-10 inventory has been commonly used in other economic studies (Donato et al., 2017; Qian et al., 2020).

[41] 1 mu=0.067 ha.

We used farm household's contracted land size and the number of contracted land plots as indicators of farm household's natural assets.[42] Productive asset endowment and livestock endowment were used as indicators of physical assets. The productive asset endowment was obtained by adding up the monetary values of various types of machinery, including tractors, harrows, sowers, pesticide sprayers, irrigation pumps, and harvesters. The livestock endowment was represented by a binary variable that indicates whether a household owns livestock assets or not. These physical assets may also reflect financial assets, as they often serve as a source of self-insurance and liquidity for financially constrained household (Marenya & Barrett, 2009). We also included a binary variable indicating household's access to credit as an additional measure for financial assets. The total number of laborers in the household, the share of female laborers, and age and education of the household head were included as indicators of human assets. Lastly, we proxied social assets by a binary variable indicating if any of the household members was a township or village cadre (i.e., administrative officials).

In terms of household characteristics, we included the household level dependency ratio, defined as the share of household members aged over 65 or under 16 years. We measured the output price of rice by the reported price in the local currency at which rice output was sold. Variable input prices collected in the survey include the prices paid for synthetic fertilizer, seeds, and pesticides. We calculated the synthetic fertilizer (NPK) price by adjusting the price a farm household paid for the synthetic fertilizer for the NPK content of the reported fertilizer types.[43] We proxied the seed prices and the pesticide prices by their total costs per unit of arable land, because the data set does not contain information on the prices paid per kg or litre. We also included a binary variable for double-season rice to take into account that farmers growing rice twice a year use higher levels of fertilizers than farmers growing a single rice crop.

4.4 Empirical approach

4.4.1 Multivariate regression analysis

To test whether risk and time preferences predict Chinese farmers' fertilizer-use decisions, we first conducted a multivariate regression analysis of the factors affecting synthetic fertilizer (SF) and organic fertilizer (OF) use:

[42] In rural China, arable land is allocated by the village committee to farm households living in the village. Farm households do not own this so-called contracted land but are granted long-term use rights to it.
[43] The information about the NPK content is available on the package bags of fertilizer purchased by a farm household.

$$SF_{ij} = \alpha_0 + \alpha_1 RS_{ij} + \alpha_2 P_{ij} + \alpha_3' OCEAN_{ij} + \alpha_4' Z_{ij} + \varepsilon_{ij}^{SF}, \quad (3.1)$$

$$OF_{ij} = \beta_0 + \beta_1 RS_{ij} + \beta_2 P_{ij} + \beta_3' OCEAN_{ij} + \beta_4' Z_{ij} + \varepsilon_{ij}^{OF}, \quad (3.2)$$

where SF_{ij} and OF_{ij} are the two key outcome variables in the model, representing the synthetic fertilizer use intensity and the adoption of organic fertilizer of farm household i residing in village j, respectively. RS_{ij} and P_{ij} represent the measures for risk seeking and patience, respectively. $OCEAN_{ij}$ is a vector of the Big-Five personality traits. Z_{ij} is a vector of control variables, including farm endowments, prices of rice output and variable inputs, and household characteristics; it also includes province dummy variables to account for differences in external factors that may play a role and tend to be relatively similar within the same province, such as agro-ecological conditions and rural institutions and policies. A log-transformation is applied to the productive asset endowment variable as its distribution resembles a lognormal distribution.[44] ε_{ij}^{SF} and ε_{ij}^{OF} are village-clustered robust error terms. We estimate equation (3.1) using ordinary least squares (OLS) regressions and equation (3.2) using probit regressions because SF_{ij} is a continuous variable and OF_{ij} is a binary variable. As explained in Section 2.4, we do not include household decisions that are made jointly with fertilizer use decisions in the regression models, but focus on the reduced-form equations. This means that the regression results for the key variables should be interpreted as estimates of their total impact on fertilizer use decisions, i.e., the sum of their direct effects plus their indirect effects through the omitted household decision variables (such as land rentals, labor hiring, or use of machinery services).

Furthermore, the effects of risk and time preferences on fertilizer use may also depend to some extent on the specific personality traits of farmers. To examine these potential trait-specific moderation effects of economic preferences, we estimate regression models that include the interaction terms of preferences and personality traits. Since we have two economic preference measures and five personality traits, we estimate ten models containing an interaction term as an additional explanatory variable for each fertilizer use variable.

4.4.2 Two-stage probit least squares model

The multivariate regression analysis described above does not consider that farmers' decisions on synthetic and organic fertilizer use may be related to each other. To some extent, however, nutrients provided through synthetic and organic fertilizers can substitute each other. But organic fertilizer also

[44] We used the method suggested by (Battese, 1997) to deal with zero values of productive asset endowments.

provides soil organic matter (SOM) and soil microorganisms that are not supplied by synthetic fertilizer; hence, synthetic and organic fertilizers may also be complementary (Conway & Barbier, 2013; Holden & Lunduka, 2012; Koning et al. 2001).[45] Potential interactions between both dependent variables can be taken into account by estimating the following two simultaneous equations:

$$SF_{ij} = \alpha_0 + \alpha_1 OF_{ij} + \alpha_2 RS_{ij} + \alpha_3 P_{ij} + \alpha_4' OCEAN_{ij} + \alpha_5' Z_{ij} + \varepsilon_{ij}^{SF}, \quad (3.3)$$

$$OF_{ij} = \beta_0 + \beta_1 SF_{ij} + \beta_2 RS_{ij} + \beta_3 P_{ij} + \beta_4' OCEAN_{ij} + \beta_5' Z_{ij} + \varepsilon_{ij}^{OF}, \quad (3.4)$$

where equation (3.3) includes organic fertilizer use and equation (3.4) synthetic fertilizer use as explanatory variables. Since the intensity of synthetic fertilizer is a continuous variable and the adoption of organic fertilizer is a binary variable, we employed the two-stage probit least square (2SPLS) approach to estimate this model (Keshk et al., 2003; Maddala, 1983). In the first stage of the 2SPLS approach, OLS and probit regressions are used to estimate equations (3.1) and (3.2), respectively, and to derive predicted values of the dependent variables. In the second stage, the endogenous explanatory variables OF_{ij} in equation (3.3) and SF_{ij} in equation (3.4) are replaced by the predicted values, $\widehat{OF_{ij}}$ and $\widehat{SF_{ij}}$, from the first stage. The standard errors of the equations in the second stage are corrected by a recalculation approach following Keshk (2003).

To identify the simultaneous equation system, at least one independent variable, the so-called excluded instrument(s), must be included in one of the equations but not in the other. In equation (3.3), we use the synthetic fertilizer (NPK) price for this purpose. It is expected to have a direct effect on synthetic fertilizer use intensity, but not on the use of organic fertilizers. In equation (3.4), the ownership of livestock asset serves a similar purpose. Owning livestock is strongly related to the use of organic manure, but is not likely to affect the amount of synthetic fertilizer use directly (Koppmair et al., 2017; Place et al., 2003). An F-test on the excluded instruments in the first stage of the estimation can be used to test for weak instruments, i.e., excluded instruments that are only weakly correlated with the endogenous variables.

[45] Preserving adequate amount of SOM in a long run can contribute to a lower level of nitrogen (N) loss, being essential for sustainable agricultural production (Duan et al., 2016).

4.5 Results

4.5.1 Descriptive analysis

Table 4.1 presents the descriptive statistics of the outcome and independent variables. It shows that all sampled farm households used synthetic fertilizer in their crop production. On average, farm households applied 31.84-kilogram synthetic (NPK) fertilizer per mu (i.e., 477.6 kg per ha) of arable land at a mean price of 5.33 yuan per kilogram (i.e., about 0.8 USD per kilogram).[46] Only 8 percent of the households used organic manure. Farm households in the sample were on average endowed with 7.99 mu (i.e., 0.53 ha) of arable land, spread over 4.43 plots on average. This data shows that farm sizes were small and fragmented. The average number of laborers within a farm household corresponded to 2.92, and 34 percent of them were female. There was large variation between the interviewed households in the ownership of productive assets, with some households owning zero and others owning up to two-million-yuan worth of these assets. About 19 percent of households owned livestock on farm. Interviewed farmers were mainly male, on average 58.40 years old, and varied greatly in the number of years of schooling (between 0 and 18 years; 6.63 years on average).

[46] One CNY corresponded to approximate 0.15 USD in February, 2019.

Table 4.1. Descriptive statistics

Variable of interest	N	M	SD	Min	Max
Fertilizer use (outcome variables)					
Synthetic fertilizer (NPK) input intensity, kg/mu	815	31.84	12.38	3.97	94.28
Organic manure, 1=yes	815	0.08	0.28	0	1
Preference and Personality traits					
Risk preference (Risk seeking)	815	0	1	-1.02	2.12
Time preference (Patience)	815	0	1	-1.14	1.41
Openness	815	3.02	1.01	1	5
Conscientiousness	815	4.14	0.79	1	5
Extraversion	815	3.92	0.91	1	5
Agreeableness	815	3.93	0.73	1	5
Neuroticism	815	2.33	0.89	1	5
Control variables					
Contracted land size, mu	815	7.99	6.19	0	60
Number of contracted plots	815	4.43	4.05	0	38
Owning productive asset, 1=yes	815	0.55	0.50	0	1
Productive asset value, thousand yuan	815	45.02	184.10	0	2065.00
Owning livestock, 1=yes	815	0.19	0.39	0	1
Credit access, 1=yes	815	0.24	0.42	0	1
Total family laborers	815	2.92	1.36	0	8
Share of female laborers	815	0.34	0.17	0	1
Household head age, years	815	58.40	8.94	27	87
Household head gender, 1=female	815	0.04	0.19	0	1
Household head education, years	815	6.63	3.21	0	18
Household member as cadre, 1=yes	815	0.11	0.31	0	1
Household dependency ratio	815	0.28	0.28	0	1
Price of rice, yuan/kg	815	2.52	0.34	1.46	5.00
Price of NPK fertilizer, yuan/kg	815	5.33	0.90	2.40	8.63
Costs of seeds, yuan/mu	815	92.44	62.72	1.50	320
Costs of pesticides, yuan/mu	815	87.26	62.64	0.07	300
Double-season rice, 1=yes	815	0.24	0.43	0	1

Note: 1 mu=0.067 ha.

Figure 4.2 presents the zero-order correlation matrix heatmap of the key variables in the analysis, i.e., the two measures of economic preferences, the five measures of personality traits, and the two measures of farmers' fertilizer use. The warmer the colour of the cells outside the diagonal, the larger the positive correlation; the colder the colour, the larger the negative correlation. The strongest correlation, with 0.33, is between risk preferences (risk-seeking) and time preferences (patience). The correlation coefficients in general are considerably low, indicating that all these variables are sufficiently distinct from each other. All correlations with absolute values equal to or higher than 0.07 are statistically significant at the 5% level. Looking at these significant levels, we find that the use of synthetic fertilizer is not significantly correlated with risk and time preferences nor personality traits, while the use of organic fertilizer is significantly correlated with risk and time preferences.

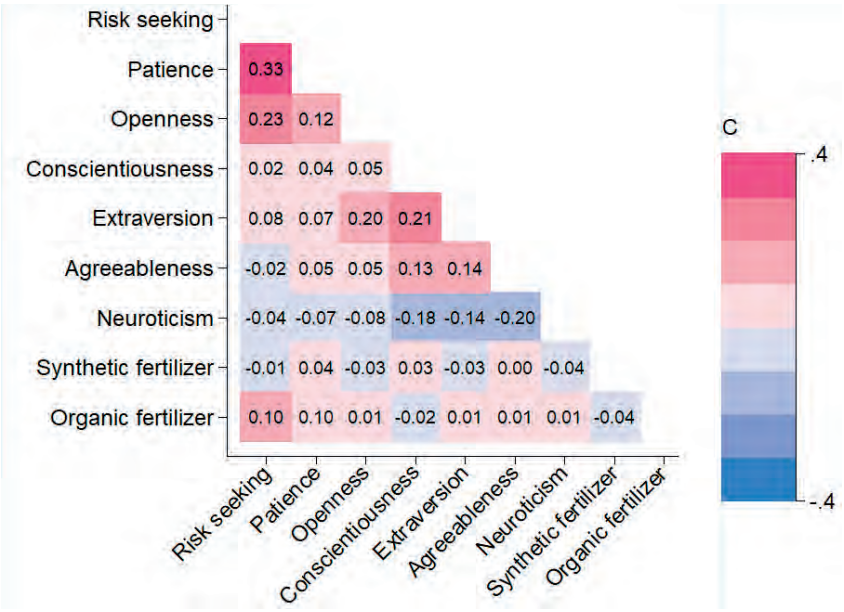

Figure 4.2 Correlation matrix heatmap of economic preferences, personality traits, and fertilizer use behaviour

4.5.2 Multivariate regression results

Estimation results of the multivariate regressions are reported in Table 4.2. Columns (1) – (3) report the results for the intensity of synthetic fertilizers (NPK), and columns (4) – (6) report the results for organic fertilizer use.

Table 4.2 Regression result of economic preference and fertilizer use

	Intensity of synthetic fertilizers use (NPK), OLS			Organic fertilizer use, Probit		
	(1)	(2)	(3)	(4)	(5)	(6)
Risk seeking	-0.524	-0.736	-0.689	0.024**	0.022*	0.023**
	(0.567)	(0.554)	(0.570)	(0.012)	(0.011)	(0.011)
Patience	0.768	0.716	0.675	0.023**	0.022**	0.023**
	(0.592)	(0.566)	(0.576)	(0.011)	(0.010)	(0.010)
Openness			-0.195			-0.003
			(0.366)			(0.011)
Conscientiousness			0.721			-0.006
			(0.478)			(0.010)
Extraversion			-0.315			-0.002
			(0.490)			(0.009)
Agreeableness			-0.124			0.008
			(0.580)			(0.013)
Neuroticism			-0.501			0.006
			(0.471)			(0.012)
Contracted land size, mu		0.002	0.008		-0.002	-0.002
		(0.063)	(0.062)		(0.002)	(0.002)
Number of contracted plots		-0.194	-0.188		0.000	0.000
		(0.152)	(0.152)		(0.002)	(0.002)
Log productive asset value		-0.514*	-0.527*		0.007	0.007
		(0.282)	(0.287)		(0.007)	(0.007)
Zero productive asset		-6.197**	-6.259**		0.037	0.041
		(3.019)	(3.061)		(0.072)	(0.075)
Owning livestock, 1=yes		0.837	0.895		0.069**	0.069**
		(1.027)	(1.038)		(0.028)	(0.028)
Credit access, 1=yes		1.516*	1.457		0.018	0.018
		(0.904)	(0.908)		(0.020)	(0.020)
Total family laborers		-0.225	-0.222		-0.000	-0.000
		(0.334)	(0.335)		(0.008)	(0.008)
Share of female laborers		-8.062**	-7.780**		-0.054	-0.053
		(3.649)	(3.684)		(0.063)	(0.063)
Household head age, years		-0.006	-0.009		0.001	0.001
		(0.062)	(0.063)		(0.001)	(0.001)
Household head gender, 1=female		5.233**	5.154**		0.037	0.039
		(2.537)	(2.521)		(0.065)	(0.065)
Household head education, years		-0.126	-0.118		0.000	0.000
		(0.154)	(0.158)		(0.003)	(0.003)
Household member as cadre, 1=yes		1.527	1.363		-0.019	-0.018
		(1.558)	(1.581)		(0.021)	(0.021)

Household dependency ratio		-3.662*	-3.723*		-0.009	-0.006
		(2.201)	(2.207)		(0.046)	(0.044)
Price of rice, yuan/kg		-0.763	-0.723		-0.016	-0.017
		(1.287)	(1.335)		(0.032)	(0.032)
Price of NPK fertilizer, yuan/kg		-3.076***	-3.130***		0.002	0.003
		(0.602)	(0.597)		(0.009)	(0.009)
Costs of seeds, yuan/mu		0.030***	0.031***		-0.000	-0.000
		(0.009)	(0.009)		(0.000)	(0.000)
Costs of pesticides, yuan/mu		0.018**	0.018**		-0.000	-0.000
		(0.007)	(0.007)		(0.000)	(0.000)
Double-season rice, 1=yes		7.539***	7.469***		0.015	0.015
		(1.945)	(1.957)		(0.036)	(0.034)
Jiangsu Province	1.825	-0.245	-0.324	0.024	0.007	0.010
	(1.374)	(1.410)	(1.430)	(0.034)	(0.029)	(0.031)
Jiangxi Province	1.600	-5.259***	-5.049***	0.052	0.041	0.040
	(1.543)	(1.704)	(1.685)	(0.033)	(0.036)	(0.035)
Constant	30.560***	57.336***	57.991***	–	–	–
	(0.817)	(6.996)	(8.035)	–	–	–
Observations	815	815	815	815	815	815
(Pseudo) R-squared	0.006	0.164	0.168	0.037	0.073	0.076

Note: (1) Robust standard errors in parentheses, * p < 0.1. ** p < 0.05. *** p < 0.01. Average marginal effects are reported in columns (4) – (6).
(2) Variance Inflation Factors (VIF) of all independent variables (except for the province dummies) are calculated to test for the multicollinearity. The mean VIF is 1.28 and the highest VIF value is 2.48, indicating multicollinearity appears not to be an issue in this study.

For both outcome variables, we estimate the regressions in a hierarchical way. Columns (1) and (4) report the results with only risk and time preferences and province dummy variables included as independent variables. Neither risk nor time preference are significantly related to the intensity of synthetic fertilizer use, but they are significantly associated with the use of organic fertilizer ($p<0.05$; joint test of significance p-value=0.001). The estimated coefficients are positive, suggesting that more patient and more risk seeking farmers are more willing to invest in soil quality by adding organic fertilizer. In other words, farmers more willing to take risks are more tolerant to the risk of introducing weeds and pests that may come with the use of organic fertilizers in return for potentially higher yields. The coefficient estimates indicate that a one standard deviation increase in the level of risk-seeking causes a 2.4 percentage points increase in the probability of applying organic fertilizer, while a one standard deviation increase in the level of patience corresponds to a 2.3 percentage points increase.

Columns (2) and (5) show the results when variables representing potentially relevant heterogeneities among farm households are added to the models, and columns (3) and (6) present the results of the models that also include personality traits. Two main conclusions emerge from the results in these columns. First, the estimated effects of economic preferences on organic fertilizer use remain positive and statistically significant when these covariates are added to the model, and their estimated effects on the intensity of synthetic fertilizer use remain insignificant. Second, contrary to our expectations, we do not find significant effects of any of the personality traits on the use of synthetic fertilizer nor on the use of organic fertilizer. It may be noted that the latter finding also implies that personality traits do not serve as mediating variables between risk and time preferences on the one hand and fertilizer use decisions on the other hand.[47]

The results further suggest that some of the control variables do significantly affect synthetic fertilizer use. In particular, smallholders owning productive assets apply significantly more synthetic fertilizer but the quantity declines with the value of those productive assets. Gender aspects seem to play a significant role as well. Households with a higher share of female laborers use significantly less synthetic fertilizer. Households with a female head apply more synthetic fertilizer than households with a male head. A potential explanation of this finding is that female-headed households are more likely to receive remittances when the husband has migrated and works elsewhere (FAO, 2010). As expected, the price of synthetic fertilizer is negatively associated with the use of synthetic fertilizer

[47] Estimation results reported in the Table 4.A1 suggest that personality traits do not predict fertilizer use without controlling for economic preferences or any other control variables. As such, economic preferences cannot mediate these (insignificant) relationships.

while the costs of other variable inputs (i.e., seeds and pesticides) are positively related to synthetic fertilizer use. The size of the contracted land and the number of contracted land plots are not significantly associated with synthetic fertilizer use per mu. Farmers planting double-season rice instead of a single rice crop indeed use significantly more synthetic fertilizer per unit land area. The estimated coefficients suggest that fertilizer use by double-season rice farmers is about 24 percent higher than that of single rice crop farmers. Finally, we find some evidence suggesting that consumption preferences may play a role in the production decisions of the households, as the dependency ratio relates to less use of synthetic fertilizer ($p<0.1$).

As for organic fertilizer use, we do not find significant effects for any of the control variables except livestock ownership. As expected, households owning livestock have a significantly higher probability to use organic fertilizer ($p<0.05$) than households without livestock. This finding suggests that the organic fertilizer used by rice farmers are likely to be recycled from their own livestock manure rather than commercial organic fertilizer purchased through the market.

4.5.3 Moderation analysis results

As a next step, we investigate whether and to what extent personality traits moderate the relationships between risk and time preferences and fertilizer use decisions. As explained in Section 3.3.1, we do this by adding each of the interaction terms between an economic preference and one of the personality traits to the regression model. The models reported in Table 4.2, columns (3) and (6), serve as the basis for this analysis. The results are summarized in Tables 4.A2.1 and 4.A2.2 in the online appendix. They suggest that none of the interaction terms has a statistically significant impact, except for the interaction between risk preference and extraversion in the model explaining organic fertilizer use. However, analysing multiple hypotheses raises the concern that a false positive result would occur (Type-I error). Using a conservative Bonferroni-adjusted p-value to identify significant results (p=0.005), this interaction term is not significant anymore.[48]

4.5.4 Synthetic versus organic fertilizer: are they jointly determined by farmers?

Before the two-stage probit least squares model is estimated, the validity of instruments should first be examined by weak identification tests applied to the first-stage regressions in the two-stage probit least squares (2SPLS) procedure. The F-statistics for the first-stage result of synthetic fertilizer use and organic fertilizer use models are 43.00 and 10.29, respectively, indicating these instrumental variables are not weak given the "rule of thumb" threshold (Staiger & Stock, 1997).[49]

Table 4.3 reports the estimated coefficients for the simultaneous Eqs. (3.3) and (3.4) using the 2SPLS specification. Columns (1) and (2) of Table 4.3 present the results for the synthetic fertilizer intensity model and organic fertilizer adoption model, respectively. The estimated coefficients of organic fertilizer in the synthetic fertilizer use regression and synthetic fertilizer use in the organic fertilizer use regression are both not significantly different from zero. This finding suggests that farmers do not make joint decisions about the applications of synthetic and organic fertilizer. Some farmers may view organic fertilizer as an extra supplement to synthetic fertilizer in the rice production.

[48] The Bonferroni correction suggests that the p-value in a hypothesis test with multiple comparisons should equal a critical α value that is the original α value divided by the number of tests performed. In our case, we run each of the synthetic fertilizer use and organic fertilizer use regressions with 10 specifications with different interaction variables included. Hence, we use the new Bonferroni adjusted p-value of 0.05/10=0.005.

[49] In case of 1 endogenous variable, the rule of thumb suggests that the null hypothesis of weak instruments can be rejected if the first stage F-statistic is greater than 10. The estimated results of first-stage regressions could be found in Table 4.A3 in the appendix.

Table 4.3 Estimated results of two-stage probit least squares model

	Intensity of synthetic fertilizer use (NPK)	Organic fertilizer use
Organic fertilizer	1.727	
	(2.562)	
Intensity of synthetic fertilizers (NPK)		-0.006
		(0.024)
Risk seeking	-1.077	0.167*
	(0.747)	(0.092)
Patience	0.333	0.178**
	(0.733)	(0.087)
Contracted land size, mu	0.133	-0.018
	(0.092)	(0.014)
Number of contracted plots	-0.310***	0.007
	(0.121)	(0.019)
Log productive asset value	-0.418	0.041
	(0.339)	(0.048)
Zero productive asset	-5.629*	0.189
	(3.149)	(0.477)
Owning livestock, 1=yes		0.435***
		(0.150)
Credit access, 1=yes	1.257	0.139
	(1.128)	(0.162)
Total family laborers	-0.520	0.009
	(0.370)	(0.057)
Share of female laborers	-6.519*	-0.518
	(3.877)	(0.606)
Household head age, years	0.009	0.008
	(0.061)	(0.009)
Household head gender, 1=female	4.697*	0.268
	(2.435)	(0.378)
Household head education, years	-0.036	-0.002
	(0.146)	(0.022)
Household member as cadre, 1=yes	1.637	-0.135
	(1.482)	(0.229)
Household dependency ratio	-4.636*	-0.042
	(2.439)	(0.392)
Price of rice, yuan/kg	-0.262	-0.165
	(1.397)	(0.213)
Price of NPK fertilizer, yuan/kg	-3.099***	
	(0.488)	
Costs of seeds, yuan/mu	0.031***	-0.000
	(0.007)	(0.001)
Costs of pesticides, yuan/mu	0.017**	-0.001
	(0.008)	(0.001)
Double-season rice, 1=yes	4.452***	0.254
	(1.349)	(0.210)
Constant	55.162***	-1.457
	(9.320)	(1.423)
Personality traits (OCEAN)	Yes	Yes
Province dummies	Yes	Yes
Observations	815	815

Note: Corrected standard errors in parentheses, * p < 0.1. ** p < 0.05. *** p < 0.01.

The results presented in Table 4.3 confirm the main findings of the OLS/Probit estimation discussed in Section 4.2, namely that farmers' risk-seeking and patience significantly affect farmers' organic fertilizer-use decisions but do not influence synthetic fertilizer farmers use. Personality traits do not have a significant effect on fertilizer use decisions.[50]

4.6 Conclusion

In this paper we investigate whether risk preference, time preference, and personality traits affect the use of synthetic and organic fertilizers among Chinese rice farmers. We find that risk seeking and patient farmers are more likely to use organic fertilizer as compared to risk averse and impatient farmers. However, risk and time preferences do not significantly affect synthetic fertilizer use quantities. Personality traits do not play a significant, direct or indirect (through moderating the effects of preferences), role in fertilizer use decisions.

Our paper contributes to the literature on the factors that explain farmers' decisions to use synthetic (inorganic) and organic fertilizer in arable faming. While much of the existing literature focuses on the impact of institutional, socioeconomic, and farm endowment factors, only few papers investigate whether farmer's preferences and personality traits may explain fertilizer use decisions (e.g., Ali et al., 2019; Khor et al, 2018; Le Cotty et al., 2018). Our finding that risk preferences do not affect synthetic fertilizer use of Chinese rice farmers contrasts with a recent result by Khor et al. (2018) who find a significant relationship between risk preferences and synthetic fertilizer use in Vietnam. These different findings may be related to institutional and market differences between the two countries. Rice farmers in China are generally less exposed to risk factors related to market price fluctuations because a system of a minimum purchase prices for rice and other grains is in place. Moreover, Chinese farmers often farm spatially separated plots of land which can mitigate the risk of weather variability and unpredicted soil erosion to some extent (Blarel et al., 1992; Tan et al., 2008). In addition, the decision to use synthetic fertilizer may be perceived as less risky in China compared to other countries, because synthetic fertilizer has been used in rice production for many years all over the country and agricultural support measures have also considerably reduced and stabilized the marginal costs of using synthetic fertilizer (Li et al., 2014; Wu et al., 2019)

[50] Results for personality traits are not shown in the table, but can be obtained from the first author upon request.

The paper also contributes to recent research investigating associations between risk and time preferences and pro-environmental behaviour. This literature finds limited evidence for this association (Fuhrmann-Riebel et al., 2020; He et al., 2019; Lades et al., 2021). Our results for organic fertilizer use enrich this literature by finding evidence that risk and time preferences do play a significant role in crop farmers' adoption of more sustainable farming practices.

A few limitations of our research should be noted. First, we do not have information about the amount and type of organic fertilizer (e.g., commercial organic fertilizer, green manure, or animal manure) that farmers use. Hence, we can only investigate whether farmers use at least one type of organic fertilizer or not. Second, one of our main positive findings concerns organic fertilizer use which is used by only 8% of the farmers, i.e., 65 out 815, in the sample. Third, the preferences and personality traits used in this study were obtained for the respondent that was interviewed. In most cases (over 90%), the respondent was the head of the household who is likely to play a major role in the farming decisions of the household. No information was obtained, however, about preferences and personality traits of other household members who may have affected those decisions.

Several policy implications can be derived from this paper. First, to promote organic fertilizer use by crop farmers, policies reducing farmers' perceived exposure to risks related to organic fertilizer use may play an important role. For instance, risks in transporting organic manure from livestock farms to arable farms during the planting season may be reduced by spatially reallocation of farms so that the distances between the two types of farms are decreased. In addition, agricultural extension services may pay more attention to the technical knowledge about organic fertilizer application that is disseminated to crop farmers. The finding that impatient farmers are less likely to use organic fertilizer suggests that there may be value in education programs that highlight the long-term benefits of organic fertilizer use and aim to reduce high subjective discount rates among farmers (Bauer & Chytilová, 2010). We also found evidence that Chinese farmers do not consider organic fertilizer as a substitute for synthetic fertilizer in rice production. This finding, and the fact that only 8 percent of the surveyed farmers use organic fertilizer, suggests that changes in farmers' knowledge and attitudes towards organic fertilizer can make an important contribution to the transition towards a more sustainable agricultural system in China. Further development of the commercial organic fertilizer market in rural China may play an important role in this respect.

Appendix

Table 4.A1 Regression result of personality traits and fertilizer use (economic preferences as potential mediators)

	Intensity of synthetic fertilizers use (NPK), OLS			Organic fertilizer use, Probit		
	(1)	(2)	(3)	(4)	(5)	(6)
Openness	-0.290	-0.258	-0.195	0.004	0.003	-0.003
	(0.379)	(0.360)	(0.366)	(0.011)	(0.011)	(0.011)
Conscientiousness	0.435	0.738	0.721	-0.003	-0.004	-0.006
	(0.535)	(0.488)	(0.478)	(0.011)	(0.011)	(0.010)
Extraversion	-0.585	-0.315	-0.315	0.003	-0.000	-0.002
	(0.519)	(0.489)	(0.490)	(0.011)	(0.010)	(0.009)
Agreeableness	0.033	-0.061	-0.124	0.007	0.007	0.008
	(0.595)	(0.579)	(0.580)	(0.013)	(0.013)	(0.013)
Neuroticism	-0.524	-0.517	-0.501	0.003	0.004	0.006
	(0.474)	(0.471)	(0.471)	(0.014)	(0.013)	(0.012)
Risk seeking			-0.689			0.023**
			(0.570)			(0.011)
Patience			0.675			0.023**
			(0.576)			(0.010)
Jiangsu Province	1.921	-0.306	-0.324	0.028	0.009	0.010
	(1.416)	(1.430)	(1.430)	(0.036)	(0.031)	(0.031)
Jiangxi Province	1.789	-5.059***	-5.049***	0.059*	0.045	0.040
	(1.549)	(1.687)	(1.685)	(0.033)	(0.036)	(0.035)
Constant	32.912***	57.803***	57.991***	–	–	–
	(3.569)	(8.041)	(8.035)	–	–	–
Control variables	Yes	Yes	Yes	Yes	Yes	Yes
Observations	815	815	815	815	815	815
(Pseudo) R-squared	0.008	0.165	0.168	0.013	0.054	0.075

Note: (1) Robust standard errors in parentheses, * p < 0.1. ** p < 0.05. *** p < 0.01. Average marginal effects are reported in columns (4) – (6).
(2) Control variables included in the model are exactly the same as the ones in Table 4.2.

Table 4.A2.1 Regression result of economic preference and synthetic fertilizer use including interaction variables

	Intensity of synthetic fertilizers use (NPK), OLS									
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Risk seeking	1.347	-0.701	-0.323	-0.690	0.903	-0.696	0.953	-0.700	-0.434	-0.695
	(1.892)	(0.572)	(3.044)	(0.570)	(2.072)	(0.571)	(3.031)	(0.575)	(1.303)	(0.575)
Patience	0.686	-0.363	0.674	0.197	0.682	-0.229	0.664	3.376	0.673	-1.584
	(0.576)	(1.413)	(0.575)	(2.549)	(0.576)	(2.150)	(0.577)	(2.954)	(0.577)	(1.398)
Openness	-0.243	-0.214	-0.192	-0.196	-0.205	-0.198	-0.197	-0.211	-0.196	-0.180
	(0.366)	(0.359)	(0.369)	(0.364)	(0.365)	(0.365)	(0.367)	(0.365)	(0.366)	(0.365)
Conscientiousness	0.767	0.715	0.724	0.709	0.748	0.717	0.730	0.711	0.718	0.707
	(0.487)	(0.478)	(0.484)	(0.489)	(0.485)	(0.478)	(0.479)	(0.480)	(0.477)	(0.477)
Extraversion	-0.326	-0.316	-0.312	-0.314	-0.325	-0.319	-0.312	-0.347	-0.321	-0.319
	(0.489)	(0.489)	(0.484)	(0.490)	(0.489)	(0.489)	(0.490)	(0.497)	(0.492)	(0.493)
Agreeableness	-0.107	-0.107	-0.123	-0.120	-0.124	-0.104	-0.125	-0.155	-0.121	-0.169
	(0.575)	(0.583)	(0.581)	(0.583)	(0.579)	(0.581)	(0.576)	(0.585)	(0.576)	(0.583)
Neuroticism	-0.509	-0.495	-0.502	-0.502	-0.515	-0.497	-0.486	-0.499	-0.513	-0.528
	(0.474)	(0.470)	(0.470)	(0.471)	(0.473)	(0.472)	(0.472)	(0.473)	(0.466)	(0.479)
Risk×Openness	-0.649									
	(0.547)									
Time×Openness		0.344								
		(0.445)								
Risk×Conscientiousness			-0.087							
			(0.715)							
Time×Conscientiousness				0.115						
				(0.607)						
Risk×Extraversion					-0.396					
					(0.494)					
Time×Extraversion						0.227				
						(0.498)				
Risk×Agreeableness							-0.411			
							(0.750)			
Time×Agreeableness								-0.688		
								(0.705)		
Risk×Neuroticism									-0.113	
									(0.568)	
Time×Neuroticism										1.012*
										(0.572)
Constant	58.406***	58.048***	58.003***	58.052***	58.391***	57.787***	57.960***	58.294***	58.096***	58.411***

	(7.956)	(8.030)	(8.035)	(8.116)	(7.950)	(8.065)	(8.040)	(8.079)	(8.066)	(8.129)
Control variables	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Province dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	815	815	815	815	815	815	815	815	815	815
R-squared	0.170	0.169	0.168	0.168	0.169	0.168	0.168	0.169	0.168	0.172

Notes: (1) Robust standard errors in parentheses, * p < 0.1. ** p < 0.05. *** p < 0.01.
(2) Full results, including those for the control variables, are available upon request from the first author.

Table 4.A2.1 Regression result of economic preference and organic fertilizer adoption including interaction variables

	Organic fertilizer use, Probit									
	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
Risk seeking	0.020	0.023**	-0.026	0.023**	-0.078**	0.023**	0.013	0.023**	0.043	0.023**
	(0.030)	(0.011)	(0.048)	(0.011)	(0.039)	(0.011)	(0.066)	(0.011)	(0.030)	(0.011)
Patience	0.023**	0.015	0.023**	-0.043	0.022**	-0.009	0.023**	0.027	0.023**	0.005
	(0.010)	(0.033)	(0.010)	(0.050)	(0.010)	(0.047)	(0.010)	(0.061)	(0.010)	(0.029)
Openness	-0.003	-0.003	-0.003	-0.003	-0.002	-0.003	-0.003	-0.003	-0.002	-0.002
	(0.011)	(0.011)	(0.011)	(0.011)	(0.011)	(0.011)	(0.011)	(0.011)	(0.011)	(0.011)
Conscientiousness	-0.006	-0.006	-0.008	-0.009	-0.008	-0.006	-0.006	-0.006	-0.006	-0.006
	(0.010)	(0.010)	(0.010)	(0.011)	(0.010)	(0.010)	(0.010)	(0.010)	(0.010)	(0.010)
Extraversion	-0.002	-0.003	-0.003	-0.002	-0.004	-0.004	-0.002	-0.003	-0.003	-0.003
	(0.009)	(0.009)	(0.010)	(0.009)	(0.009)	(0.010)	(0.009)	(0.010)	(0.009)	(0.009)
Agreeableness	0.008	0.008	0.008	0.008	0.008	0.009	0.008	0.008	0.008	0.008
	(0.013)	(0.013)	(0.013)	(0.012)	(0.013)	(0.013)	(0.013)	(0.013)	(0.013)	(0.013)
Neuroticism	0.006	0.007	0.007	0.006	0.007	0.006	0.006	0.006	0.007	0.005
	(0.012)	(0.012)	(0.012)	(0.012)	(0.013)	(0.012)	(0.012)	(0.012)	(0.012)	(0.013)
Risk×Openness	0.001									
	(0.010)									
Time×Openness		0.003								
		(0.010)								
Risk×Conscientiousness			0.012							
			(0.012)							
Time×Conscientiousness				0.016						
				(0.012)						
Risk×Extraversion					0.025**					
					(0.010)					
Time×Extraversion						0.008				
						(0.012)				
Risk×Agreeableness							0.003			
							(0.017)			
Time×Agreeableness								-0.001		
								(0.015)		
Risk×Neuroticism									-0.009	
									(0.011)	
Time×Neuroticism										0.008
										(0.013)
Control variables	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Province dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	815	815	815	815	815	815	815	815	815	815

Notes: (1) Robust standard errors in parentheses, * p < 0.1. ** p < 0.05. *** p < 0.01.
(2) Average marginal effects are reported in columns (11) - (20).
(3) Full results, including those for the control variables, are available upon request from the first author.

Table 4.A3 First-stage results of two-stage probit least squares model

	Intensity of synthetic fertilizer use (NPK)	Organic fertilizer use
Risk seeking	-0.779	0.172*
	(0.571)	(0.089)
Patience	0.634	0.174**
	(0.521)	(0.085)
Contracted land size, mu	0.102	-0.018
	(0.073)	(0.014)
Number of contracted plots	-0.295***	0.008
	(0.112)	(0.018)
Log productive asset value	-0.343	0.043
	(0.309)	(0.047)
Zero productive asset	-5.246*	0.221
	(2.977)	(0.456)
Owning livestock, 1=yes	0.743	0.430***
	(1.051)	(0.150)
Credit access, 1=yes	1.481	0.129
	(1.012)	(0.158)
Total family laborers	-0.499	0.012
	(0.348)	(0.056)
Share of female laborers	-7.335**	-0.473
	(3.464)	(0.574)
Household head age, years	0.022	0.008
	(0.055)	(0.009)
Household head gender, 1=female	5.105**	0.236
	(2.240)	(0.353)
Household head education, years	-0.038	-0.002
	(0.138)	(0.022)
Household member as cadre, 1=yes	1.389	-0.143
	(1.354)	(0.228)
Household dependency ratio	-4.658**	-0.013
	(2.309)	(0.373)
Price of rice, yuan/kg	-0.540	-0.161
	(1.275)	(0.214)
Price of NPK fertilizer, yuan/kg	-3.066***	0.019
	(0.460)	(0.073)
Costs of seeds, yuan/mu	0.030***	-0.000
	(0.007)	(0.001)
Costs of pesticides, yuan/mu	0.015**	-0.001
	(0.007)	(0.001)
Double-season rice, 1=yes	4.839***	0.224
	(1.156)	(0.177)
Constant	52.083***	-1.783
	(7.885)	(1.252)
Personality traits (OCEAN)	Yes	Yes
Province dummies	Yes	Yes
Observations	815	815

Note: Corrected standard errors in parentheses, * p < 0.1. ** p < 0.05. *** p < 0.01.

Chapter 5 Do farmers' personalities affect how well they perform? The impact of personality traits on technical efficiency of Chinese rice farmers[51]

Abstract: The growing literature on the effects of psychological factors on individual decision making and labour market performance has revealed the important role played by personality traits. Given the risks and uncertainties inherent to agricultural production, it may be expected that personality traits affect farm performance as well. This study employs a large rural household survey data set collected in three rice-producing provinces in China to examine whether and to what extent farmers' personality differences explain some of the variations in technical efficiency of the interviewed farmers. We find that openness to experience, and internal locus of control have favourable effects on technical efficiency, while extraversion, agreeableness, neuroticism, and external locus of control are associated with lower technical efficiency. Cognitive skills measured by years of education, as a traditional indicator of human capital, is not significantly related to the technical efficiency of the interviewed farmers. These results imply that the effectiveness of policies aimed at improving rural welfare may be increased by paying more attention to personality heterogeneities among farmers, while long-run agricultural output and incomes may be improved through intervention programs enhancing farmers' skills to overcome unfavourable personality traits in agricultural production.

Keywords: technical efficiency; personality traits; human capital; stochastic frontier analysis; China

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5.1 Introduction

Agricultural production requires farm households to engage in multiple activities and often complex decision making. Operating a farm can be compared to owning a small business, and farmers have to sensibly adapt their resources (e.g., land, labour, and capital) to changing market circumstances and environmental conditions (Nuthall, 2001; Rosenzweig, 1980). The extant literature seeking to identify factors explaining the variation of work performance has underlined the importance of human capital in raising income or productivity (Hanushek & Woessmann, 2008; Heckman et al., 2018; Serneels, 2008). Many studies in agricultural economics have also suggested that human capital is a critical determinant of agricultural productivity and technical efficiency (Abdulai & Huffman, 2000; Battese & Coelli, 1992; Huffman, 2001).

Recent empirical evidence of the effect of farmers' educational attainment and farming experience — measures widely considered to be proxies for human capital — on technical efficiency is rather mixed. Some studies found significant positive effects of education on technical efficiency (e.g., Ma et al., 2017; Solis et al., 2009; Tan et al., 2010), while many other studies fail to find significant effects (e.g., Hong et al., 2019; Koirala et al., 2016; Villano & Fleming, 2006). Given this mixed evidence, it has been argued that there might be other human factors besides education that serve as key determinants of technical efficiency (Huffman, 2001).

Personality traits could be such human factors affecting farmers' performances. Rougour et al. (1998) noted the importance of psychological aspects, including drives and motivations, in the definition of managerial capability. Nuthall (2001) argued that besides intelligence, personality is crucial in shaping managerial ability. In fact, the conventional concept of human capital has been broadened by incorporating non-cognitive and motivational components, defined as a broad set of psychological factors including personality traits, goals, and preferences (Heckman & Kautz, 2014; Polyhart, 2012; Shelly, 2017).[52]

Recent studies have provided strong evidence of the role of personality traits in explaining career success and earning differentials in wage employment sectors (Cubel et al., 2016; Heineck, 2011; Linz & Semykina, 2009; Nyhus & Pons, 2005). These personality traits are, in some cases, even found to

[52] These non-cognitive and motivational factors are often referred to as non-cognitive or soft skills in the literature (e.g., Cunha & Heckman, 2007; 2009; Cunha et al., 2010; Heckman & Kautz, 2012). We choose not to do so, because they are to some extent predispositions that can be inherited, and we refer to them as non-cognitive motivations.

be more powerful predictors of labour market outcomes than cognitive skill indicators (e.g., education and IQ) (Heckman et al., 2006; Heckman & Rubinstein, 2001; Heineck & Anger, 2010). For instance, Heckman and Rubinstein (2001) found that the career performances of graduates from a General Educational Development (GED) program in the US are inferior to those of ordinary high school graduates with equal cognitive abilities due to lower non-cognitive motivations (persistence, tenacity, and discipline, etc.).

Other studies stress that human personality traits are crucial factors underpinning an individual's entrepreneurship (e.g., Marcati et al., 2008; Zhao & Seibert, 2006). Compared to non-agricultural enterprises, engaging in agricultural production is somewhat unique because farmers face considerable risks and uncertainty related to weather changes, occurrence of pests and diseases, and input and output markets. Growing crops not only requires physical inputs in many farm operations (e.g., seeding, applying fertilizers, spraying pesticides, irrigating, and harvesting), but also entails various mental tasks, such as making managerial decisions about the quantity and timing of certain inputs under a variety of risks and uncertainties (Allen & Lueck, 1998). Consequently, farmers' attitude towards risk, the capacity to conduct multitasks, and other personality characteristics unlikely to be captured by the measures of cognitive capabilities may shape their on-farm performances. Therefore, personality traits can also be expected to play a role in agricultural performance. However, few studies have investigated this potentially important link so far. Among the few studies in this field, Wilson et al. (2001) and Berkhout et al. (2010) found that farmer's capability of information seeking and heterogeneities in goals and attitudes are associated with agricultural performance as measured by technical efficiency. Ali et al. (2020) provided evidence that differences in technical efficiency among Ghanaian rice farmers can be explained by certain personality characteristics (i.e., work centrality and polychronicity) and that the size of the estimated impacts exceeds that of traditional human capital measures.

This study contributes to the rapidly growing literature on the effects of personality factors on individual decision making by investigating the effects of farmers' personality traits on their technical efficiencies in agricultural production. We develop a conceptual framework of the relationships between personality traits and farm performance and apply a coherent set of indicators (i.e., the so-called Big Five indicators and locus of control) measuring personality factors in the analysis. Empirical analysis is conducted by estimating a stochastic production frontier model and a model explaining the factors that affect the estimated technical inefficiencies based on a data set collected from 835 rice farmers in three rice-producing provinces in China.

The structure of the rest of this paper is as follows. Section 2 presents the conceptual framework of the relationships between personality traits and technical efficiency. The econometric model and estimation strategy are presented in Section 3, while the data set and the variables used in the analysis are introduced in Section 4. The results of the empirical analysis are presented and discussed in Section 5, while policy implications and recommendations for further research are presented in Section 6.

5.2 Personality traits and technical efficiency

There is an increasing recognition that noncognitive motivations, especially personality traits, can be crucial components in explaining differences in working performance of people having similar cognitive capabilities (e.g., working experience or education level) (Cobb-Clark & Tan, 2011; Cubel et al., 2016; Linz & Semykina, 2009; Nyhus & Pons, 2005). Borghans et al., (2008) suggest that differences in personality traits can exert both direct and indirect effects on performance. On the one hand, an individual's personality may partly serve as a set of productive traits that directly affect his/her overall decision making, just like education and working experience do; on the other hand, personality traits may influence an individual's choice of schooling as well as occupation type and thereby indirectly affect work performance (Chamorro-Premuzix & Furnham, 2003).

The relationship between personality and individual work performance is found to be a relatively complicated one in the literature, possibly due to the variety of psychometric notions and in specific job types examined in different studies (Barrick & Mount, 1991). More recently, a general high-order taxonomy of personality traits, commonly called the Five-Factor Model (FFM) or the Big Five, is increasingly used for describing an individual's personality. It distinguishes five broad dimensions (factors): openness, conscientiousness, extraversion, agreeableness, and neuroticism (John and Srivastava, 1999; McCrae & Costa, 2003). The FFM is intended to be a unifying framework underlying a range of psychological variables, including values, preferences and attitudes, in which each of the five factors can be subdivided into lower-order facets to provide a more fine-grained description of one's personality. It has several important psychometric advantages, making it increasingly popular. The five trait factors are likely to be independent from each other (McCrae & John, 1992), primarily determined by biological maturation rather than life experience (Strivastava et al., 2003), fairly stable during adulthood (Roberts et al., 2006), and uncorrelated with cognitive skills (Stankov, 2005).

A commonly used measure of the economic performance of firms and farms is technical efficiency (TE). Applied to farms, it refers to the farmer's ability to either maximize agricultural production output for given input quantities (output-oriented measure of TE) or to minimize input quantities for a given output level (input-oriented measure of TE) (Coelli et al., 2005; Kumbhakar & Lovell, 2003). In other words, technical efficiency reflects how well farmers can transform a certain set of inputs into final output. It can have a large variation across farmers, as technological advancement and changes in relative prices in input and output markets require farmers to make substantial efforts in decision making and practices to adjust their farm operations to these changing circumstances. Schultz (1975) refers to these 'efforts' as "an ability to deal with disequilibrium".

This managerial capacity of farmers is likely to be related to human factors such as personality traits. Rougour et al. (1988) define management capacity as "having appropriate personal characteristics and skills to deal with the right problem and opportunities in the right moment and in the right way". Hence, it can be expected that farmers with favourable personality traits (for agricultural production) have relatively low technical inefficiency, while farmers with less favourable personality traits experience much higher technical inefficiency. Technical efficiency in this sense might be related to rationality, which implies striving to obtain the best possible outcomes, given one's preferences and available information (Luke, 1985). Striving to obtain the best possible outcomes may be hindered by less favourable personality traits, such as unwillingness to engage in novel experiences and to expend effort, and by emotional instability. The FFM provides a basis for studying the effects of personality traits on technical efficiency, to be described in some detail below.

Openness (to experience) describes people's tendency to become involved in intellectual activities as well as novel experiences (Busato et al., 2000). In relation to job performance, Judge et al. (1999) proposed that open individuals may stand out in the workplace because of their higher intellectual curiosity, creativity, and behavioural flexibility. However, this effect may be subject to the specific job type. In some occupations, openness may also be detrimental for job performance, particularly in a work environment where rigidly prescribed rules apply, as it is also associated with autonomy and non-conformity (Goldberg, 1992). Given the nature of farming, openness is expected to be a favourable productive personality trait for farmers to excel in farm management. This is not only because more open farmers are likely to be the first in adopting innovative technology and attending agricultural training, but they also have fewer working rules to follow compared to employees in the non-agricultural sector.

Conscientiousness is related to one's degree of order, self-discipline, hard-working, and achievement-thriving (Chamorro-Premuzix & Furnham, 2014; Costa & McCrae, 1992). The empirical literature has correlated conscientiousness with higher working performance (e.g., job status and salary) and productivity in a laboratory setting (Judge et al., 1999; Cubel et al., 2016). Austin et al. (1999) and Crase and Maybery (2004) suggested that conscientiousness is associated with farmers' production-oriented behaviour such as operating a larger farm and on more fertile land, possibly due to their achievement motivation. Robertson et al. (2000) proposed that conscientiousness may sometimes be detrimental to managerial performance as it can lead people to perform fewer tasks and take a longer time to complete them. As agricultural production in China is still somewhat labour-intensive and requires farmers to perform multiple decision making (e.g., seeding, fertilization, and irrigation), those who are more conscientious are likely to work hard to apply appropriate agricultural inputs in an orderly fashion, but may also have to expend more endeavour or time than other farmers to achieve this. Hence, conscientiousness can have either a positive or a negative effect on managerial performance.

Extraversion is another personality trait frequently associated with the performance of work involving social interactions (Judge et al., 1999; Chamorro-Premuzic & Furnham, 2005). This trait typically refers to the degree of being social-oriented, active, and positive (McCrae & Costa, 2008) and has been positively correlated with managerial potential in a team-based job environment (Craik et al., 2002; Moutafi et al., 2007). Nevertheless, previous research has found mixed results concerning the relationship between extraversion and working performance (Gelissen & de Graaf, 2006; Nyhus & Pons, 2005). Flinn et al. (2019) further found that extraversion does not significantly increase productivity or bargaining in the job. Considering that agricultural production is sensitive to the right timing of using inputs or reaping the harvest, and hiring inputs such as labour or machinery services often rely on local social contacts in rural China, we expect extraversion to be a favourable trait for farmers to acquire inputs at the proper time. Hence, the extravert farmer is expected to have lower technical inefficiency.

Agreeableness encompasses the extent to which an individual is cooperative, warm, sympathetic, and altruistic (John and Srivastava, 1999; McCrae & Costa, 2008). Its effect on the job market outcome has been well studied, suggesting that agreeableness is associated with a lower probability of career success in terms of level of earnings or remuneration (Boudreau et al., 2001; Nyhus & Pons, 2005). In particular, the altruistic character of agreeable individuals leads them to sacrifice their own success in order to please other people (Hogan & Hogan, 2002). It may also result in less bargaining power in

distributive bargaining situations such as haggles over the purchase price of goods or resources (Barry & Friedman, 1998). Agricultural production by family households requires relatively less teamwork, but obtaining agricultural inputs via bargaining with sellers or service providers is very important for farm management. A more agreeable farmer may be less able to obtain the optimum amount of input or to hire input services at the right time than a farmer being more agonistic. We thus expect that high agreeableness may not be a favourable personality trait in farm operation, thus leading to technical inefficiency.

Neuroticism, or the inverse of emotional stability, characterizes to what extent people tend to be stressful, tense, and anxious (McCrae & Costa, 2008). Previous studies have shown rather consistently that neuroticism is negatively associated with career success, characterised by lower productivity, earning less money or salary, and lower management capability (Cubel et al., 2016; Gelissen & de Graaf, 2006; Moutafi et al., 2007). It is suggested that neurotic individuals tend to perform more poorly due to their vulnerability to stress as well as weak abilities to adapt to or cope with external stimulation (Carver & Connor-Smith, 2010). As weather shocks or market price fluctuations are likely to be major concerns for small farmers, more neurotic farmers may respond more slowly in developing adaptation strategies to these external shocks than those who are more emotionally stable. Consequently, neuroticism is not a favourable personality fit for practising agriculture and farmers with high neuroticism are expected to have a higher technical inefficiency in general.

In addition, locus of control (LOC) is the most widely studied personality trait besides the FFM in predicting individual behaviour. LOC is best described as one's belief that life outcomes are primarily due to his/her own efforts or primarily due to external factors (e.g., luck or fate) (Rotter, 1966; Spector, 1988). The former belief is called internal LOC, while the latter is referred to as external LOC. People with an internal LOC appear to achieve labour market success more easily than those with an external LOC (Allen et al., 2005; Nyhus & Pons, 2005). Abay et al. (2017) found that Ethiopian farmers with an internal LOC have a higher propensity to use fertilizer, improved seeds, and irrigation. It may also be expected that farmers with an internal LOC will attribute their farm performance to their own endeavours and put more effort into optimizing their farm management, resulting in lower technical inefficiency. Likewise, external LOC is expected to contribute to higher technical inefficiency.

5.3 Empirical approach

To assess technical efficiency in farming, both parametric (e.g., Stochastic Frontier Analysis (SFA)) and nonparametric methods (e.g., Data Envelope Analysis (DEA)) have been commonly distinguished and applied in the literature (Bravo-Ureta et al., 2007; Thiam et al., 2001). DEA has the advantage of being free of ex-ante specification of production function or parametric restrictions, while the strength of the parametric SFA is that it explicitly takes stochastic noise in the data into account, is less sensitive to measurement errors, and permits analysis of inefficiency determinants (Coelli et al., 2005). Considering the probability of measurement errors in rural household survey data, the fact that farm production is highly influenced by uncontrollable factors such as weather disturbances and natural disasters (Tan et al., 2010), and the need to perform an analysis of inefficiency determinants, the parametric stochastic frontier approach was selected for this study.

5.3.1 Stochastic production frontier model

The stochastic production frontier model was originally proposed by Aigner et al. (1977) and Meeusen and van den Broeck (1977). The general form of the model can be expressed as follows:

$$\ln(Y_i) = f(x_i;\beta) + \epsilon_i, \quad (1)$$

$$\epsilon_i = v_i - u_i, \quad (2)$$

$$v_i \sim N(0, \sigma_v^2), \quad (3)$$

$$u_i \sim N^+(0, \sigma_u^2), \quad (4)$$

in which Y_i is the output of the *i*-th farm household; x_i is a $K \times 1$ vector of logarithms of productive farm inputs; β is a $1 \times K$ vector of parameters to be estimated. ϵ_i is the error term, which is comprised of two independent error components, v_i and u_i. v_i is a symmetric random error term accounting for statistical noise (e.g., measurement error and exogenous shocks affecting agricultural production), which is assumed to be independently and identically distributed (*i.i.d*) as $N(0, \sigma_v^2)$. u_i is a non-negative (one-sided, or half-normal) unobserved random error term capturing technical inefficiency in production, also being assumed to be independently and identically distributed. The estimated frontier thus captures agricultural production with zero inefficiency, while the non-negative u-term indicates the extent to which observed output is below the maximum feasible output level given the stochastic frontier. Hence, the output-oriented measure of technical efficiency, TE_i, being defined as the ratio of

realized output to the potential maximum feasible output, takes a value between 0 and 1 and can be derived as (Battese et al., 1996):

$$TE_i = \exp(-u_i)\,. \tag{5}$$

5.3.2 Estimation strategy

To estimate technical efficiency and identify its determinants, the stochastic production frontier model needs to be estimated. Using a two-stage approach – in which the stochastic frontier is estimated and the technical efficiency scores derived in the first stage, and the technical efficiency is regressed on a set of explanatory variables in the second stage – has been shown to lead to inconsistent results (Battese & Coelli, 1995; Huang & Liu, 1994; Kumbhakar et al., 1991; Wang & Schmidt, 2002) and results that are likely to be biased downward (Caudill & Ford, 1993). Hence, in this study, we follow the suggestion of Wang and Schmidt (2002) to estimate both the stochastic frontier function and the inefficiency function through a single-step maximum likelihood estimation (MLE) procedure.

Another important issue is the distributional assumption with respect to the technical inefficiency error term, u_i, and the specification of its relationship with its explanatory factors (Belotti et al., 2013; Wang & Schmidt, 2013). In the literature, there are two commonly-used specification approaches for u_i proposed by either Kumbhakar et al. (1991), Huang and Liu (1994), Battese and Coelli (1995) (KGHMLBC model, hereafter), or Reifschneider and Stevenson (1991), Caudill and Ford (1993) and Caudill et al. (1995) (RSCFG model, hereafter). The KGHMLBC model assumes a truncated normal distribution for u_i, with $N^+({z_i}'\delta, \sigma_u^2)$, and specifies the mean of the pre-truncation inefficiency distribution as a linear function of a set of exogenous variables z'. The RSCFG model assumes u_i to be half-normally distributed as $N^+(0, \sigma_u({z_i}, \delta)^2)$, setting the location (mean) parameter equal to zero and parameterizing the variance σ_u^2 as a function of exogenous determinants, z_i. The RSCFG model is generally recommended given its attractive scaling property, which is more convenient and flexible in allowing heteroskedasticity in u_i (Belotti et al., 2013; Simar et al., 1994; Wang & Schmidt, 2002). For this study, we estimated the RSCFG model using a single-step MLE procedure.[53]

5.3.3 Model specification

Following the RSCFG model explained above (Caudill et al., 1995), the model that we estimate in this study is specified as follows:

[53] A more detailed discussion about these two models can be found in Wang and Schmidt (2002).

$$\ln(Y_i) = \beta_0 + \sum_{j=1} \beta_j \ln(X_{ij}) + \beta_c C_i + v_i - u_i, \quad (6)$$

$$v_i \sim N(0, \sigma_v^2), \quad (7)$$

$$u_i \sim N^+(0, \sigma_u(z_i, \delta)^2), \quad (8)$$

$$\sigma_u(z_i, \delta)^2 = \exp(z_i{}'\delta), \quad (9)$$

where, Y_i is the rice yield of farm household *i* and X_{ij} are the quantities of productive inputs *j* used by this farm household in the rice production, often including land, labour, machinery, fertilizers, and other variable inputs (e.g., pesticides and seeds). C_i represents a set of other variables affecting the rice output, i.e., the type of rice cultivation (single-season or double-season rice cultivation) and regional characteristics. z_i represents a vector of exogenous determinants of technical inefficiency including key indicators of farmer's personality traits that we aim to identify in this paper. δ is a vector of parameters to be estimated. The non-negative error term u_i captures technical inefficiency. Hence, personality traits and other explanatory variables that are found to exert a significant positive effect have an opposite, i.e., negative, effect on technical efficiency.

A Cobb-Douglas (C-D) specification is used in Eq. (6). Alternatively, the more flexible translog form may be applied (e.g., Villano & Fleming, 2006; Ma et al., 2017; Zhou et al., 2019). A specification test was conducted to examine which specification is most appropriate for the current study.

5.4 Data

5.4.1 Data set

The data used in this study comes from a large farm household survey administered in three major rice-producing provinces in eastern China in early 2019. The three provinces Liaoning, Jiangsu, and Jiangxi were chosen to reflect the geographical and economic diversity of central-east China. The main objective of the survey was to gather information on farm households' land rentals and resource management. The collected data includes detailed information about the family composition and agricultural production of farm households in the year 2018. A variety of other information such as personality factors of the respondent was also obtained in the survey.

A multi-stage stratified random sampling strategy was applied. Firstly, two counties were chosen within each province by consulting with researchers and local administrative contacts to facilitate the

field work. The selected counties serve as good representatives of the whole region in terms of their topography, distance to the provincial capitals, and economic development. Second, for each county, five townships were chosen (by selecting every 5th township on the list) from a list of townships sorted on the basis of per capita arable land. Then, four villages within each township were chosen using a similar method. At the village level, households were classified into three different stratums, i.e., renting-in, renting-out, and autarkic households, based on their land renting status. Within each stratum, four households were randomly chosen and interviewed without being given notice in advance and village leaders not being present. In total, the sampling strategy yielded 1,420 rural households.[54] In this study, we focus on farm households that grow rice as their major crop. This is because rice is the only staple crop grown in all the three provinces and using a single crop for technical efficiency analysis is expected to give more precise estimates. Therefore, we excluded 584 households that either did not grow rice or grew it as a minor crop. We also excluded two observations with missing information on personality factors. Thus, our analysis is based on 834 rice-producing farm households. In almost all cases, the head of the household was the respondent in the interview.[55]

5.4.2 Measures and definitions of variables

The dependent variable in the production frontier is the total rice output of the farm household. Productive input factors, including labour, machinery, fertilizer, pesticide, and seeds, are the main variables explaining rice output.[56] Land input was measured by the total sown area with rice (in mu[57]), where land planted with double-season rice is counted as twice the sown area of land planted with a single rice crop. Labour input was measured by the total amount of (family and hired) labour used for rice production (in man-days) in the previous year. Machinery input was measured by the total monetary value of productive machinery owned by the farm household (in yuan). Fertilizer input was measured by aggregating the total amount of nitrogen, phosphorus, and potassium (N-P-K) applied in kilograms. Pesticide and seed inputs were both measured by the total cost spent by the farm household. In addition to these six productive input variables, we also included a dummy variable that equals one for households growing double-season rice and two dummy variables representing two of the three provinces. The province-level dummy variables are included to control for differences in agro-ecological conditions, market conditions, institutions and policies between the three provinces.

[54] Because the number of households in certain stratums was less than four in some villages, 1,420 instead of 1,440 households were interviewed.
[55] In the few cases that the head of the household was absent, another household member responsible for agricultural decision making was interviewed.
[56] Organic fertilizer is not included in the rice production function as we only have data on whether farmers use it, but we do not have information on the quantity of organic fertilizer that was applied.
[7] 15 mu equals 1 hectare.

The main explanatory variables of interest in the technical inefficiency model are the personality factors, including the Big-Five personality traits and locus of control. The Big-Five personality traits were measured using a 10-item short version of the Big-Five Inventory in Chinese, a commonly adopted psychometric scale measuring personality traits with appropriate reliability and validity worldwide (Qian et al., 2020; Rammstedt & John, 2007). Each of the five personality dimensions was elicited by two items on a 5-point Likert-type scale, ranging from 1 ('completely disagree') to 5 ('completely agree'). A list of these items can be found in Table 5.A1. We constructed the locus of control measure using 10 statements taken from Rotter's (1966) scale, with each statement self-evaluated by the respondents on similar 5-point Likert-type scales. Internal and external locus of control variables were determined based on latent factors loaded from these items, using exploratory factor analysis.[58]

Other human capital factors, representing farmers' cognitive skills such as education and farming experience, were included as control variables in the technical inefficiency model. Education, measured by the respondent's years of schooling, is expected to reduce technical inefficiency since better-educated farmers are more skilled in using complex and innovative technologies. The respondent's age was used as a proxy of farming experience, which may have a negative effect on technical inefficiency.[59]

Other explanatory variables in the inefficiency model comprise respondent's gender, degree of land fragmentation, and tenure security (Ma et al., 2017; Seymour, 2017; Tan et al., 2010). When there is a female head of the household, the male spouse has generally either passed away or is living elsewhere, which may affect technical inefficiency. The number of contracted plots owned by households was used as an indicator of the degree of fragmentation of the entire land contracted by the household, while a dummy variable that equals one when a household possessed a land certificate issued by the government was used as an indicator of land tenure security. Higher land fragmentation may cause higher technical inefficiency, as traveling to more spatially dispersed plots will increase management inconvenience. The expected effect of land certificates on technical inefficiency is negative as it is commonly found that more secure property rights enable more efficient allocation of (land, labour, credit) resources (Feng, 2008; Ma et al., 2017).

[58] The loading plots are available upon request. The results show that items 1, 2, 3, 4, 5, 10 (in the locus of control scale) load onto one latent factor – interpreted as external locus of control, while items 6, 7, 8, 9 load onto another latent factor – interpreted as internal locus of control.
[59] The potential nonlinearity of age is considered by including the square of age in the model.

5.5 Results

5.5.1 Descriptive statistics

Table 5.1 presents the descriptive statistics for the variables used in the estimation of the stochastic frontier and the technical efficiency equations. Regarding the rice production, average total rice output per household equalled 41,586 kilograms, varying from 150 kg to 1,440,000 kg. The average rice sown area was 72.33 mu (i.e., 4.82 ha). Farm households on average were endowed with 4.47 plots. The average labour input in producing rice was 121.35 days, while the average value of productive machinery owned by the farm household was around 44,328 yuan (i.e., 6,452 USD). The mean chemical (N-P-K) fertilizer input in rice growing was about 2,265 kg. The surveyed farm households spent 5,215 yuan on pesticides and 6,308 yuan on rice seed on average. The relatively high mean values and standard deviations of all input variables are mainly due to the large variation in farm sizes, in which nearly 60 percent of the farm households cultivated rice on land sizes less than 15 mu (i.e., 1 ha). The mean land size is substantially greater than the mean size in China as a whole, which was equal to 7.8 mu (i.e., 0.52 ha) in 2018 (CNBS, 2019). This is partly caused by the stratified sampling strategy and partly because one of the selected provinces (i.e., Liaoning) is located in north-eastern China, where farm sizes are much larger on average.[60]

In addition, about 23 percent of households grew double-season rice in our sample. Interviewed farmers were primarily male (95 percent) and relatively old (58.4 years old). On average, they have had more than six years of schooling, which is equivalent to completing elementary school. Slightly more than half of the households, i.e., 53 percent, possessed a land certificate.

5.5.2 Specification tests

A few specification tests were carried out before presenting the estimation results. We first performed a likelihood ratio (LR) test in order to test whether the C-D or the translog functional form is more appropriate for the production frontier (including the technical inefficiency part). The LR test statistic ($\chi^2(21)$) is 22.35, which is below the 5 percent critical value of 32.07 (Kodde & Palm, 1986). This result suggests that the null hypothesis that the quadratic and interaction terms in the translog specification are jointly insignificant cannot be rejected. Thus, the C-D functional form is preferred over the translog form. Another likelihood ratio (LR) test was conducted to test the null hypothesis that the sampled rice farms are perfectly technical efficient. The LR test statistic ($\chi^2(12)$) equals 317.08, exceeding the critical value of 25.55 at the 1% level. This result indicates that the null hypothesis should be rejected.

[60] Average sizes of the surveyed farms in Liaoning, Jiangsu, and Jiangxi were equal to 135.5 mu, 69.7 mu, and 34.9 mu, respectively.

Table 5.1 Descriptive statistics of the variables used in the stochastic production frontier and inefficiency models (*N*=834)

Variable of interest	Unit	Mean	SD	Min	Max	Definition	Expected effect
Production frontier							
Rice output	Kg	41,586	113,701	150	1,440,000	Total rice output	
Land	Mu	72.3	210.2	0.5	3,600	Land area sown with rice	
Labour	Days	121.4	525.5	0.2	12,170	Total (family and hired) labour used in rice production	
Machinery	Yuan	44,328	182,183	0	2,065,000	Total monetary value of self-owned machinery	
Fertilizer	Kg	2,265	6,378	4.38	97,632	Total amount of fertilizer (N-P-K) applied in rice	
Pesticide	Yuan	5,215	17,699	0	278,400	Total cost of pesticide used in rice production	
Seed	Yuan	6,308	21,513	0	290,000	Total cost of rice seeds	
Double-season rice		0.23	0.42	0	1	Binary, =1 if farm household grows double-season rice; =0 otherwise	
Jiangsu		0.30	0.46	0	1	Binary, =1 if farm household resides in Jiangsu province, = 0 otherwise	
Jiangxi		0.44	0.50	0	1	Binary, =1 if farm household resides in Jiangsu province, = 0 otherwise	
Inefficiency model							
Openness		3.01	1.02	1	5	Respondent's score on openness	−
Conscientiousness		4.14	0.79	1	5	Respondent's score on conscientiousness	+/−
Extraversion		3.92	0.91	1	5	Respondent's score on extraversion	−
Agreeableness		3.93	0.73	1	5	Respondent's score on agreeableness	+
Neuroticism		2.33	0.89	1	5	Respondent's score on neuroticism	+
Internal locus of control		4.16	0.64	1	5	Respondent's score on internal locus of control	−
External locus of control		3.11	0.77	1	5	Respondent's score on external locus of control	+
Age	Year	58.4	9.01	27	88	Respondent's age	−
Female gender		0.05	0.21	0	1	Binary, =1 if respondent is a female; =0 if respondent is a male	+
Education	Year	6.65	3.22	0	18	Respondent's education	+/−
Plots	Piece	4.47	4.06	0	38	Number of contracted plots on farm	+
Land certificate		0.53	0.50	0	1	Binary, =1 if farm household holds a land certificate; =0 otherwise	−

Note: 1 mu=0.067 ha; 1 yuan=0.15 USD.

5.5.3 Production frontier and technical efficiency scores

Table 5.2 presents the maximum likelihood estimates of the parameters in the production frontier. The method proposed by Battese (1997) was used to deal with households having zero values for machinery, pesticides, or seed inputs.

Table 5.2 Estimation results for Cobb-Douglas production frontier

Explanatory variables	Coefficient
ln(land)	0.947***
	(0.021)
ln(labour)	0.005
	(0.007)
ln(machinery)	-0.008
	(0.006)
ln(fertilizer)	0.037**
	(0.017)
ln(pesticide)	0.004
	(0.005)
ln(seed)	0.014
	(0.010)
Double-season rice	0.417***
	(0.025)
Jiangsu	0.005
	(0.019)
Jiangxi	-0.131***
	(0.027)
Constant	6.436***
Log-likelihood	81.73
Observations	834
Scale elasticity	0.99

Note: Standard errors in parentheses. *, **, *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively.

As the output and all the main input variables are expressed in logarithmic forms, the estimated coefficients of those input variables can be interpreted as input-output elasticities. Land is found to be the most important factor affecting rice production, with an elasticity of 0.947. This result indicates that a 1 percent increase in land size is associated with an approximately 0.95 percent increase in rice output. The estimated elasticities for the other inputs are not significantly different from zero, except for fertilizer. The estimated elasticity for fertilizer equals 0.037. The results obtained for land and fertilizer are in line with the findings of several studies of rice production in the same regions and other parts of China (Ma et al., 2017; Tan et al., 2010; Yang et al., 2016; Zhou et al., 2019). The scale elasticity, calculated as the sum of all the estimated input-output elasticities, is not significantly different from 1. This finding indicates that rice production in the research areas exhibits constant returns to scale, which is similar to that of Zhou et al. (2019) for the same three provinces using a different data set.

Figure 5.1 shows the kernel density distribution of the estimated technical efficiency scores. The score ranges from 0.058 to 0.972, with a mean value of 0.783. This indicates that eliminating technical inefficiency can further enhance rice production by 27.7 percent [(1–0.783)/0.783]. The average technical efficiency score is comparable with the scores estimated in other studies on rice production in China, which range from 0.76 to 0.91 (Tan et al., 2010; Tong et al., 2019). Summary statistics of the technical efficiency scores in each province are shown in Table 5.3. They indicate that rice production is more efficient in Jiangsu and Liaoning provinces than in Jiangxi province, and that farms with very low efficiency (below 0.40) are located in Jiangxi and Jiangsu, but not in Liaoning province.

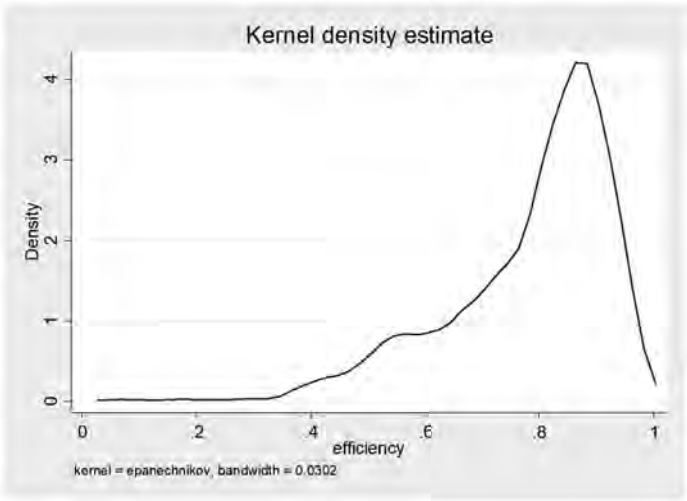

Figure 5.1 Kernel density distribution of technical efficiency

Table 5.3 Estimated technical efficiency scores.

	N	Mean	Min	Max
Overall	834	0.783	0.058	0.972
Liaoning	212	0.808	0.403	0.959
Jiangsu	254	0.839	0.073	0.964
Jiangxi	370	0.731	0.058	0.972

5.5.4 Determinants of technical inefficiency

The estimation results for the technical inefficiency model are presented in Table 5.4. To examine the impact of adding personality factors to the model, we first present the estimation results of the inefficiency model without personality factors in column (1). The estimated coefficient of the education variable is statistically insignificant, suggesting that educational attainment of a farmer does not affect technical inefficiency of rice production. The estimated coefficient for age, the proxy for

farm experience, is significantly different from zero at 10% level and thereby indicates that more farming experience is associated with less technical inefficiency.

The full regression results of the technical inefficiency model, including personality traits, are presented in column (2) of Table 5.4. First, all personality traits except for conscientiousness are significant at 10 percent level or lower in explaining technical inefficiency. Turning to the separate dimensions of the Big-Five personality traits, it is found that openness to experience has a significant negative effect on technical inefficiency. Hence, more open farmers tend to be more efficient in rice production. Potential explanations are that more open farmers are more likely to invest in technological innovations and to attend relevant trainings. Agreeableness is found to have a significant positive effect on technical inefficiency. Hence, being more agreeable tends to have an efficiency-reducing effect. This finding supports the presumption that more agreeable farmers are less able to purchase the optimum amount of input or to hire input services at the right time than agonistic farmers. Neuroticism is also found to have a significant inefficiency-enhancing effect. This indicates that neuroticism is not a favourable personality trait in operating rice farms, possibly because it associates with lower adaptation ability when a farmer encounters external shocks. Extraversion is found to have a statistically significant inefficiency- enhancing effect (at a 10 percent testing level). Hence, this finding contradicts our expectation that more extravert farmers are better able to hire inputs such as labour or machinery services at the right time than introvert farmers. Finally, conscientiousness – the fifth of the Big-Five personality traits – is not found to have a significant effect on technical inefficiency. This finding suggests that the asserted beneficial and detrimental effects of conscientiousness seem to cancel each other out.

Estimated effects of internal and external locus of control (LoC) are highly significant and in the opposite direction as expected. Internal LoC appears to be an inefficiency-reducing personality trait, suggesting that farmers holding a belief that their efforts can convert into desired outcomes perform better in operating rice farms than farmer who believe they have little control over their fate.

Another important finding is that the effect of education remains insignificant when personality traits are included in the model. This result implies that the motivational component of human capital (i.e., personality traits) is of much greater importance for a farmer's managerial performance than cognitive skills attained through formal education. It provides further support for the finding of Ali et al. (2020), for Ghanaian rice farmers, that the effects of noncognitive motivations on technical efficiency exceed those of traditional human capital measures such as education. Age is found to have a significantly

negative effect on technical inefficiency, further confirming that more experienced farmers manage their farms more efficiently.

Finally, the results obtained for the control variables show that farms with more spatially dispersed plots are associated with higher technical inefficiency, while possession of certificates significantly reduces technical inefficiency. The positive impact of land fragmentation is consistent with the finding by Chen et al. (2009) in other parts of China. The result obtained for land certificates is in line with the negative effect of land tenure security on technical inefficiency previously observed by Ma et al. (2017) and Zhou et al. (2019). Gender of the head of the household is not found to be correlated with technical efficiency in rice production.

Table 5.4 Single-step maximum likelihood estimation results for the technical inefficiency model.

Variables	Coefficients	
	(1)	(2)
Openness		-0.153**
		(0.060)
Conscientiousness		-0.124
		(0.080)
Extraversion		0.126*
		(0.071)
Agreeableness		0.277***
		(0.083)
Neuroticism		0.195***
		(0.068)
Internal locus of control		-0.229**
		(0.098)
External locus of control		0.211**
		(0.084)
Age	-0.095*	-0.126**
	(0.051)	(0.054)
Age^2	0.001	0.001*
	(0.000)	(0.000)
Female gender	0.407*	0.415
	(0.251)	(0.256)
Education	0.003	0.006
	(0.015)	(0.017)
Plot	0.053***	0.054***
	(0.015)	(0.015)
Land certificate	-0.643***	-0.544***
	(0.117)	(0.121)
Constant	1.397	1.342
Log-likelihood	57.84	81.02
Observations	834	834

Note: Standard errors in parentheses. *, **, *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively.

5.6 Conclusion

It is well-known that personality influences an individual's thinking, feeling, and behaving. Personality is viewed as one of the important attributes of noncognitive motivations in neoclassical human capital theory (Heckman & Kautz, 2014; Polyhart, 2012). The recent literature has identified the important role played by personality traits on individual decision making and labour market performance (Cubel et al., 2016; Heckman et al., 2006; Heineck, 2011). But whether personality traits affect individual performance in the rural agricultural sector has received little attention so far. Given the risks and uncertainties inherent to agricultural production, it may be expected that personality traits affect farm performance. In this paper, we examined the contribution of personality traits to the technical efficiency of Chinese rice farmers by applying stochastic frontier analysis to household-level survey data collected in three major rice-producing provinces in China. In doing so, we apply the so-called Big-Five personality traits which are likely to be independent of each other, primarily determined by biological maturation rather than life experience, fairly stable during adulthood, and uncorrelated with cognitive skills. In addition, we include another widely studied personality trait predicting individual behaviour, namely internal and external locus of control.

We find strong evidence that personality traits of farmers significantly affect their technical efficiency in rice production. In particular, openness to experience and internal locus of control are found to be negatively related to technical inefficiency. Hence, farmers possessing these traits tend to have better capabilities in operating their farms. On the other hand, farmers who are more extravert, agreeable, or neurotic, or with an external locus of control, tend to perform worse in the management of their rice farms.

Another important finding is the insignificant effect of education in the model explaining technical inefficiency. This finding contributes to the available literature in labour economics showing that the impact of personality may exceed that of education in determining performance in wage employment (e.g., Heckman et al., 2006; Linz & Semykina, 2009). Our study and the study for Ghana by Ali et al. (2020) indicate that personality traits have similar performance effects, exceeding that of formal education, in the self-employed farming sector in developing countries.

Establishing causality in the personality–inefficiency relationship should be done with caution. Personality traits have been long viewed as stable during adulthood as they are largely determined by genetic inheritance and parenting investments in early childhood (Bouchard & Loehlin, 2001; Cobb-

Clark & Schurer, 2012; Srivastava et al., 2003). More recently, some scholars have argued that personality traits might change throughout the whole life and even respond to environmental influences and rewards, or lack thereof (Borghans et al., 2008; Specht et al., 2011). More research in specific farming contexts is needed to examine the extent to which for example sudden shocks or climate change and other stressors affect personality traits like the ones used in this study.

Keeping in mind the aforementioned limitation, the main findings of our research suggest considerable implications for agricultural and rural policymaking in China and possibly also elsewhere. First, as technical efficiency is closely linked to farm profitability, this study contributes to the broader discussion of the relationship between individual personality and earnings (Heineck, 2011; Nyhus & Pons, 2005). As Bowles et al. (2001) suggested, certain personalities may reinforce the likelihood that people are trapped in poverty over time. Farmers with a high external locus of control may face low earnings, which may further strengthen their belief of having little control over obtaining desired outcomes in life. Hence, policies aimed at enhancing the welfare of groups lagging behind in rural China may increase their effectiveness by taking personality heterogeneity into consideration in designing interventions. Agricultural training programs, which often focus on the improvement of cognitive skills of farmers (e.g., agricultural knowledge), may be adapted by also including training on fostering behavioural and social skills that are known to enhance managerial abilities (Nuthall, 2018), especially for those with unfavourable personality traits. Second, the finding that personality traits dominate over education in explaining technical efficiency reiterates the importance of early childhood interventions (e.g., parenting and schooling) that are beneficial to the development of personality in the long run. In addition to delivering academic knowledge, formal education at rural primary and vocational schools should underline the promotion of the psychological health and development of students to foster certain personality traits (e.g., emotional control) that can be rewarded at a later stage in the labour market (Heckman, 2000) or through self-employment in farming or otherwise. In sum, several policy measures may take the farmer's personality into account by stimulating certain favourable personality traits via education in the long run, or enhancing skills to overcome unfavourable traits in the medium or short run.

Chapter 6: Synthesis

6.1 Introduction

Smallholder farming dominates agricultural production in most developing countries and it plays a substantial role in global agricultural systems. Smallholder farmers shape their livelihoods and economic lives based on their skills, household assets, markets and other factors. In general, they produce between 60 and 80 percent of the total food consumed in developing countries (FAOSTAT, 2018). Although the differences across countries in these small farms could be significant due to the rather diverse agro-climatic systems, a common characteristic shared by all smallholders is that they have to make a range of decisions in an economic environment where markets are often incomplete, imperfect or even absent and many risks and uncertainties are involved, such as volatile prices and adverse weather conditions. Therefore, unravelling factors affecting smallholders' farm decision making in such circumstances to improve agricultural development and smallholders' welfare in rural areas is of importance to society and academia.

The importance of individual differences in decision making has been looming large since the growth in development of behavioural economics. In particular, differences in individual personality traits have been considered pivotal in manifesting differences in thoughts, feelings, and actions (John et al., 2010). Recent publications by Borghans et al. (2008) and Rustichini (2009) further called for research attempting to integrate personality traits and decision theory in order to provide more behavioural insights to understand human behaviour. Inspired by these pieces of literature, as well as a growing awareness of the use of personality and economic preferences (and individual differences in general) in economic research (Almlund et al., 2011; Becker et al., 2012; Rustichini et al., 2016), this thesis sets out to understand the smallholders' farm decision making and behaviour by examining the contribution of individual differences in personality traits and economic preferences, to which much less attention has been paid in the literature up till now.

This thesis addresses four specific research questions to provide more insights into this research gap for the benefit of policy making. First, given that perception of land tenure security is an important precondition for smallholders to make farm investments that are beneficial to sustainable agricultural production, are psychological differences the driving factors in shaping this perception, and if so, how do these psychological factors play such a role (Chapter 2)? Second, as land is an essential (quasi-

fixed) input in agricultural production, what is the effect of personality traits on smallholders' land renting behaviour, and what are the underlying mechanisms through which personality traits exert this effect (Chapter 3)? Third, what are the associations between smallholders' risk and time preferences, and their decisions on using variable inputs, such as fertilizers? Do personality traits also play a role in these associations (Chapter 4)? Last, but not least, what is the impact of personality traits on the overall farm performance (e.g., technical efficiency)?

This last chapter aims to present and discuss key findings obtained from the research chapters of the thesis. Lessons learned from each chapter are then integrated from a thesis-wide perspective to draw a general conclusion and provide implications for policy making. Limitations and recommendations for future studies are also discussed. The remainder of this chapter is as follows. Section 6.2 recaps the key findings for each of the four research questions mentioned above. Section 6.3 presents a reflection on the contribution of this thesis to scientific literature. Section 6.4 draws an overall conclusion by combining all the research findings as a whole. Section 6.5 suggests implications for policy making. Finally, Section 6.6 addresses limitations of this study and offers suggestions for future research.

6.2 Key findings

6.2.1 ***Personality traits are related to both cognitive and affective components of smallholders' perception on land tenure security***

In Chapter 2, we decompose the concept of perceived tenure insecurity (PTIS) of land into two theoretically different components (i.e., cognitive PTIS and affective PTIS), based on social-psychological dual-process theories. The empirical estimation results from a recursive structural cognitive–affective model that shows that the cognitive PTIS and the affective PTIS of smallholders in rural China may not be linearly related. In contrast, this study finds a non-linear (inverse "U-shape") relationship between (cognitive) expectations and (affective) worry or fear, showing that the two components may diverge. In other words, a farmer's high expectation of potential land reallocations in the future may not necessarily mean that he/she will have a serious degree of anxiety or worry about it. Hence, PTIS is a composite psychological concept and is subject to both cognitive (i.e., thought-related) and affective (i.e., feelings-based) considerations.

Further investigation into the factors affecting these two components of perceived land tenure security reveals that neuroticism undermines smallholders' overall perceived tenure security. Our results indicate that, on the one hand, smallholders scoring high on neuroticism cognitively perceive a higher

probability of unstable land tenure due to possible land reallocations in the near future. On the other hand, this study shows that more neurotic smallholders are also more likely to be affectively worried about the potential land reallocations. Other personality and preference factors do not show significant relationships with PTIS, with one exception: that farmers scoring high on extraversion perceived a higher likelihood of future land reallocations (cognitive PTIS). We also find that cognitive and affective PTISs are affected by different socio-economic factors, which supports the notion that they are essentially two inter-related, but different elements.

*6.2.2 **Personality traits affect smallholders' land renting behaviour***

In Chapter 3, we investigate the effect of smallholders' personality traits on their land rental market decisions. The results from our empirical analysis show that, beyond external factors such as socio-demographic and institutional factors, personality traits do significantly affect smallholders' farmland renting behaviour. Specifically, estimates from a probit model show that the main personality traits affecting smallholders' overall land rental market participation are openness to experience and locus of control [LoC]. Smallholders with a higher level of openness are more active in participating in the farmland rental market, while smallholders with strong internal LoC generally tend to seize opportunities to rent in land, rather than rent out land and focus on off-farm opportunities. Furthermore, results from the causal mediation analysis suggest that smallholders' achievement desire (need for achievement) is the channel through which internal LoC incentivizes a smallholder's intention to rent land. These findings show that certain traits may intrinsically motivate individuals to participate in land renting activities.

*6.2.3 **Preferences towards risk tolerance and patience predispose rice smallholders to use green (organic) fertilizers***

In Chapter 4, we investigate whether risk preference, time preference, and personality traits affect the use of synthetic and organic fertilizers among Chinese rice farmers. We find that risk tolerance and patience are positively associated with the use of organic fertilizers in rice production, while the intensity of synthetic fertilizer use is not significantly associated with the economic preference measures. We then find that personality traits do not directly affect fertilizer use decisions by including Big-Five personality traits factors into the model. Also, by adding interaction terms in the model, we further show that the associations between risk and time preferences and (synthetic and organic) fertilizer use do not depend on specific personality traits, indicating that personality traits do not play a significant indirect role (through moderating the effects of preferences) in fertilizer use decisions either. In addition, the same associations regarding the possibility that farmers may make joint

decisions about the uses of synthetic and organic fertilizers are examined through a simultaneous equation system. The result suggests that the two forms of fertilizer are not viewed as substitute inputs for each other by farmers in rice production.

*6.2.4 **Personality traits have a direct impact on farm performance***

In Chapter 5, we focus on the overall contribution of personality traits to farm performance by using the farm's technical efficiency as an indicator for performance, and applying stochastic frontier analysis to household-level survey data collected in three major rice-producing provinces in China. This study finds strong evidence that rice farmers' personality traits significantly affect their technical efficiencies in rice production. In particular, farmers who are open and conscientious as well as having an internal locus of control are found to have better capabilities in operating their farms. On the other hand, farmers who are more extravert, agreeable, or neurotic, or who have an external locus of control, tend to perform worse in the management of their rice farms. Another important finding from this study is the insignificant effect of education in explaining technical efficiency. These findings, as a whole, show that personality traits, as the motivational component of human capital, can be of much greater importance for farmer's managerial performance than cognitive skills attained through formal education.

6.3 Scientific relevance

This overall thesis draws a full picture of how those often-unobservable human factors, such as personality traits and preferences, are of relevance to smallholder farmers' decisions and behaviours regarding agricultural production and farm operation. By providing theoretical and empirical evidence from rural China, its contributions to the scientific literature mainly fall under the following dimensions.

*6.3.1 **How to measure the perceived land tenure security: a revisit?***

Compared to legal- or *de facto* land tenure security, perceived land tenure security is often considered more important as farmers themselves are believed to make land-related investment decisions based on their subjective perceptions of tenure security (Ma et al., 2015; Sjaastad & Bromley, 2000). However, what exactly this perception is has not been well-defined in the literature. Most of the empirical research on perceived tenure security merely uses landholders' subjective estimates of the likelihood of future eviction to proxy perceived land tenure insecurity (Ghebru & Lambrecht, 2017; Holden & Yohannes, 2002; Ma et al., 2013; Ren et al, 2019a). But an important presumption

underlying this is the consequentialist reasoning of decision making, which portrays decision making as a purely cognitive process (Elster, 2009). In other words, it presumes that a farmer's utility of a specific tenure situation arises from a thought-based calculus of land eviction, which is associated with his/her emotional feeling in a linear-like way (Rick & Loewenstein, 2008). However, few studies have challenged the authority of this consequentialist reasoning and argue that perceptions of tenure security can be a dual process, consisting of both a cognitive component and an affective component reflecting the feelings of worry and anxiety evoked by an insecure situation (Van Gelder, 2007; 2009). Indeed, emerging behavioural studies show that thought-based risk perception may diverge or even flow in opposite directions from the affect-based mental operations in decision making (Loewenstein, 2001; Nesse & Klaas, 1994; Slovic et al., 2002; Van Gelder, 2007).

Our findings in Chapter 2 also contribute to the academic debate about the accurate measurement of perceived land tenure security in developing countries. We found a non-linear (inverse "U-shape") relationship between farmers' cognitive expectation (risk perception) of land tenure and affective worry or fear, showing that these two components can diverge. In other words, without taking a farmer's affective component into account, measuring cognitive expectations alone may only partially reflect a farmer's perceived land tenure security or insecurity. This insight is in line with the claims by Van Gelder (2007) that the notion of perceived tenure security should go beyond the traditional concept as a purely cognitive probability assessment and should also include psychological components.

6.3.2 ***Incorporate personality traits into the economic analysis of smallholders' decisions making?***

In recent years, economists have called for research attempting to integrate two different theories of human behaviour – the personality theory developed by psychologists and the decision theory derived from the *a priori* analysis by economists – in explaining individual differences in economic behaviour (Borghans et al., 2008; Rustichini et al., 2011). In fact, it has been argued that internal or psychological characteristics might be fundamental factors affecting rural smallholders' agricultural production and investment decisions (Bernheim et al., 2015; Bertrand et al., 2004; Duflo et al., 2011; Haushofer & Fehr, 2014). However, although a growing number of empirical studies have started focusing on the roles of personality traits in people's decision making in various research areas, including financial investment, labour market participation, and households' asset allocation (Brown & Taylor, 2014; Fletcher, 2013; Flinn et al., 2020; Oehler et al., 2018), only a few studies address the role of personality traits in agricultural production decisions of rural residents, and this is done in a rather piecemeal way (Abay et al., 2017; Ali et al., 2020; Wuepper et al., 2020).

By providing a comprehensive conceptual framework with corresponding empirical evidence, this thesis enriches this strand of literature. It primarily adds value to scientific knowledge on the effect of personality traits on the decision making of rural smallholders based on the following three dimensions. First, Chapter 2 shows that personality traits shape farmers' perceptions and beliefs on land tenure security. This finding may help to provide empirical evidence that connecting personality traits with the widely-known theory of planned behaviour, in which various forms of belief are considered as the major determinants of intentions and behaviour, could be possible (Ajzen, 2005). Second, findings in Chapter 3 show that openness is associated with smallholders' participation in the farmland rental market and internal locus of control is associated with their intention to rent land. These findings offer insights into the role of personality traits in smallholders' strategies regarding farm scale management using land rental markets. Third, Chapter 3 also shows that personality traits can influence land renting decisions through smallholders' achievement desires. This mechanism supports the idea that personality traits can create a predisposition to entrepreneurial activities, as suggested by other studies (Hansemark, 2003; Zhao et al., 2010). Hence, incorporating personality traits into the economic analysis of farmers' behaviour is very valuable for sketching a more complete picture of their decision-making process.

6.3.3 ***What are the relationships between personality traits and economic preferences?***

Although personality traits and economic preferences seem to be conceptually related, much empirical debate has focused on the question of whether they are actually substitutes for each other or mutually exclusive. Some literature suggests that economic preferences might be specific facets or aspects of personality as they are found to be closely associated with a few dimensions of the Big-Five personality traits (Borghans et al., 2009; Costa & McCrae, 1988; Daly et al., 2009), while other studies argue that preferences and personality traits are rather complementary to each other (Becker et al., 2012; Borghans et al., 2008; Ferguson et al., 2011; Roberts, 2009). Drawing upon these arguments, one might speculate that there are possibilities that economic preferences may mediate or moderate the effects of personality constructs in determining human behaviour. Empirical evidence for these potential relationships, however, is rather limited.

Our empirical findings in Chapter 3 and Chapter 4 enrich this strand of literature. In Chapter 3, we tested the potential possibility that risk preferences could be mediators for the effect of personality traits on land renting decisions. The correlation analysis shows that risk preference (risk-seeking) is significantly correlated with Big-Five personality traits and locus of control at the 1% significance level, which is much in line with previous observations by Becker et al. (2011) and Dohmen et al.

(2010). However, mediation analysis shows that no significant mediation effect of risk preference is found. On the other hand, we investigated if risk and time preferences could serve as moderators for personality traits, or the other way around, in shaping smallholder farmers' fertilizer use decision in Chapter 4. Although we used a different set of survey data in this study, the correlation matrix shows a very similar result regarding the correlations between personality traits and economic preferences, compared to the one we obtained in Chapter 3. Nevertheless, estimation results show that no significant moderation effect is found, suggesting that the associations between risk and time preferences and (organic) fertilizer use do not depend on personality traits. Taking findings from these two chapters as a whole, we can conclude that Big-Five traits and economic preferences are inter-related, but represent distinctive features of personality, which supports Becker et al.'s suggestion (2012) that personality traits may be used as a complement to economic preferences in the analysis of inter-individual differences. A similar empirical result is also found when it comes to explaining Ukrainians' propensity to migrate (Ayhan et al., 2019). Furthermore, despite not being found in our studies, potential mediation or moderation effects may still exist in other decision making of a farmer as the effect of economic preference could be very situational- or domain-specific (Weber et al., 2002).

*6.3.4 **Human capital and farm performance: making space for personality traits?***

A large body of research has documented the importance of human capital, particularly cognitive skills such as education, IQ, and experience, in producing social and economic success (Hanushek & Woessmann, 2008; Heckman et al., 2018; Serneels, 2008). However, these conventional human capital measures have come under criticism as they could not adequately capture noncognitive motivations—personality traits, goals, and preferences that are also valued in schools, in the labour market, and in many other domains (Cobb-Clark & Tan, 2011; Heckman et al., 2006; 2013; Sutin et al., 2009). In some cases, noncognitive traits are even found to be more powerful in explaining labour market outcomes than cognitive skill indicators (e.g., education) (Heckman & Rubinstein, 2001; Heineck & Anger, 2010). In light of those studies, we scrutinized the literature for the effect of human capital on agricultural performance, and found rather mixed results regarding the effects of farmers' education and farming experience on the technical efficiency of a farm. Education in some studies is found to be significant (e.g., Solis et al., 2009; Ma et al., 2017; Tan et al., 2010), but not in others (e.g., Hong et al., 2019; Koirala et al., 2016; Villano & Fleming, 2006). Nevertheless, little is known about whether noncognitive motivations can also help to explain variation in farm performance among rural farmers.

Chapter 5 contributes to filling this scientific research gap by providing strong evidence that almost all personality traits, except for conscientiousness, are significantly associated with Chinese rice

farmers' abilities to maximize their farm-level rice output for given input quantities. Another notable finding in this chapter is the insignificant effect of education in explaining farm technical efficiency, which contributes to the literature in labour economics. It shows that the noncognitive motivations are more powerful factors than cognitive skills attained from formal education, not only in determining performance in wage employment as shown in the literature, but also in the self-employed farming sector. This is also consistent with the finding observed from Ghanaian smallholders by Ali et al. (2020).

6.4 General remarks and policy implications

Combining all research findings as a whole, this thesis shows that individual differences in personality traits and preferences are very much relevant in explaining heterogenous decisions and behaviours observed in smallholders' agricultural production and farm management. In particular, we find that different personality traits are directly associated with different kinds of smallholder farmers' decision-making processes, including subjective beliefs or perceptions, intentions, and behaviours. These results provide evidence that personality traits are one of the most fundamental patterns of thought, feelings, and behaviour that can persist from one decision situation to another (Wood & Boyce, 2017), and thereby underline the importance of personality traits in the context of agricultural decision making, which has received very little attention in the literature up till now. On one hand we find that personality traits may indirectly affect land renting behaviour through higher achievement desire, which to some extent opens the black box of showing the mechanism through which these fundamental individual differences in terms of personality traits exert their effects on people's behaviour. On the other hand, this thesis shows that risk and time preferences, instead of personality traits, affect farmers' decisions on fertilizer use in production. These results suggest that the role economic preferences and/or personality traits play in agricultural decision making differs by different types of decisions.

Taken as a whole, although our study is based on the premise that reducing external constraints (i.e., market failures for land, labour, and/or food) retains a central role for facilitating rural agricultural development and rural welfare, we emphasize that smallholder farmers may also suffer from intrinsic psychological constraints in making agricultural decisions. For instance, neuroticism is found to not only undermine smallholders' overall perceived tenure security (Chapter 2), but to also have a significant inefficiency-enhancing effect on farm management (Chapter 5). On the other hand, farmers who are open to experience and who have a strong internal locus of control are more inclined to

participate in land rental markets (Chapter 3), and demonstrate higher technical efficiency in operating farms (Chapter 5). Furthermore, risk aversion and impatience tend to pose barriers for farmers' consideration of using more sustainable agricultural inputs (Chapter 4). These findings imply that reducing those external socio-economic constraints alone may not translate into straightforward and immediate improvements in rural smallholders' welfare, nor in gains in agricultural production through greater technical efficiency as policymakers expected.

Designing policies based on how people should behave on average without considering heterogeneous behaviour has frequently resulted in unintended outcomes. The findings outlined above therefore have the important policy implication that taking rural smallholders' personality traits into account may increase the effectiveness of rural policies aimed at improving agricultural development and enhancing the welfare of groups lagging behind in rural areas of China and possibly also other developing countries. This thesis proposes the following four main directions that can be helpful in tackling the aforementioned personality-related constraints.

First, in the medium- or short run, policymakers may consider training and intervention programmes that can directly improve personality traits. For instance, Jackson et al. (2012) find that inductive reasoning training programmes, supplemented by crossword and Sudoku puzzles, could enhance senior people's openness to experiences. Moreover, Bernard et al. (2014) document some simple behavioural interventions that can improve farmers' locus of control and forward-looking behaviour. Roberts et al. (2017) further observe that neuroticism could still be directly improved via social skills training or cognitive–behavioural therapy in adulthood. As our findings highlight the positive roles of openness and internal locus of control, and the negative role of neuroticism on smallholder's decision making and farm performance, such interventions have the potential to enhance rural smallholders' farm management performance, and so improve their welfare and the overall agricultural production. In addition, providing more extensive rural entrepreneurial programmes for young and middle-aged farmers could yield positive outcomes for family farm operations, given the mediating role of need for achievement found in this study.

Second, policy instruments focusing on enhancing cognitive and social skills may also be considered to help farmer overcome unfavourable traits in certain circumstances. Directly nudging farmers' personality traits may not be an easy task sometimes. As a result, those agricultural training programs can think of improving farmers' competitive skills to offset the negative effects of their unfavourable personality traits or behavioural biases on farm management. For instance, Duflo et al. (2011) show

that farmers may underinvest essential productive inputs (i.e., fertilizers) at an appropriate period of time due to their nature of being present biased and procrastination, and a low-cost commitment device can help to overcome this time-inconsistency. Moreover, other 'soft' or social skills that might be related to entrepreneurial success are also crucial to farmers as they are not always work alone and their farms are open systems that interact with other actors. These competences may include self-management, communicational skills, the ability to work under pressure, critical thinking, attention to detail, emotional intelligence, and so on (Chamorro-Premuzic et al., 2010; McElwee, 2006). Introvert farmers, for instance, may benefit from such kind of trainings focusing on communication skills.

Third, in the long run, government can intervene in the formal education system in rural areas. The current rural education system, which has long focused on the improvement of cognitive skills (e.g., knowledge), should also consider fostering character-, behavioural-, and social skills that are likely to be rewarded in later life outcomes in the long run. Personality traits tend to be fairly stable during adulthood (Cobb-Clark & Schurer, 2012; Roberts et al., 2006), but empirical evidence has shown that they can be shaped particularly in childhood and young adulthood (Roberts et al., 2006; Robins, 2001). Researchers therefore have suggested that character education is necessary to develop moral and emotional strengths (Dweck, 2007; Heckman, 2000; Heckman & Kautz, 2014). This kind of character education might be achieved through, for example, a cinematic approach. For instance, the film classic "The Wizard of Oz" has shown the effectiveness of encouraging character traits such as openness and determination (Russell III & Waters, 2010).

Fourth, policymakers may customize the promotion of sustainable agricultural practices according to smallholders' risk and time preferences profiles. Given our findings that risk and time preferences may predispose or motivate smallholders' organic fertilizer use decisions, it is reasonable to assume that a policy promoting the voluntary use of sustainable agricultural inputs (e.g., organic fertilizer) can run into a bottleneck. Unlike capital market investors, rural farmers could not actively conduct risk allocation according to their own preferences due to the pervasive external risk factors involved in agricultural production. Therefore, these one-size-fits-all policy approaches may not function well. Moreover, risk reduction measures are necessary as well rather than depending on pure financial incentives (e.g., subsidies) to foster organic fertilizer use. For instance, farmers' perceived risk of growing weeds or attracting pests when organic fertilizers are adopted could be eliminated by introducing agricultural extension programmes that pay more attention to disseminating technical knowledge about organic fertilizer application.

6.5 Limitations and suggestions for future studies

To our knowledge, this thesis is the first attempt to systematically investigate the effect of personality traits and economic preferences on smallholder farmers' heterogenous decision making in agricultural production and farm management. Despite the extensive analysis we have conducted, there are several limitations in this study we have to acknowledge.

A major limitation revolves around the difficulty of measuring smallholders' personality traits, which are among the core variables in this study but cannot be directly observed like many socio-economic and demographic variables (e.g., prices, age, gender, and etc). Throughout all of the four empirical research outlined in this thesis, we adopted the 10-item version of the Big-Five inventory (BFI-10) developed by Rammstedt & John (2007) to measure farmers' Big-Five personality traits as the response time for each farmer participant was truly limited. Although this measure is proved to be an appropriate measure retaining sufficient reliability and validity in China and elsewhere compared to the well-proven 44 items from the BFI (BFI-44) (Carciofo et al., 2016), the possibility of measurement errors remains compared to using full-scale BFI-44 (Gosling et al., 2003). Thus, BFI-44 possessing clear psychometric advantages is encouraged to use in the future when testing time is not extremely limited.

Second, establishing either a causal personality–land renting or a causal personality-efficiency relationship should be done with caution. We viewed personality trait factors as fixed variables in the model estimations because they are largely determined by genetic inheritance and parenting investments in early childhood (Bouchard & Loehlin, 2001; Cobb-Clark & Schurer, 2012; Srivastava et al., 2003). Moreover, the analysis is limited by the only available cross-sectional data on the other. Nevertheless, some scholars recently have argued that this kind of assumption might be too arbitrary as personality traits and also economic preferences might still change throughout the lifespan, due to age-related maturation and degeneration processes, environmental influences, and rewards or lack thereof (Schildberg-Hörisch, 2018; Specht et al., 2011; 2014). We therefore could not completely exclude the concern of endogeneity of personality traits and we advise future studies focusing on the effect of personality on specific agricultural decision making to address this identification issue using longitudinal data.

Third, although we conceptualized several underlying factors through which personality traits and preferences may affect farmers' on-farm decision making, they may actually represent only a small

fraction of possibilities in the black box of the personality–behaviour relationship. Future research may endeavour to explore possible underlying factors in order to disentangle the intermediate roles played by economic and non-economic motivations in shaping this relationship.

Fourth, this study mainly focuses on rice farming in China. Farmers growing other crops make similar (land and fertilizer) input use decisions and may perceive similar tenure insecurity caused by government policies and regulations. There are no a priori reasons to expect that personality traits, like openness or neuroticism, would affect these decisions and perceptions differently. Some of the main results obtained in this study are therefore expected to be also valid for farmers growing other crops in the same regions. The results for technical efficiency, however, are more likely to be related to the type of crop that is grown. Production technologies differ between different crops, and management requirements and therefore also technical efficiency may differ accordingly.

Last, our study employed several large data sets showing a large variety of farmers' behaviours and personalities. Since our results on the structural relationships between personality, preferences and behaviours are based on such a large variety of information, we expect that they will also hold in different areas where behaviours and personalities fall within the range observed in the data sets that we used. However, care should be taken in generalizing the results to more ethnically diverse regions, as the respondents in our study areas almost entirely belong to the Han majority. Certain behaviour of farmers may be sensitive to ethnicity or indigenous culture, as has been observed for example for land rental market participation (Min et al., 2017). We therefore recommend that future studies test the external validity of our main findings in various other settings.

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Summary

A large literature highlights the impact of individual differences, including personality traits and economic preferences, on key labour market outcomes. Yet, much of their impact on rural smallholder farmers' agricultural production decisions remains unclear. Managing a farm requires making and implementing a range of decisions under uncertain conditions and, in many developing countries, often imperfect or even absent markets for inputs and outputs. The outcomes of these decisions have important consequences for the livelihoods of their households as well as rural welfare in a broader sense.

The current thesis aims to unravel the roles of personality traits and economic preferences in smallholders' farm management. It starts with an investigation of smallholders' perceived land tenure security from a psychological perspective, where the farmer's tenure insecurity perception is conceptualized as having both a cognitive and an affective component. Psychological factors such as personality traits are expected to influence both components. The subsequent two chapters examine the effects of personality traits and preferences on two important agricultural production decisions: land renting and fertilizer use. This is followed by an investigation of the effect of smallholders' personality traits on their overall farm management performance, using technical efficiency as an indicator. The data sets used for the empirical analyses are based on two different farm household surveys. One survey took place in Liaoning, Jiangsu, and Jiangxi provinces of China in February 2019. The other survey was held in Handan prefecture, Hebei province on the North China Plain in February 2018.

The thesis consists of six chapters in total. Chapter 1 provides a general introduction. It presents the motivation of the research, the main objective and research questions, the theoretical framework, and the empirical methodologies.

Chapter 2 studies the influence of psychological factors on farmers' perceived land tenure insecurity. The concept of perceived tenure insecurity (PTIS) is decomposed into a cognitive and an affective component. A recursive structural cognitive-affective model is developed and estimated using structural equation modelling. The estimation results indicate that a non-linear (inverse "U-shape") relationship exists between farmers' risk perceptions of land tenure and their affective feeling of worry to it, suggesting that these two components may diverge. Farmers expecting a land reallocation in the

near future may not necessarily attach a high degree of anxiety or worry to it. This supports the "risk-as-feeling" proposition that feelings do not always correspond with perceived risk estimates. We further find that farmers' perceptions of land tenure insecurity are significantly affected by neuroticism and extraversion, but not by the other personality traits nor economic preferences that we distinguish.

Chapter 3 investigates the effect of smallholders' personality traits and preferences on their land rental market decisions. The results from our empirical analysis show that, beyond external factors such as socio-demographic and institutional factors, personality traits do significantly affect smallholders' farmland renting behaviour. Specifically, estimates from a probit model show that the main personality traits affecting smallholders' overall land rental market participation are openness to experience and locus of control [LoC]. Smallholders with a higher level of openness are more active in participating in the farmland rental market, while smallholders with strong internal LoC generally tend to seize opportunities to rent in land. Furthermore, results from the causal mediation analysis suggests that desire for achievement is the channel through which internal LoC incentivizes a smallholder's intention to rent land.

Chapter 4 examines whether risk aversion, impatience, and personality traits are associated with Chinese rice farmers' use of synthetic and organic fertilizers. We find that risk tolerant and patience are positively associated with the use of organic fertilizer in rice production, while the intensity of synthetic fertilizer use is not significantly associated with economic preference measures. Personality traits are found not to play a direct role nor an indirect role, through moderating the effects of preferences, in fertilizer use decisions. The estimation results from a simultaneous equation system suggest that the two forms of fertilizer are not viewed as substitute inputs to each other by farmers in rice production.

Chapter 5 focuses on the overall contribution of personality traits to farm performance, using farm's technical efficiency as an indicator of performance. Applying stochastic frontier analysis to input and output data collected among rice farmers, we find strong evidence that personality traits significantly affect their technical efficiency. In particular, farmers who are open and conscientious as well as have an internal locus of control are found to have better capabilities in operating their farms. On the other hand, farmers who are extravert, agreeable, or neurotic, or who have an external locus of control, tend to perform worse in the management of their rice farms. Another important finding from this study is the insignificant effect of education on technical efficiency. These findings, as a whole, show that

personality traits, as the motivational component of human capital, can be of much greater importance for farmer's managerial performance than cognitive skills attained through formal education.

Lastly, chapter 6 presents a synthesis. Key findings obtained from the research chapters, lessons learned, policy implications, limitations, and recommendations for future studies are discussed. Specifically, this thesis concludes that, although reducing external constraints (particularly, market failures for land, labour, and/or food) retains a central role in facilitating rural agricultural development and rural welfare, smallholder farmers may still suffer from intrinsic psychological constraints in making agricultural decisions.

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Chen Qian
Wageningen School of Social Sciences (WASS)
Completed Training and Supervision Plan

Name of the learning activity	Department/Institute	Year	ECTS*
A) Project related competences			
Advanced Econometrics, YSS-34306	Wageningen University & Research	2017	6
Advanced Microeconomics, ECH-51806	Wageningen University & Research	2017	6
Behavioural and Experimental Economics, ECH-51306	Wageningen University & Research	2017	6
Research Proposal	Wageningen University & Research	2017	6
B) General research related competences			
Introduction Course	WASS	2017	1
Research Methodology: From topic to proposal	WASS	2017	4
'Personality traits, preferences, and arable land renting decisions'	10th CAER-IFPRI Annual Conference, Guangzhou, China	2018	1
'Building a model to stimulate: How the New Socialist Countryside Program affects rural residences' social welfare'	Chinese Economists Society (CES) Conference 2019, Dalian, China	2019	1
'Land tenure insecurity in rural China: An economic psychological perspective'	IAMO Workshop, Halle, Germany	2020	1
'Economic preferences, personality traits, and fertilizer application: Evidence from rice farmers in Eastern China'	2021 International Conference in Development Economics (Online), Bordeaux, France	2021	1
C) Career related competences/personal development			
Teaching Assistant: Rural Households and Livelihood Strategies (DEC-20306)	Development Economic Group	2017	2
Scientific Writing	Wageningen in'to Languages	2017	1.8
Academic Writing and Presenting in English	WGS	2016	1.75
Efficient and Effective Academic Development	WGS	2016	1.75
Total			**40.3**

*One credit according to ECTS is on average equivalent to 28 hours of study load

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