Essays on the Transformation of the Rural Economy in Rubber Producing Areas in Southwest China

Von der Wirtschaftswissenschaftlichen Fakultät

der Gottfried Wilhelm Leibniz Universität Hannover

zur Erlangung des Grades

DOKTORIN DER WIRTSCHAFTSWISSENSCHAFTEN

– Doctor rerum politicarum –

Dr. rer. pol.

genehmigte Dissertation von

M.Sc. Haowen Zhuang

2022

Referent: Prof. Dr. Hermann Waibel

Institut für Entwicklungs- und Agrarökonomik

Wirtschaftswissenschaftliche Fakultät

der Gottfried Wilhelm Leibniz Universität Hannover

Korreferent: Prof. Dr. Shi Min

Huazhong Agricultural University

Wuhan, China

Tag der Promotion: 25. Nov. 2022

ACKNOWLEDGMENTS

Finally, my long PhD journey has reached the moment to conclude.

First and foremost, I would like to extend my sincere gratitude towards Professor Dr. Hermann Waibel who have supported me to win the CSC scholarship and provided me the opportunities to conduct a PhD research in the Institute of Development and Agricultural Economics, Leibniz Universität Hannover. Under his supervision and guidance, I grow up gradually from a person who was new to Stata to whom now is able to complete a research paper independently. His patience, encouragements always surround me whenever I lose confidence. His dedication, enthusiasm for real knowledge and surveys have impressed and inspired me. Without his continuous support, invaluable advice and guidance, it wouldn't have been possible for me to reach here. I am greatly grateful to all his contributions during my PhD journey. All the experience we've had in Germany and Xishuangbanna definitely are the precious treasure I will always cherish.

Then I would like to thank Prof Dr. Shi Min for agreeing to be my second supervisor. His preceding efforts and contributions have laid a solid foundation for our follow-up surveys and researches in Xishuangbanna. His involvement, guidance, suggestion and fully support are also an important guarantee of the success of the third wave survey conducted in 2019. His valuable and constructive comments have helped me improve my papers and thesis.

I also would like to thank all the friends and colleagues at the Institute of Development and Agricultural Economics and at the Institute for Environmental Economics and World Trade, Leibniz Universität Hannover, Germany for their valuable comments on my papers and company of my doctoral life. My specially thanks go to Prof. Dr. Ulrike Grote for her invaluable comments during the doctoral seminars. I particularly thank Dr. Shaoze Jin for his insightful suggestions to help me improve my papers. I also want to thank all of my supportive friends (Jiafeng, Mango, Linyun, Yilin, Heng Zhang, Manuela etc) who have accompanied me, cheer me up with their mental support in the long journey of my PhD life. In addition, I feel fortunate to meet my role model: Ms. Xiao Wang and her "Chenzao community" who inspires me to embrace difficulties and challenge myself.

Moreover, I am grateful to the members of "Dream team" in Xishuangbanna project. Besides Prof Dr. Shi Min and Dr. Shaoze Jin, specially thanks to Professor Dr. Jikun Huang, Prof. Dr. Junfei Bai, Dr.Ting Meng for their continuous support and concern of the field surveys conducted in Xishuangbanna. Also, without the efforts and cordial participation of Niels Wendt, Hanning Lu, Dr.Da Li, Yizhou, Zac and all enumerators, the field survey in 2019 and case study in Manxiu village would not have conducted so smoothly.

In addition, I would like to take this opportunity to thank China Scholarship Council (CSC) who have offered me financial support to study in Germany between 2016 and 2020, and also thank the Deutsche Forschungsgemeinschaft (DFG), and the National Natural Science Foundation of China (NSFC) for the financial support of Xishuangbanna project.

Subsequently, I like to thank my family members in China –my parents, my younger brother and my relatives, for their immense support and unconditional love. Even though we do have experienced something unexpected and had some struggling time within these years, they still don't put too much pressure on me. I feel grateful and would love to express my earnest love to my mom, my father and my brother.

Finally, I would like to thank all the things I have experienced, all the people I have encountered in this journey, good or bad, up or down, all have constituted my doctoral life. No matter how hard it is, there is always beauty can be found!

Thank you! 感谢!

Haowen Zhuang 庄皓雯

August 2022

Hannover, Germany

ZUSAMMENFASSUNG

Ziel dieser Arbeit ist es, ein besseres Verständnis über die Strategien von kautschukproduzierenden Kleinbauern in Südwestchina zur Sicherung deren Lebensunterhaltes zu schaffen. Dabei bezieht sich die Arbeit auf die autonome Präfektur Dai in Xishuangbanna (XSBN) in der Provinz Yunnan. In dieser Region haben sich die Naturkautschukplantagen aufgrund der hohen Kautschukpreise stark ausgeweitet und dabei traditionelle Anbausysteme und den Regenwald verdrängt. Dadurch hat wurde Wirtschaftswachstum und Armutsminderung erreicht, es sind gleichzeitig aber auch negative Umwelteffekte entstanden. Allerdings sind die Kautschukpreise ab 2011 wieder gefallen, was insbesondere in marginalen Gegenden, mit geringerer Produktivität, d.h. in höheren Lagen, zu Einkommensverlusten geführt hat. Gleichzeitig sind in der Region aber auch außerlandwirtschaftliche Arbeitsplätze entstanden, wodurch neue Beschäftigungsmöglichkeiten für Kautschukbauern geschaffen wurden.

Die vorliegende Arbeit hat drei Ziele, die in drei Artikeln behandelt werden. Diese werden in den Kapiteln zwei bis vier in der Dissertation vorgestellt: (1) Identifizierung und Klassifizierung der Lebensunterhaltsstrategien von Kautschuk-Kleinbauern sowie deren kurz- und mittelfristige Anpassung (Papier 1); (2) Analyse der Auswirkungen der außerlandwirtschaftlichen Beschäftigung von Kautschuk-Kleinbauern auf das Haushaltseinkommen und die Wohlfahrt (Papier 2); (3) Abschätzung der Auswirkungen einer Beteiligung am Landpachtmarkt auf das Haushaltseinkommen und dessen Zusammensetzung (Papier 3). Die Daten für diese Arbeit stammen aus einem Paneldatensatz über drei Wellen. Die Daten wurden bei 612 Kautschuk-Kleinbauern in XSBN in den Jahren 2013, 2015 und 2018 erhoben. Es wurde ein geschichtetes Zufallsstichprobenverfahren unter Berücksichtigung von Standort und Kautschukfläche verwendet. Die Stichprobe gilt als repräsentativ für den kleinbäuerlichen Kautschukanbau in XSBN. Als Erhebungsinstrumente wurden standardisierte Haushalts- und Dorffragebögen eingesetzt.

Um die Ziele zu erreichen, wurden verschiedene methodische Ansätze verwendet. In der ersten Arbeit wird das theoretische Konzept zur Analyse dynamischer Lebensunterhaltsstrategien sowie eine hierarchisch-agglomerative Clusteranalyse verwendet, um die Lebensunterhaltsstrategien zu identifizieren. Darauf aufbauend erfolgt eine multi-nomiale Logit-Regression und eine Schätzung mit Hilfe eines Kleinstquadrate-basierten Logit-Regressionsmodell, mit dem Ziel die Determinanten der Dynamik der Lebensunterhaltsstrategien zu identifizieren. In der zweiten Arbeit wird ein zweistufiges Kleinstquadrate-Modell verwendet, um die Faktoren zu identifizieren, die Kautschukbauern zur Aufnahme außerlandwirtschaftlicher Beschäftigung veranlassen. Daran schließt sich ein bi-variates endogenes Switchingmodell mit instrumentellen Variablen an, um die Auswirkungen der Aufnahme außerlandwirtschaftlicher Beschäftigung auf das Haushaltseinkommen abzuschätzen. In der dritten Arbeit werden eine zweistufige Regression mit der Methode der kleinsten Quadrate, ein Tobit- und ein Probit-Modell verwendet, um die durchschnittlichen Effekte der Teilnahme am Landpachtmarkt ab zu schätzen. Des Weiteren wurde eine Mediationsanalyse durchgeführt, um eine mögliche Endogenität zu berücksichtigen.

Die Ergebnisse der Dissertation tragen in vielfältiger Weise zur empirischen Literatur bei. In der ersten Studie wurde festgestellt, dass die Mehrheit der Landwirte zwischen 2012 und 2017, als Reaktion auf sinkende Kautschukpreise, Ressourcen umverteilt und ihre Lebensgrundlagenstrategie geändert haben. Faktoren, die maßgeblich mit der Wahl der Lebensunterhaltsstrategien zusammenhängen, sind, berufliche Tätigkeit und Geschlecht des Haushaltsvorstands, Betriebsgröße, Höhenlage und Transportkosten. Das Haushaltseinkommen unterschied sich signifikant zwischen den Lebensunterhaltsstrategien, ebenso wie der Einkommenseffekt von Änderungen der Lebensunterhaltstrategie. Strategien, die auf selbständiger Tätigkeit, Lohnarbeit oder Landverpachtung basieren, dominieren kautschukbasierte Haushaltssysteme. Durch betriebliche Umstellung konnten konnte die Mehrzahl der Bauern trotz niedrigerer Kautschukpreise ein Absinken des Einkommens verhindern, d.h. sie sind in der gleichen Einkommensgruppe geblieben. In weniger als 20 % der Fälle, bewegten sich die Haushalte in eine niedrigere Einkommensklasse. Nur in wenigen Fällen gelang es, in eine höhere Einkommenskategorie

aufzusteigen. Angesichts des Rückgangs der Kautschukpreise haben sich die Landwirte insgesamt gut auf die neue Situation eingestellt.

In der zweiten Arbeit wurde festgestellt, dass Haushaltsmerkmale und –vermögen, signifikant mit der Erwerbsbeteiligung außerhalb landwirtschaftlicher Betriebe korrelierten. Die Behandlungseffekte sind signifikant, d. h. Haushalte, die am Arbeitsmarkt teilnahmen, erzielten ein höheres Einkommen als Nichtteilnehmende. Die kontrafaktische Analyse (ATU) deutet darauf hin, dass das geschätzte Einkommen erheblich gestiegen wäre, wenn nicht teilnehmende Haushalte teilgenommen hätten. Darüber hinaus hätte ein Verzicht der teilnehmenden Haushalte zwischen 2012 und 2017, deren Einkommen erheblich verringert. Jedoch ist eine wechselnde Beteiligung am außerlandwirtschaftlichen Arbeitsmarkt schlechter als eine Nichtbeteiligung.

In der dritten Studie, zeigen die Ergebnisse, dass die Entscheidungen der Haushalte, Land zu vermieten, signifikant und positiv mit dem Haushaltseinkommen korreliert sind. Im Durschnitt führt die Verpachtung von Land zu einem höheren Haushaltseinkommen, bei gleichzeitiger Verringerung des landwirtschaftlichen Einkommens, was zu erwarten war. Die Ergebnisse der Mediationsanalyse haben gezeigt, dass die Gesamtwirkung einer Teilnahme am Landpachtmarkt sowohl direkte Effekten als auch indirekte Effekte hat, wobei die indirekte Wirkung in der mit der Verpachtung ermöglichten Aufnahme einer landwirtschaftlichen Beschäftigungsmöglichkeit besteht.

Stichworte: Lebensunterhaltsstrategien, außerlandwirtschaftliche Beschäftigung, Landpachtmarkt, Haushaltseinkommen, Südwestchina

ABSTRACT

This thesis aims to contribute to an improved understanding of the livelihood strategies of smallholder rubber farmers in Southwest China, in particular in Xishuangbanna Dai Autonomous Prefecture (XSBN), Yunnan Province. In this region, driven by high commodity prices, plantations of natural rubber have expanded hugely, replacing traditional farming systems and rainforest. This has resulted in economic growth and the reduction of poverty but has also led to environmental externalities. Furthermore, by 2011, the rubber price started to decline, causing income loss, especially in marginal areas with lower productivity, i.e. in higher elevations. At the same time, however, regional labor markets expanded, thus providing potential off-farm employment opportunities for smallholder rubber farmers.

Against this background this thesis has three objectives which are being dealt with in three papers, presented in chapters two to four, respectively: (1) identify and classify the livelihood strategies of smallholder rubber farmers, as well as their transitions on the short and medium term and the impact of changes on household income (paper 1); (2) analyze the effects of off farm labor market participation by smallholder rubber farmers on household income and their overall well-being (paper 2); (3) estimate the impact of land rental market participation on household income and its compositions (paper 3).

The data for this thesis are drawn from a three-wave panel dataset, collected among 612 small holder rubber farmers in XSBN in 2013, 2015 and 2018. A stratified random sampling method was applied, using location and rubber cultivation area as criteria. The sample is believed to be representative for smallholder rubber farming in XSBN. Standardized household and village questionnaires were used as survey instruments.

Different methodological approaches have been applied to achieve the objectives. In the first paper, a dynamic livelihood strategy framework is applied and a hierarchical agglomerative cluster analysis is used to identify livelihood strategies, followed by a multinomial logit regression and an ordered logit regression model to estimates the determinants of livelihood dynamics. In the second paper, a two-stage

least square model is used to identify factors influencing smallholder rubber farmers off farm labor market participation and its intensity. This is followed by endogenous switching instrumental variable models to assess the impact of labour market participation and its transitions on household income. In the third paper, a two-stage least square regression and a tobit and probit model were used to estimate the correlation between renting out land and household income, its compositions. Propensity score matching (PSM) method is then used to estimate the average treatment effects of land rental market participation. Furthermore, a mediation analysis was applied to decompose total impact of renting out land. In order to account for possible endogeneity problems, instrumental variable is included in the analysis.

The results from the thesis contribute to the empirical literature in a number of ways.

In the first study, five livelihood strategies were identified. It was found that majority of farmers reallocate resources and have changed their livelihood strategy between 2012 and 2017, in response to declining rubber prices. Factors significantly related to the choice of livelihood strategies are: occupation and gender of the household head, farm size, altitude and transportation costs. Household income differed significantly between livelihood strategies. The same is true for the income effect of livelihood transitions. Livelihood strategies based on self-employment, wage employment or renting out land dominated rubber-based livelihood system brings largest income for rubber farmers, whereas rubber absolutely dominant strategy falls in the low-income category. By means of livelihood transitions, majority of farmers were able to remain in the same income group in spite of lower rubber prices. 10 % of them in 2014 and 24% in 2018 moved to a lower income category, while approximately 20% of households in 2014 and 2018 have moved in livelihood strategies with higher income. Hence, considering the decline in rubber prices, farmer did well in coping with the situation.

In the second paper, it was found that household characteristics and assets were significantly correlated of labor market participation. The treatment effects are significant, i.e. households who participated in off farm labor markets achieved higher income than non-participants. The counterfactual analysis (ATU) suggests that if non-participating households had participated, their estimated income would have increased significantly. Furthermore, between 2012, 2014 and 2017, households with continuous

participation would have significantly decreased income had they adopted non or discontinuous participation. Income of discontinuous participation would decrease had they never participated. It is can be concluded that continuous participation was superior to non- and discontinuous participation strategies.

In the third study, results show that household's decisions to rent out land is significantly and positively correlated with household income. Results of the average treatment effect on the treated, shows that renting out land can increase total household income while reducing farm income, as expected. Results from the mediation analysis showed that the overall impact of land rental market participation consists of a direct effect and an indirect effect, whereby the indirect effect is through labor market participation facilitated by reducing cultivated land.

Keywords: Livelihood strategies, off farm wage employment, mobility, land rental, household income, Southwest China

TABLE OF CONTENTS

ACKNOWLEDGMENTS ..... **ii**
ZUSAMMENFASSUNG ..... **vi**
ABSTRACT ..... **ix**
TABLE OF CONTENTS ..... **xii**
LIST OF TABLES ..... **xv**
LIST OF FIGURES ..... **xviii**
LIST OF ABBREVIATIONS ..... **xix**
CHAPTER 1: INTRODUCTION **1**
1.1 Background and motivation **1**
1.2 Objectives **5**
1.3 Methodologies **5**
1.4 Data **7**
1.4.1 Research area **7**
1.4.2 Sample selection and data collection **9**
1.5 Results **10**
1.6 Conclusion and future research **12**
1.7 Outline **13**
References **16**
CHAPTER 2: DYNAMICS OF LIVELIHOOD STRATEGIES OF SMALLHOLDER RUBBER FARMERS IN SOUTHWEST CHINA **20**
Abstract **20**
2.1 Introduction **21**
2.2 Study design **23**
2.2.1 Study sites 23
2.2.2 Data collection 24
2.3 Theory and conceptual framework **25**
2.4 Empirical strategy **27**
2.4.1 Choice of activity variables and classification of livelihood strategies 27
2.4.2 Comparing income level of livelihood strategies 28
2.4.3 Identifying the determinants of livelihood strategy choices 28
2.4.4 Identifying the determinants of livelihood strategy mobility 29
2.4.5 Specification of model variables 30
2.5 Descriptive statistics **32**

2.5.1 Major variables of the sample 32
2.5.2 Changes of household's income-generating activities 34
2.6 Model results **37**
2.6.1 Livelihood strategy classification 37
2.6.2 Livelihood strategies transition 38
2.6.3 Determinants of livelihood strategy choices 42
2.6.4 Ordering livelihood strategies based on return 46
2.6.5 Determinants of livelihood strategy mobility between different income levels 48
2.7 Summary, conclusions and policy implications **51**
References **53**
Appendix **56**
CHAPTER 3: PARTICIPATION IN OFF-FARM LABOR MARKETS: A GOOD STRATEGY FOR FARMERS IN SOUTHWEST CHINA TO COPE WITH DECLINING RUBBER PRICES? 67
Abstract **67**
3.1 Introduction 68
3.2 Research area and data collection 71
3.2.1 Research area 71
3.2.2 Data collection 72
3.3 Conceptual framework 73
3.4 Empirical strategy 77
3.4.1 Modelling the participation of labor market 77
3.4.2 Impact of off farm employment participation on household income 79
3.4.3 The income effects of labour market participation over time 81
3.4.4 Specification of model variables 84
3.5 Descriptive statistics 86
3.5.1 Major variables of the sample 86
3.5.2 Household Income and its composition 87
3.5.3 Comparing households with and without labor market participation 88
3.5.4 Characteristics of wage employment 90
3.6 Model results 93
3.6.1 Factors related to labour market participation 94
3.6.2 Impact of labor market participation on household income 98
3.6.3 Impact of dynamics of off farm employment on household income 100
3.7 Summary and conclusions 101
References 104
Appendix 108

CHAPTER 4: LAND RENTAL, OFF FARM EMPLOYMENT AND HOUSEHOLD INCOME GROWTH IN SOUTHWEST CHINA 118

Abstract 118

4.1. Introduction 118

4.2. Theoretical framework and research hypotheses 121

4.3. Research area, data source and descriptive analysis 125

4.3.1 Research area and data source 125

4.3.2 Descriptive analysis 126

4.4. Empirical methods 128

4.4.1 Impacts of land rental on household income 128

4.4.2 Impacts of land rental on labor market participation 130

4.4.3 Mediation model of land rental on household income 131

4.4.4 Specification of model variables 132

4.5. Estimation results 136

4.5.1 The impacts of land rental on household income 136

4.5.2 The impacts of land rental on wage employment participation 142

4.5.3 Mediation results analysis land rental' impact path on household income 143

4.6. Conclusions 145

References 147

Appendix 150

LIST OF TABLES

Table 1.1 Overview of the essays in the dissertation 15

Table 2.1 Description of the variables included in the model 31
Table 2.2 Descriptive Statistics comparison of the variables included in the model 33
Table 2.3 Livelihood strategies and distribution of households in each strategy 38
Table 2.4 Livelihood strategy transition matrix (%) between 2012-2014 40
Table 2.5 Livelihood strategy transition matrix (%) between 2012-2018 41
Table 2.6 The determinants of livelihood strategy choices in 2014 by MLM regression 44
Table 2.7 Overview of second order stochastic dominance between livelihood strategies 47
Table 2.8 Transition matrices for income groups of rural livelihood strategies (%) 48
Table 2.9 Estimations of ordered logit regression between 2012 and 2014 49

Table 2A.1 Average net income and income source in 2012,2014,2018 56
Table 2A.2 Average value of activity variables in each livelihood strategies over years 57
Table 2A.3 Pairwise comparison of activity variables using Bonferroni method in 2018 58
Table 2A.4 Pairwise comparison of activity variables using Bonferroni method in 2014 59
Table 2A.5 Pairwise comparison of activity variables using Bonferroni method in 2012 60
Table 2A.6 The determinants of livelihood strategy choices in 2018 by MLM regression 61
Table 2A.7 Per capita income distributions of livelihood strategies 63
Table 2A.8 One-way ANOVAS of livelihood strategies (Bonferroni comparison test) 63
Table 2A.9 Estimations of ordered logit regression between 2012 and 2018 65

Table 3.1 Conditional expectations, treatment effects and heterogenous effects 80
Table 3.2 Average treatment effects on the treated (ATT) of dynamic wage employment typology 83
Table 3.3 Average treatment effects on the untreated (ATU) of dynamic wage employment typology 83
Table 3.4 Definition and description of the variables in the three models 85
Table 3.5 Descriptive statistics of the sample, major variable 87
Table 3.6 Annual Household net income (in 1000 RMB) and income shares in % 88
Table 3.7 Participation in off farm wage employment during the panel period 89
Table 3.8 Comparing household gross income between labor market participants and non-participants over time 89
Table 3.9 Wage employment by sector in % 90
Table 3.10 Full- time and part-time wage employments (in %) 91

Table 3.11 Location of full-time and part-time employment....92
Table 3.12 Dynamics of Labor Market Participation....93
Table 3.13 Determinants of off farm labor market participation by using random effects and fixed effects with IV model....95
Table 3.14 Dynamics estimation results of dynamic employment by multinomial logit regression....98
Table 3.15 Average expected household per capita income(log-transformed),treatment and heterogneity effects....100
Table 3.16 ATT estimation of dynamics of off farm employment (log per capita income)....101
Table 3.17 ATU estimation of dynamics of off farm employment (log per capita income)....101

Table 3A.1 Rubber price changes over the year at the county level in XSBN....108
Table 3A.2 Contract types of off farm wage employment participants....109
Table 3A.3 Working intensity in household level....109
Table 3A.4 Multicollearity check....110
Table 3A.5 Endogenous switching regression estimates of off farm employment participation and corresponding income impacts....111
Table 3A.6 Exogenous test on the validity of the selected instruments- Determinants of participation....114
Table 3A.7 Selection bias correction based on the multinomial logit model....115
Table 3A.8 Test on the Validity of the selection instruments –Determinant of employment dynamic typology....117

Table 4.1 Income comparison and differences between households with and without renting out land....127
Table 4.2 Recipients of rented-out land....127
Table 4.3 Characteristics of renting out land....128
Table 4.4 Summary of variables included in the analysis....135
Table 4.5 Results of 2SLS regressions to estimate the effect of land rental on total income and farm income....138
Table 4. 6 IV-Tobit regressions estimating the effects of land rental on farm and non-farm wage employment income....141
Table 4.7 Average treatment effects of land rental on household income (ATT) using PSM....142
Table 4.8 Results of IV-probit regressions estimating the effect of land rental on wage employment participation....143
Table 4.9 Estimation results of mediation analysis....144
Table 4.10 Decomposition of effects of land rental on household income (IV-median analysis)....145

Table 4A.1 The descriptions of variables included in the analysis....150

Table 4A.2 Multicollinearity test 151

LIST OF FIGURES

Figure 1.1 General framework 4
Figure 1.2 The location of research area and the distribution of samples in XSBN 8

Figure 2.1. Household dynamic livelihood strategy framework 26
Figure 2.2 Income composition and changes in 2012 2014 and 2018 36
Figure 2.3 Average per capita income and standard deviation among clusters over years 47

Figure 3.1 Household Labor Allocation and Income without access to Off-Farm Labor Markets under High(H) and Low(L) Rubber Price 76
Figure 3.2 Household Labor Allocation and Income with participation in Off-Farm Labor Markets under High (H) and Low (L) Rubber Price 76
Figure 3.3 Household Labor Allocation and Income with participation in Off-Farm Labor Markets under High (H) and Low (L) Rubber Price and lower wage level. 77

Figure 3A.1. World rubber price changes 108

Figure 4.1 Land rental, off farm wage employment and household income 124

LIST OF ABBREVIATIONS

ATT	Average treatment effects on the treated
ATU	Average treatment effects on the untreated
BH	Base heterogeneity
DMF2	Normalized Dubin McFadden model
DE	Direct effect
ESR	Endogenous switching regression
GLMM	Generalized linear mixed model
HRS	Household responsibility system
IV	Instrumental variable
IE	Indirect effect
LS	Livelihood strategy
MLR	Multinomial logit regression
MASL	Meters above sea level
OLR	Ordered logit regression
OLS	Ordinary least squares
PSM	Propensity score matching
PCA	Principal component analysis
RLCL	Rural land contracting law
TH	Transitional heterogeneity effect
TE	Total effect
TRSP	Three Rights Separation Policy
2SLS	Two stage least square
VIF	Variance inflation factor
XSBN	Xishuangbanna Dai Autonomous Prefecture

CHAPTER 1: INTRODUCTION

1.1 Background and motivation

Rubber cultivation was originally introduced into XSBN for strategic purpose in the 1950s. Facilitated by government support, continuously high rubber price, rubber cultivation has strongly expanded in XSBN. Cultivation area has tripled from 1992 to 2010 (Xu et al.,2014), and reached up to 4.55 million mu by the end of 2014 (Bureau of Statistics of Xishuangbanna Dai Autonomous Prefecture, 2015), accounting for more than one fifth of total land in XSBN. Furthermore, the rubber produced in XSBN has made up of 40% of total rubber production in China, producing 0.32 million tons of dry rubber (Bureau of Statistics of Xishuangbanna Dai Autonomous Prefecture, 2015). More than 50% of rubber plantations are cultivated by smallholder rubber farmers, most of them are indigenous ethnic minorities. Consequently, rubber cultivation, accounting for approximately 30% of regional economy in 2008 (Hu et al., 2008), has contributed to local economic improvement and poverty reduction (Fox et al, 2014). However, the downsides of monoculture rubber should be considered. Rubber monoculture has made rubber farmers income highly dependent on rubber cultivation which results in less diversified livelihood strategies practiced by farmers (Jin et al.,2021). Furthermore, the high sunk cost of investing into rubber makes smallholder rubber farmers subject to potential risks, such as a decline in rubber prices (Min, 2018). Since 2011, rubber price in the global market started to decline, high profitability of rubber cultivation comes to an end. The resulting drop in incomes forced farmers to adjust their livelihood strategies. The major options for smallholder rubber farmers are to rent out land and participate in the labor market.

Land rental markets in China play an increasingly important role in the transformation of the agricultural sector. The Chinese government has recently promoted rural land rental markets (Huang et al., 2012, Feng et al., 2010; Kimura et al., 2011). As a policy measure, a long-term certificate for land tenure has been proposed under the “Rural Land Contract Law” promulgated in 2002 which allows land rights to be exchanged, leased, transferred, and assigned to others much more easily than was possible before (Chang et al.,2018; Yan & Huo.,2016). A fixed 30-year certificate for farmland tenure (Wang et al., 2011) has

been established. A new round of forest tenure and land titling projects have also been undertaken in China with a 70-year duration and the certificate of forestland tenure can be renewed upon maturity (Yin et al., 2013). The availability of a land tenure certificate increases farmers' participation in land rental markets. By 2013, the area of rented-out land has more than tripled compared to 2008, reaching 340 million mu (22.68 million hectares) (Ye, 2015). By 2015, approximately 63 million rural households in China have rented out their cultivatable farmland which accounts for nearly 33% of the total contracted farmland area (Committee of China Agriculture Yearbook, 2010–2016). However, the process of land tenure certificate issuance in XSBN is lagging behind other regions in China (Min, 2017a).

The response of farmers to price volatility of agricultural products are an important research issue related to farmers' welfare. In XSBN, the falling rubber price and other economic conditions have induced farmers to diversify their livelihood strategy. The objective of this thesis therefore is to empirically estimate the responses of smallholder farmers to a decline in the price of rubber and the growth in off farm labor markets.

There are three major focuses in this thesis. First, as illustrated in Figure 1.1, rural households allocate land and labor resources in a range and combination of income-generating activities, in order to reduce risk and lower livelihood vulnerability (Ellis, 1998; Reardon, 1997; Cavendish, 2000). Furthermore, facing pressures and opportunities, households also continuously adapt their resource allocation to different activity choices. Hence, livelihood strategies are dynamic (Barrett et al., 2005; Ellis, 2000; Scoones, 2009). Therefore, it is helpful to classify livelihood strategies and identify their transitions in a rigorous and quantitative analysis.

Second, the development of labor markets facilitates the reallocation of rural labor resources in China, especially, the transfer of labor from farm to off-farm sectors, contributing to reducing poverty and lowering the vulnerability to agricultural shocks (de Brauw et al. 2002, de Janvry, et al., 2005; Huang et al., 2009). With the increase in off-farm employment, the marginal product of labor in agriculture will rise and eventually compete with the secondary and tertiary sectors for labor, i.e. when agriculture has

reached the commercialization point (Ranis and Fei, 1961). This is especially relevant for agricultural systems in which perennial cash crops, like oil palm or natural rubber are dominant. This is the case for the study on off-farm labor market participation of rubber farming households in Southwest China (see Figure 1.2).

Third, a well-functioning land rental market plays an essential role in rural development. Farmers with higher agricultural productivity can rent in land from farmer with lower agricultural productivity. This can facilitate labor transfer to off farm employment (Cheng at al.,2019). Furthermore, in this way, land becomes a more valuable collateral asset, which improves landholders access to credit (Deininger, 2003a, b).

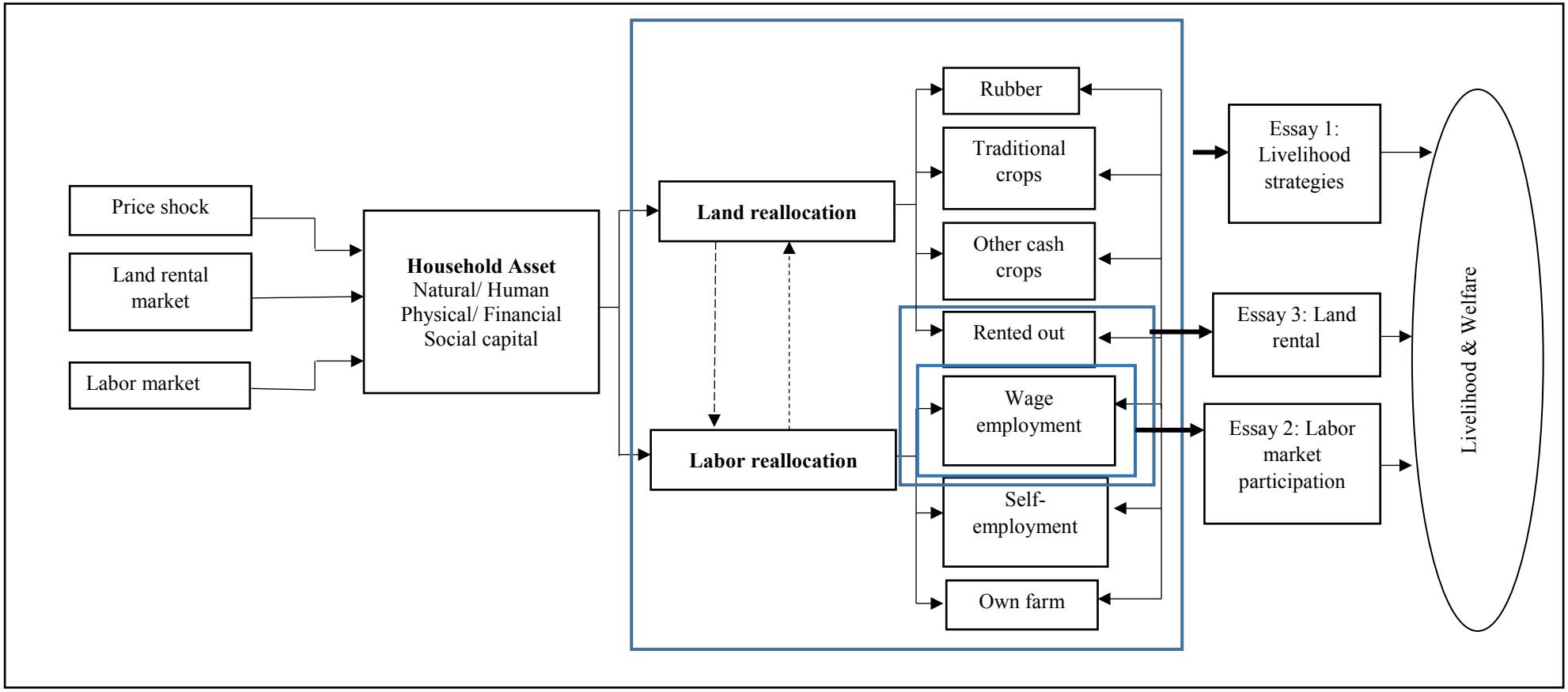

Figure 1.1 General framework

Source: Author's illustration

1.2 Objectives

The central objective of this thesis is to investigate how smallholder rubber farmers in XSBN have changed their livelihood strategies in response to the declining rubber price and emerging off farm labor and land rental market opportunities. To achieve this objective, three specific research questions have been outlined as follows:

1. To investigate how smallholder rubber farmers have adjusted their livelihood strategies in order to cope with declining rubber price, to capture the transitions of these strategies on the short term and on the medium term and to asses the corresponding economic effects.

2. To estimate the factors influencing off farm labor market participation, and its impact on rubber farmers' income on the short and medium term.

3. To estimate the impact of renting out land on household income and its composition and to decompose the direct and indirect effects.

1.3 Methodologies

This thesis is comprised of three thematic papers aiming to answer the specific research questions listed above. Different theoretical and empirical methodologies have been employed in each paper. In this section, an overview of all the models is given briefly.

In the ***first*** essay, following dynamic livelihood strategy framework, we classify the livelihood strategies practiced by rubber farmers, identify the changes of strategies over the seven-year observation period. The factors which are correlated with the choices in a particular year and their mobility over time are identified, and their effects on income are assessed. Several methods in a stepwise procedure have been applied, First, a hierarchical cluster analysis to classify livelihood strategy choices of rubber farmers. Activity variables, reflecting resource allocation help to establish a link between a household's resource allocation

and its livelihood strategy. A total of 17 activity variables were selected for the cluster analysis. Second, a stochastic dominance analysis is used to rank livelihood strategies by the per capita income of the panel households in the three observation periods. To capture the livelihood dynamics, the distribution of income was divided into three income levels, namely low, medium and high. Mobility of households was then determined in terms upward, downward movement or no change. Third, a multinomial logit model as well as an ordered logit model was developed to estimate the factors which could explain the choices and mobility of a livelihood strategy.

In the ***second*** essay, based upon the three-wave panel dataset, we hypothesized that households who continuously participated in the labor markets will have a better performance in coping with declining rubber prices than those households who did so either discontinuously or never participated. Following on the conceptual basis of household theory, the empirical analysis is carried out by means of three models: (i) a logit model to identify factors that can explain a household's decision to engage in off farm employment; (ii) a multinomial logit IV model to estimate different variables which are responsible for the choice between a continuous and discontinuous wage employment over time; (iii) an endogenous switching regression model to assess the average treatment effect with counterfactual analysis.

In the ***third*** essay, the third wave survey data, collected in 2019, covering 600 smallholder households in XSBN was used. Our analysis, (i) using ordinary least squares and tobit model with instrumental variable, first examined the correlation between renting our land on household income and its composition, followed by applying the PSM method to measure the treatment effects of renting out land; (ii) a bivariate probit model with instrumental variable is employed to investigate the correlation between land rental and labor market participation; (iii) a mediation analysis is used to explore the underlying impact mechanism of farmers' decision to rent out land on household income. Off farm employment decision acts as a mediation variable. We have decomposed the effects of renting out land into three parts, namely total effect (TE), direct effect (DE) and indirect effect (IE).

1.4 Data

1.4.1 Research area

Xishuangbanna Dai Autonomous Prefecture (XSBN) is located in Southwest China, bordering Laos to the south and Myanmar to the west (see Figure 1.2). XSBN is a mountainous area with altitudes ranging from 475 to 2430 meters above the mean sea level, covering a total area over 19,000 km^2. In terms of the administrative division, XSBN is constituted by a county-level city, called Jinghong and two counties, named as Menghai and Mengla (see Figure 1.2). Township is the lower administrative level with a total of 32, following villages in the next lower level.

XSBN is the home of a total of thirteen ethnic groups who are native and indigenous to this region but are minorities in the whole of China. By December, 2011, there were 1.3 million registered residents in XSBN, wherein 78.5% are ethnicities. As its name shows, "Dai" ethnicity is the primary group in XSBN who predominantly resides in the lowland area, accounting for over 30% of total population, while other ethnicities like the Hani, Yao, Lahu, or Bulang gather in upland and mountain areas (Xu,2006). Different ethnic groups have implemented location-specific, culture-based and diverse livelihood activities (Min et al. 2017a).

Climatically, the area is characterized by tropical weather. Also the region is of outstanding natural beauty and can be considered a global biodiversity hotspot (Mittermeier et al., 2005). For instance, it harbors much of the biodiversity of China with an abundant species of plants, mammals and birds (Zhang and Cao, 1995). Local peoples have long traditions to use and manage the diverse landscape (Xu et al.,2014).

In the past, XSBN was mainly covered with tropical forest. However, with the dramatic expansion of rubber cultivation, land use has transformed rapidly. Since 1950s, rubber has been introduced into XSBN by initially establishing state rubber farms (Fox and Castella, 2013). In 1955, the first state rubber farm was set up by the Han Chinese, the majority ethnic group in China. The Han have migrated into XSBN from central China to work in rubber state farms (Xu et al.,2014; McCarthy, 2011). Driven by more

flexible land use policies, and governmental support, rubber cultivation has also expanded among smallholder farmers. As a result, rubber cultivation area has tripled from 1992 to 2010 with a total area over 424000 ha (Xu et al.,2014), now accounting for more than one fifth of total land in XSBN.

Rising prices made rubber cultivation highly profitable, therefore rubber monoculture has contributed to local economic development significantly and led to poverty reduction (Min et al. 2017b), accounting for approximately 30% of regional economy in 2008 (Hu et al., 2008). However, aside from negative environmental externalities, other downsides are the high dependency on rubber. After a long-term rising trend and reaching a peak in 2011, rubber price started to decline thereafter (Jin et al. 2020). The decline of rubber price has reduced profitability of rubber cultivation. At the same time, more non-farm employment opportunities (Kimura et al., 2011; Wang et al.,2011) are available in XSBN. Furthermore, constrained by a strategic minimum rubber area of 5 million mu (333,333 ha) (State Bioindustry Office, 2018) which requires farmers to get government permission to cut down rubber trees, livelihood diversification becomes challenging.

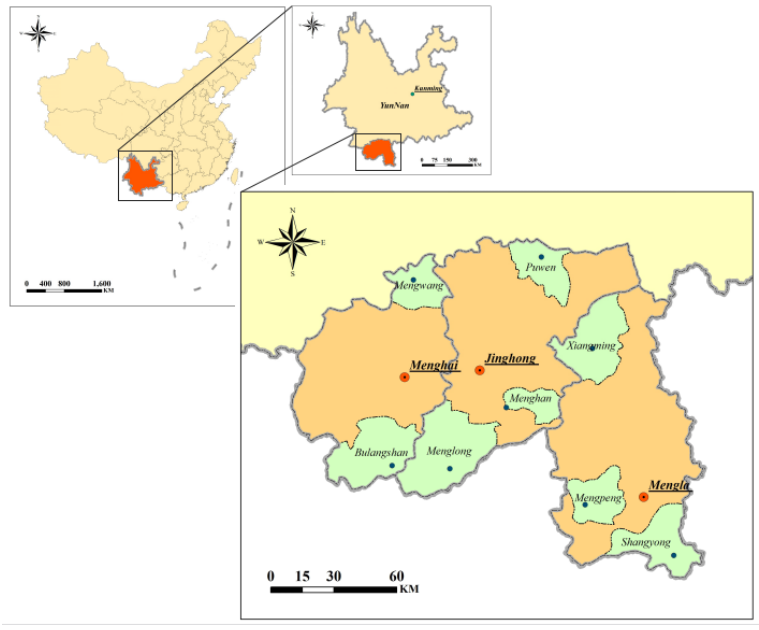

Figure 1.2 The location of research area and the distribution of samples in XSBN

Source: own illustration based on map

1.4.2 Sample selection and data collection

The data used in this thesis is from a two-wave panel data base conducted in 2013 and 2015 under a BMBF-funded project and a third panel wave implemented in 2019 in the context of a DFG project. This three-wave, comprehensive household panel dataset, consists of a sample of 612 smallholder rubber farmers in 42 villages communities of 8 townships in XSBN. In terms of ethnicity, 58% are Dai households, followed by Hani, Bulang, Yi and others, while Han Chinese only account for 5%. A stratified random sampling approach, taking the density of rubber cultivation and geographic location into account, has been applied to select a representative sample of rubber farmers. The survey was initially conducted in March 2013, using the preceding year as the reference period. During the follow-up surveys in March 2015 and 2019, the same households were interviewed. Attrition was low with only one household missing. Every respondent in a household, in most cases the household head, was interviewed face-to-face by enumerators who mastered the local dialect. Before the start of each survey, extensive training, including field practice was given to enumerators.

As survey instruments, standardized household and village head questionnaires were used. In the household questionnaire, data on demographic and household characteristics, land use and land use history as well as income-generating activities, including rubber and other crops, livestock, natural resource extraction, income from wage and self-employment and from other sources. Furthermore, modules of the questionnaire referred to information on household finance and shocks experienced during the past five years as well as risks expected by the respondents in the future. Since the panel data span over a period of 7 years, its consistency allows to identify and quantify the short-and medium term impact of economic activities of the panel households.

In the village level questionnaire, detailed information regarding village infrastructure, demography and labor profiles, crop cultivation and land use allocation were asked. These data can serve for the specification of instrumental variables in empirical models.

1.5 Results

In the following the results of each essay are summarized:

In the ***first*** essay, five livelihood clusters can be classified as follows: (1) traditional crops (rice and maize) plus wage workers (2) multiple livelihood strategy including traditional and cash crops as well as off farm employment, (3) rubber dominant, wage workers plus renting out land (4) cash crops dominated cultivation, including rubber, tea and fruit trees (5) self-employed and wage workers plus renting out land. It is remarkable that rubber still remains a major source of livelihood in all livelihood groups, albeit at different levels of intensity. It is found that majority of households have transited to other livelihood strategies: 47% between 2012 and 2014, and 65% between 2012 and 2018. We found that strategy (5), which involves labor and land rental market participation, is the most economically attractive strategy while strategy (3) with rubber domination falls in the low-income category. Strategies (1), (2) and (4) are at medium income level. Regarding the determinants of livelihood choices, in 2014, female headship, transportation costs to the township center, and the share of certified arable land, are negatively correlated with (1), while dependency ratio is significant for (2) relative to the base group, i.e. the livelihood strategy (4). Altitude is negatively related to (3) and (5), and size of rubber area is positively related compared to the base group (4). Results for 2018 show that other factors are correlated with the choice of livelihood strategies, namely, ethnicity, the Dai ethnicity are less likely to choose strategy (4). Also, the number of shocks is positively correlated with (2). With respect to the income effects of a livelihood strategy change, between 2012 and 2014, 73.5 % of households did not gain from the change, i.e. they remained in the same income category. Only for 3.3% of households did the change result in higher income and for 13.2% it resulted in lower income. On the medium term, i.e. between 2012 and 2018, 11% of households, by changing their livelihood strategy, moved into a higher income category, while 22.6% moved downward. It is concluded that most rubber farmers in XSBN, have reacted to the price decline of rubber and have adopted alternative livelihood strategies, However, in most cases a change in livelihood strategy did not result in income gains which is plausible considering past dependence on rubber.

In the ***second*** essay, we find that the participation rate of households in off farm wage employment has increased significantly between 2012 and 2018. The share of households had at least one member in wage employment has increased from 23% in 2012 to 48% in 2018 with over one third of total household income. The most prominent employment type is in the service sector, followed by working on other farms, in the construction and manufacturing sector. Mostly, household members with off-farm employment are engaged in full-time jobs but more recently part-time employment has been on the rise. Model results show that household characteristics and location factors are significantly correlated with off farm participation. Some variables, like labor capacity and altitude can explain the choice between a continuous and a discontinuous wage employment. Results of average treatment effects (ATT) show that income of households with continuous wage employment would decrease by 97 % if they would drop out of the labor market. Furthermore, counterfactual effects (ATU) results confirmed that household income would increase by 77 % if non-participating households would switch to continuous employment and by 70 % if they'd adopt discontinuous employment. In principle, and leaving aside non-economic constraints, household can gain a large income increase if they'd participate in off farm labor markets. Our study strongly suggests that off farm labor market participation is a good strategy to cope with decreasing profitability in rubber farming as a result of lower rubber prices, even though none of the panel households had left farming altogether during the seven-year observation period, i.e. all keep their own farming as a baseline income source. From our research findings, we can conclude that farming remains the backbone of rural household and a combination of on farm and off farm labor allocation is the utility maximizing strategy.

In the ***third*** essay, results show that for some farmers renting out land is significantly and positively correlated with household's total income, thus raising the share of nonfarm wage income while reducing the share of farm income. The results from average treatment on the treated (ATT) analysis shows that total income of households renting out land can significantly increase by approximately 50% while income from farming is reduced by about 50% - 65%, depending on the PSM criteria applied. Furthermore, land lessor household's land rental decision is significantly correlated with wage

employment participation at the 5% significance level and non-farm wage employment at the 10% level, implying that labor forces released from land after renting out land are more likely to join labor market. The mediation analysis has demonstrated that the total impact of renting out land comprises of two components, i.e. a direct land rental effect accounting for 37% and an indirect labor market effect with 27%.

1.6 Conclusion, policy recommendation and future research

Based on the study results and findings of each paper conclusions and policy recommendations with relevance in the transformation of rural economies and development in Southwest China with implications for the wider Mekong region are drawn. At the same time future research needs to be identified.

The major conclusion from **the first paper** is that practicing multiple livelihood strategies by diversifying income-generating activities is a successful strategy without necessarily giving up rubber farming completely. Livelihood strategies that include off farm employment yield relatively higher income compared to relying on farming only. Policy interventions targeted at promoting diverse livelihood strategies rather than a fixed farming model, e.g. intercropping, should be considered. It is important to improve skills and capacities of rural household members, e.g. through adult education, in order for them to be qualified for the future needs of off-farm labor market. Furthermore, promoting village-based small and medium size enterprises in order to create more job opportunities, the advancement of land rental markets and promoting more sustainable farming practices should be components of such policies as well. Future research may look at the impact of Covid-19 and China's Zero Covid 19 policy on the development of the rural sector in XSBN.

The results of **second paper** allows to conclude that off farm labor market participation is a good strategy to cope with decreasing profitability in rubber farming. Furthermore, staying engaged in the labor market continuously over periods is economically superior to a discontinuous labor market participation strategy. However, this does not mean that rural households in Southwest China should give up farming all together. Farming remains the backbone of rural household and a combination of on farm and off farm

labor allocation has more prospects. Therefore, our main policy recommendation is that rural development policy makers must do more than just providing more jobs in the non-farm sector. Instead, considering global economic and environmental risks, a well-planned and stable rural development policy is needed. Such policy should enable a sustainable transformation process, ecologically and economically balanced, primarily strengthening the resilience of rural households. This could include elements of the traditional self-sufficiency economy combined with the possibilities of rural labor market.

Further research in this regards should investigate other indicators beyond income such as wealth, coping capacity, resilience and stability.

The main conclusion from the **third paper** are that renting out some or all land, can be a good strategy for some households in the panel. Renting out has direct income effects and indirect effects by enabling households to participate in or intensify their participation in off farm labor markets. Policy implications are that land titling and land tenure certificate should be given increased attention especially in remote rural areas like XSBN. For future research, it will be interesting how the local labor market has developed under Covid-19 and the ongoing "Zero Covid" strategy in China.

1.7 Outline

The remainders of this thesis are comprised of four chapters with three papers illustrated in each chapter in detail. Table 1.1 offers an overview of three papers and brief descriptions of each chapter is structured as follows.

Chapter 2 includes the first paper on the classification of livelihood strategies titled as **"Dynamics of Livelihood Strategies of Smallholder Rubber Farmers in Southwest China".** Previous versions of this paper have been presented at the 2022 IAMO Forum about enhancing rural development resilience in a post-pandemic era in Halle, Germany (June 22 – 24, 2022), the 10th Asian Society of Agricultural Economists (ASAE) International Conference, Beijing, China (November 6-8 2021, online). And poster has presented at Tropentag Conference, Gent, Belgium (September 17–19, 2018). This chapter is

organized as follows: section 2.2 has introduced our research area and data collection procedure in detail. section 2.3 provides an overview of theory and conceptual framework which is the basis this paper has built up. Section 2.4 gives detailed descriptions of the empirical strategies and its estimation process, including the selection of activity variables used in cluster analysis, methods applied to analyze the determinants of livelihood strategy choices and motilities, the specification of model variables. Descriptive statistics shown in section 2.5. Section 2.6 presents the model analysis results. Section 2.7 has concluded and offered some policy implications.

Chapter 3 presents the second paper on the analysis of off farm labor market participation in southwest China titled as **"Participation in off-farm labor markets: A good strategy for farmers in Southwest China to cope with declining rubber prices?".** A previous version of this paper was presented at Tropentag Conference on Global Food Security and Food Safety in Germany (September 9 -11, 2020, online). This chapter is organized as follows. Section 3.2 gives a brief description of the research area and data collection in XSBN. Section 3.3 explains the conceptual framework. The empirical models have been illustrated in section 3.4. The descriptive analysis in section 3.5 offers an overview of income differences between households with and without labor market participation. Estimation results are shown in section 3.6. Section 3.7 summarizes and concludes this chapter.

The third paper, titled as **"Land rental, off farm employment and household income in Southwest China"** is presented in Chapter 4. An earlier version of it was presented at 20th Annual World Bank Conference on Land and Poverty in Washington DC, USA (March 25-29, 2019). This chapter is arranged as follows. First, a theoretical framework and the research hypotheses to be examined are in section 4.2. In section 4.3, we briefly introduce our research area, data used in the analysis and present the descriptive statistics. Model specifications and estimation strategies are presented in section 4.4. Estimation results and main findings have summarized in section 4.5. Conclusions and policy implications are drawn in section 4.6.

Table 1.1 Overview of the essays in the dissertation

No.	Title	Authors	Paper history
Paper 1 (elaborated in Chapter 2)	Dynamics of Livelihood Strategies of Smallholder Rubber Farmers in Southwest China	Haowen Zhuang, Shaoze Jin and Hermann Waibel	**- Paper presented at:** *IAMO Forum 2022 on Enhancing resilience in a post-pandemic era: challenges and opportunities for rural Development*, 22 - 24 June 2022, Halle (Saale), Germany **- Paper presented at:** *The 10th Asian Society of Agricultural Economists (ASAE) International Conference*, 6-8 November, 2020 Beijing, China (online) **- Poster presented at:** *Tropentag 2018 Conference: Global food security and food safety: the role of universities,* 17–19 September 2018, Gent, Belgium
Paper 2 (elaborated in Chapter 3)	Participation in Off-Farm Labor Markets: A Good Strategy for Farmers in Southwest China to Cope with Declining Rubber Prices?	Haowen Zhuang, Shi Min and Hermann Waibel	***Paper presented at:*** *Tropentag 2020 conference:Food and nutrition security and its resilience to global crises,* 9 -11, September 2020, Germany (online)
Paper 3 (elaborated in Chapter 4)	Land Rental, Off farm Employment and Household Income in Southwest China	Haowen Zhuang and Herman Waibel	**Paper presented at:** *20th Annual World Bank Conference on Land and Poverty 'Catalyzing Innovation'*, 25-29, March 2019 Washington DC, USA

Source: own compilation

References

Barrett, C. B., Clark, M. B., Clay, D. C., & Reardon, T. (2005). Heterogeneous constraints, incentives and income diversification strategies in rural Africa. *Quarterly Journal of International Agriculture, 44*, 37–60.

Chang, H., Ai, P., & Li, Y. (2018). Land tenure policy and off-farm employment in rural China. *IZA Journal of Development and Migration*, 8(1), 1-28.

Cheng, W., Xu, Y., Zhou, N., He, Z., & Zhang, L. (2019). How did land titling affect China's rural land rental market? Size, composition and efficiency. *Land Use Policy*, 82, 609-619.

Cavendish, W. (2000). Empirical regularities in the poverty–environment relationship of rural households: evidence from Zimbabwe. *World Development, 28*, 1979–2003.

Deininger, K. (2003a). Land markets in developing and transition economies: Impact of liberalization and implications for future reform. *American Journal of Agricultural Economics*, 85(5), 1217-1222.

Deininger, K. W. (2003b). *Land policies for growth and poverty reduction*. World Bank Publications.

De Janvry, A., Sadoulet, E., & Zhu, N. (2005). The role of non-farm incomes in reducing rural poverty and inequality in China (No. 1557-2016-133197).

De Brauw, A., Huang, J., Rozelle, S., Zhang, L., & Zhang, Y. (2002). The evolution of China's rural labor markets during the reforms. *Department of Agricultural and Resource Economics, UC Davis Working Paper,* (02-003).

Editing Committee of China Agriculture Yearbook. (2010–2016). *China agriculture yearbooks 2010–2016.* Beijing, China: China Agriculture Press

Ellis, F. (1998). Household strategies and rural livelihood diversification. *The Journal of Development Studies, 35*, 1–38.

Ellis, F. (2000). *Rural livelihoods and diversity in developing countries*. Oxford University Press.

Feng, S., Heerink, N., Ruben, R., & Qu, F. (2010). Land rental market, off-farm employment and agricultural production in Southeast China: A plot-level case study. China Economic Review, 21(4), 598-606.

Fox, J., & Castella, J. C. (2013). Expansion of rubber (Hevea brasiliensis) in Mainland Southeast Asia: what are the prospects for smallholders?. *The Journal of Peasant Studies*, *40*(1), 155-170.

Fox, J., Castella, J. C., & Ziegler, A. D. (2014). Swidden, rubber and carbon: Can REDD+ work for people and the environment in Montane Mainland Southeast Asia?. *Global Environmental Change, 29,* 318-326.

Hu, H., Liu, W., & Cao, M. (2008). Impact of land use and land cover changes on ecosystem services in Menglun, Xishuangbanna, *Southwest China. Environmental monitoring and assessment, 146*(1), 147-156.

Huang, J., Wu, Y., & Rozelle, S. (2009). Moving off the farm and intensifying agricultural production in Shandong: a case study of rural labor market linkages in China. *Agricultural Economics, 40*(2), 203-218.

Huang, J., Gao, L., & Rozelle, S. (2012). The effect of off-farm employment on the decisions of households to rent out and rent in cultivated land in China. *China Agricultural Economic Review*, 4(1), 5-17.

Jin, S., Huang, J., & Waibel, H. (2020). Location and economic resilience in rubber farming communities in southwest China. *China Agricultural Economic Review*.

Jin, S., Min, S., Huang, J., & Waibel, H. (2021). Falling price induced diversification strategies and rural inequality: Evidence of smallholder rubber farmers. *World Development*, *146*, 105604.

Kimura, S., Otsuka, K., Sonobe, T., & Rozelle, S. (more non-farm employment opportunities 11). Efficiency of land allocation through tenancy markets: evidence from China. *Economic Development and Cultural Change*, 59(3), 485-510.

Liu,W., Li, J., Lu,H., et.al (2013). Vertical patterns of soil water acquisition by non-native rubber trees (Hevea brasiliensis) in Xishuangbanna, Southwest China. *Ecohydrology*, *7*, 1234–1244.

Min, S., Waibel, H., Cadisch, G., Langenberger, G., Bai, J., & Huang, J. (2017a). The Economics of Smallholder Rubber Farming in a Mountainous Region of Southwest China: Elevation, Ethnicity, and Risk. *Mountain Research and Development, 37*(3), 281.

Min, S., Waibel, H., & Huang, J. (2017a). Smallholder participation in the land rental market in a mountainous region of Southern China: Impact of population aging, land tenure security and ethnicity. *Land Use Policy, 68*, 625-637.

Min, S., Huang, J., Bai, J., & Waibel, H. (2017b). Adoption of intercropping among smallholder rubber farmers in Xishuangbanna, China. *International Journal of Agricultural Sustainability, 15*(3), 223–237.

Min, S., Wang, X., Liu, M., & Huang, J. (2018). The asymmetric response of farmers to an expected change in the price of rubber: The roles of sunk costs and path dependency. *Land Use Policy*, *79*, 585-594.

Mittermeier, R. A., Robles-Gil, P., Hoffmann, M., Pilgrim, J. D., Brooks, T. M., Mittermeier, C. G., ... & Fonseca, G. (2005). Hotspots Revisited: Earth's Biologically Richest and Most Endangered Ecoregions (Cemex, Mexico City).

McCarthy, S. (2011). *Communist multiculturalism: Ethnic revival in southwest China*. University of Washington Press.

Ranis, G., & Fei, J. C. (1961). A theory of economic development. *The American economic review*, 533-565.

Reardon, T. (1997). Using evidence of household income diversification to inform study of the rural nonfarm labor market in Africa. *World Development, 1*, 62–66.

Scoones, I. (2009). Livelihoods perspectives and rural development. *The Journal of Peasant Studies, 36,* 171–196.

Wang, H., Tong, J., Su, F., Wei, G., & Tao, R. (2011). To reallocate or not: Reconsidering the dilemma in China's agricultural land tenure policy. *Land Use Policy*, 28(4), 805-814.

Wang, X., Huang, J., Zhang, L., & Rozelle, S. (2011). The rise of migration and the fall of self-employment in rural China's labor market. *China Economic Review*, 22(4), 573-584.

Xu, J., Grumbine, R. E., & Beckschäfer, P. (2014). Landscape transformation through the use of ecological and socioeconomic indicators in Xishuangbanna, Southwest China, Mekong Region. *Ecological Indicators*, 36, 749-756.

Xu, J. (2006). The political, social, and ecological transformation of a landscape. *Mountain Research and Development, 26*(3), 254-262.

Yan, X., & Huo, X. (2016). Drivers of household entry and intensity in land rental market in rural China: Evidence from North Henan Province. *China Agricultural Economic Review.*

Yin, R., Yao, S., & Huo, X. (2013). China's forest tenure reform and institutional change in the new century: What has been implemented and what remains to be pursued? *Land Use Policy*, 30(1), 825-833.

Ye, J. (2015). Land Transfer and the Pursuit of Agricultural Modernization in China. *Journal of agrarian change,* 15(3), 314-337.

Zhang, J., Mishra, A. K., & Zhu, P. (2019). Identifying livelihood strategies and transitions in rural China: Is land holding an obstacle? *Land Use Policy*, 80, 107-117.

Zhang, J., & Cao, M. (1995). Tropical forest vegetation of Xishuangbanna, SW China and its secondary changes, with special reference to some problems in local nature conservation. *Biological Conservation,* 73(3), 229-238.

CHAPTER 2: DYNAMICS OF LIVELIHOOD STRATEGIES OF SMALLHOLDER RUBBER FARMERS IN SOUTHWEST CHINA

Previous versions of this paper is presented and published as proceedings at:

IAMO Forum 2022 Enhancing resilience in a post-pandemic era: challenges and opportunities for rural Development, 22 - 24 June 2022, Halle (Saale), Germany

and

The 10th Asian Society of Agricultural Economists (ASAE) International Conference, 6-8 November 2021, Beijing, China (online)

and

Tropentag 2018 Conference: Global food security and food safety: the role of universities, 17 – 19 September 2018, Gent, Belgium

Abstract

Rapid expansion of rubber monoculture in Xishuangbanna Dai Autonomous Prefecture (XSBN), Southwest China has made household income highly dependent on rubber cultivation and vulnerable to price risks. Since 2011, the rubber price started to decline which has prompted farmers to diversify their income portfolio with an attempt to mitigate income loss. This study aims to investigate how smallholder rubber farmers have adjusted their livelihood strategies in order to cope with the declining rubber price. A three-wave panel dataset collected from 612 households in XSBN, covering the periods of 2012,2014 and 2018 are analysed within a dynamic livelihood strategy framework. A hierarchical cluster analysis is applied to classify livelihood strategies practiced in XSBN, a multinomial logit model as well as an ordered logit model were employed to estimate the factors which could explain the choices and mobility of livelihood strategy. Our analysis has classified five livelihood strategies pursued by smallholder rubber farmers in 2012,2014 and 2018. Furthermore, we found 65% of households have transited to other livelihood strategies over the six-year observation period. Livelihood diversification into wage and self-employment plus renting out land activities is found to be the most remunerative strategy in terms of income earned. Education, household head occupation, access to good-quality road, household debt can influence households to adopt higher income return strategies. The findings of this study suggest that rural development policies need to focus on farming transitions towards different livelihood strategies, rather

than promoting a fixed farming model. Improving skills and capacities of rural household members should be considered.

Keywords: Livelihood strategies, smallholder rubber farmers, mobility, Southwest China, XSBN

2.1 Introduction

A thorough understanding of livelihood activities practiced by smallholder households in developing countries is important to develop good policies for rural development (Campos et al.,2014). Smallholder farmers become highly vulnerable to multiple natural and human-caused shocks (Fan et al.,2013), such as natural disasters, pest and disease outbreaks, price shocks and others. In order to cope with shocks, rural households diversify their livelihood strategies. A livelihood strategy is a portfolio of income-generating activities practiced by household (Chambers and Conway, 1992; Ellis,2000; Scoones, 2009). The key components of a livelihood framework include asset endowments, activities and outcomes. A livelihood strategy is always dynamic as households adopt new technologies and adapt their activities in reaction to changes in external conditions (Barrett et al., 2001b; Ellis, 2000; Fan et al.,2013). The analysis of livelihood strategies in a systematic and quantitative way helps to understand the decisions of smallholder farmers and the factors that drive these decisions. The analysis also can generate results that can be useful for designing better rural development policies.

Several studies have analyzed livelihood strategies by using a set of different indicators that can help to organize the strategies for analytical purposes. To classify livelihood strategies, income-based indicators are most commonly used (Reardon,1997; Barrett et al., 2001a; Babulo et al.,2008; Paudel Khatiwada et al.,2017) since such information is mostly available. A limitation of such indicators is that they do not adequately reflect actual resource allocation which are often driven by stochastic events (Walelign et al.,2017). Other researches (Jansen,2006; Van den Berg,2010; Ansoms & Mckay,2010) have applied asset-based indices which they claim are a better determinant of livelihood choices. Another alternative approach is to utilize activity variables which represent the allocation of labor, time and other resources into each activity. Activity variables act as a bridge between asset endowment and outcome from asset

allocation. Its detachment from the influence of outcome and can well reflect livelihood choices. Our analysis is based on the inclusion of activity variables. In terms of the methodologies to cluster livelihood strategies, the majority of researches (Jiao et al.,2017; Nielsen et al.,2013; Zhang et al., 2019) with panel dataset have firstly employed a principal component analysis (PCA) which is expected to reduce the dimensionality of selected variables, and then components getting from PCA is included in cluster analysis in the second step. Even though PCA helps to minimizes the possible difficulties and distortions in further data analysis, it also weakens the characteristics of some activity variables since the trick in dimensionality reduction is to trade a little accuracy for simplicity. Furthermore, different waves dataset is pooled together to get the principal components in the first step, thereafter livelihood strategy categories are identical over periods. the dynamic differences of resource allocation over periods could be overlooked. Hence, there is possibility that livelihood strategy clustered from PCA along with cluster analysis couldn't capture the real cases of asset allocation over different periods. This can be compared with the analysis from Van den Berg (2010), livelihood strategy clusters obtained from a hierarchy cluster analysis are different in three periods.

Xishuangbanna, Dai Autonomous Prefecture (XSBN) in Southwest China, has experienced a rapid expansion of smallholder rubber cultivation with an area covering more than 20% of XSBN (Liu et al., 2013). As a result, rubber has been the major driver of economic development which has contributed to income increase and poverty reduction in XSBN. However, rubber expansion has made rubber farmers dependent on this crop. Since 2011, rubber prices started to decline which has prompted farmers to adjust their crop portfolios. At the same time, labor markets in XSBN have expanded, thus providing potential off-farm employment opportunities for rubber farming households. However, due to the strategic importance of rubber, the Chinese government has defined a minimum cultivation area of 5 million mu (333,333 ha). This policy limits the choices of farmers as they need government permission before they can give up rubber plantations and cut down rubber trees.

The general objective of this study is to classify dynamic livelihood strategies pursued by smallholder rubber farmers in XSBN and identify the determinants which can explain their choice. Specifically, our

study is conducted through five major steps. First, five livelihood strategies have been classified in XSBN based on 17 activity variables by using hierarchical cluster analysis. Second, the transitions of livelihood strategies on the short term, i.e. between 2012 and 2014 and the medium term, i.e. between 2012 and 2018 are measured. Third, all livelihood strategies are ordered and categorized into three income classes identifying as high, medium and low levels in terms of economic returns. Fourth, a multinomial logit regression is applied to assess the determinants associated with the choices of a livelihood strategy. Finally, an ordered logit regression is applied to investigate the factors which lead to upward or downward movement in income levels of a household switching her strategy.

The structure of this paper is organized as follows: in the next section an overview of the study site and the dataset is given. Section three explains the conceptual framework of livelihoods and livelihood transitions. In the fourth section, methodologies used for analysis are elaborated in detail. The description of income source changes is following in the section five. In the sixth section, estimation analysis results are explained carefully. The last section concludes and provides some policy implications.

2.2 Study design

First, this section introduces the study area, including its geographic, administrative as well as socioeconomic conditions. Second, data collection procedure has been explained in detail which drawn a representative sample of rubber farmers in XSBN.

2.2.1 Study sites

Xishuangbanna (XSBN) is located in the southwest China, bordering Laos to the south and Myanmar to the west. It's a mountainous area with altitude ranging from 475 to 2430 meters above the mean sea level, covering a total area over 19,000 km^2 (Min et al., 2017a). XSBN is a Dai Autonomous Prefecture with thirteen different ethnic groups who are native to this region but are minorities in whole China. As its name shows, "Dai" ethnicity is the primary group in XSBN who predominantly resides in the lowland area, while other ethnicities like the Hani, Yao, Lahu, or Bulang gather in upland and mountain areas

(Xu,2006). Different ethnic groups have implemented location-specific, culture-based and diverse livelihood systems (Min et al. 2017b).

In terms of the administrative division, XSBN is constituted by a county-level city, called Jinghong and two counties, named as Menghai and Mengla. The lower administrative level is township with a total of 32 ones, followed by villages and sub-villages.

In terms of ecology, in the past, tropical forest was the major land use in XSBN. However, driven by flexible land use policies, and government support, rubber cultivation has dramatically expanded in XSBN since 1950s. As a result, the rubber cultivation area has tripled from 1992 to 2010 with a total area over 424000 ha (Xu et al.,2014), accounting for more than one fifth of total land in XSBN.

2.2.2 Data collection

Our analysis is based on a three-wave panel dataset, collecting from the socioeconomic surveys which were conducted in 2013, 2015 and 2019. A stratified random sample selection was used to select the representative samples based on the density of rubber cultivation and location, hence, a total sample of 612 households in 42 villages, 8 townships has been interviewed in XSBN. A baseline survey was conducted in 2013, taking the preceding year as the reference period. In 2015 and 2019, two follow-up surveys were done to track the same 612 households as the survey in 2013. Attrition was low with only one household missing. Standardized household and village questionnaires were applied to collect information. In terms of household questionnaire, it obtained detailed information regarding household demographic characteristics, land use as well as the allocation of household asset on each income-generating activity, i.e., not only including farming activities from rubber to Traditional crops and other Cash crops cultivation but also covering non-farm income earned from wage and self-employment plus income from other sources. In the village questionnaire, information is captured with respect with demography and labor profiles, village infrastructure and institution, crop cultivation in village level as well as some general information about village head.

The panel data span over a period of 7 years which allow us to analyze quantitatively asset reallocation changes, in the short term between 2012 and 2014 and in the medium term until 2018, in response to the decline of rubber prices. The consistency of the data further permits us to assess the dynamic changes in household livelihood strategy practices in XSBN.

2.3 Theory and conceptual framework

In this paper, livelihood strategy is defined as the portfolio of income-generating activities and choices household have made and undertaken in pursuit of achieving certain livelihood goals (Jansen et al.,2006). Figure 2.1 presents the dynamic livelihood strategy framework over two periods. The main components are asset allocations, engagement in activities and their adjustments as well as outcome and performance. In a given production period, available land and labor resources are influenced by natural and human factors (e.g. weather, market failure), (e.g. Scoones,1998; Ellis,2000; Barrett et al., 2001a). For example, households may choose to engage in different income-generating activities with the aim to increase income or alleviate poverty. Over different periods, outcomes of strategy choices, derived from a previous period could influence asset reallocation in the next period which in turn can prompt households to switch to another livelihood strategy. Each livelihood strategy corresponds to an economic return level. all livelihood strategies can be categorized into three income classes: high, medium and low levels in terms of economic return. Then, three categories of mobility are recognized, namely, upward mobility, no mobility and downward mobility. Upward mobility is observed when a household moves into an economically attractive livelihood strategy while downward mobility occurs when a household transits into a strategy with lower income level. No mobility is, when household remains in the same income level strategy. In principle, the framework can be extended to more than two periods.

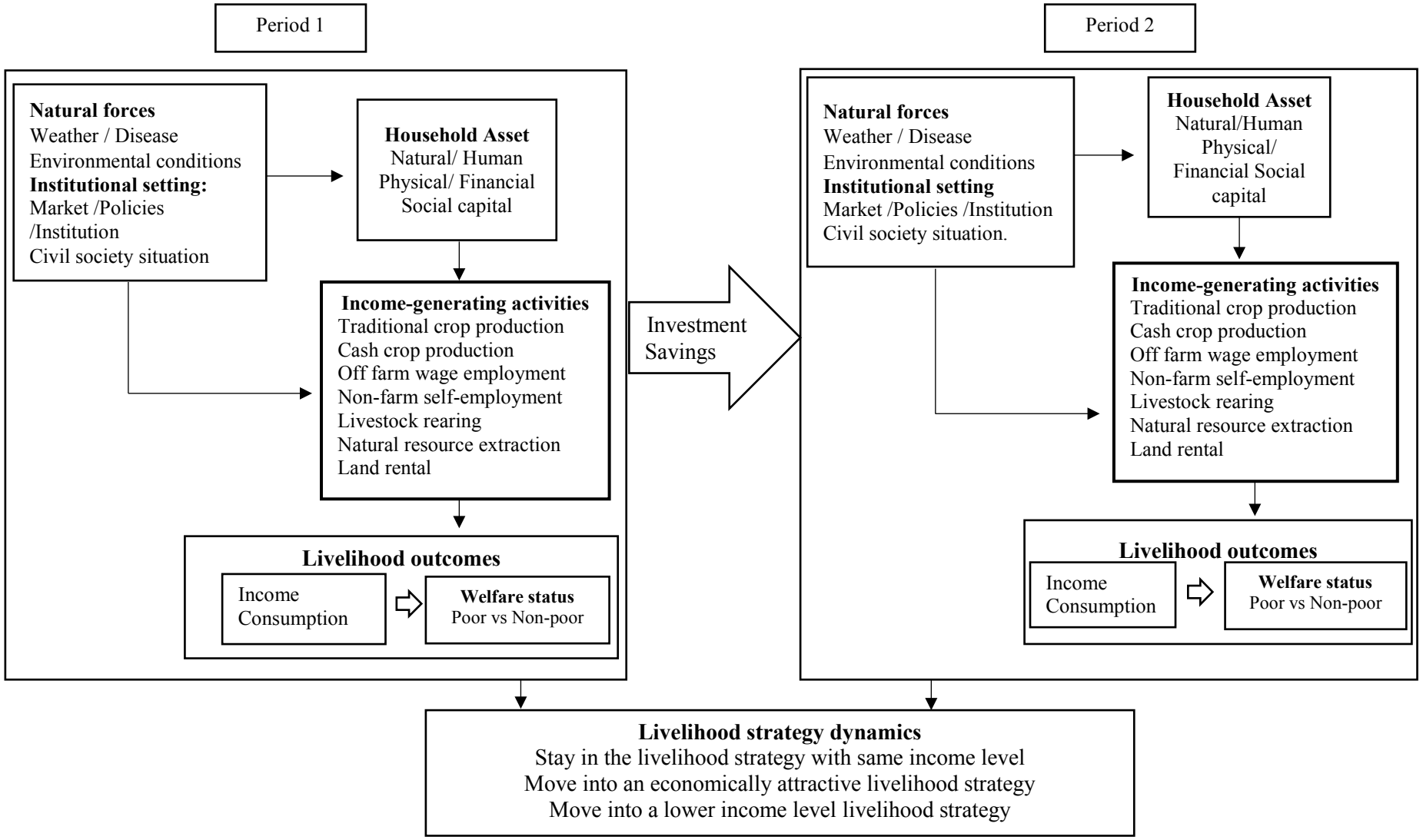

Figure 2.1. Household dynamic livelihood strategy framework

(adopted from Ellis,2000; Scoones,1998; Winters et al., 2001; Walelign et.al., 2017)

2.4 Empirical strategy

2.4.1. Choice of activity variables and classification of livelihood strategies

The first task in livelihood strategy classification relates to the indicators of interest to be used to differentiate households into distinct livelihood strategies. Since households allocate owned assets into diverse activities to earn a living, activity variables act as a bridge between asset endowment and corresponding outcome through assets allocation, thereby help to classify livelihood strategies (Barrett et al., 2001a). Therefore, a combination of activity variables which could measure the major use of assets is included to identify livelihood strategy. Following previous researches (Nielsen., et al.,2013; Van den Berg.,2010) as well as taking the actual situation in XSBN into consideration, activity variables characterizing livelihood choices are categorized into four kinds. These are: (i) land allocation for farming production; (ii) labor allocation for farm and off farm activities; (iii) expenditure spent on major activities and (iv) others. Each category is comprised of specific indicators. Specifically, they are: the percentage of land allocated to rubber cultivation, Traditional crops and other Cash crops cultivation as well as renting out land (4 activity variables); the share of family labor allocated to rubber, Traditional crops, Cash crops cultivation along with off farm wage employment and non-farm self-employment activities(5 activity variables); the percentage of expenditure spent on material input and hired labor cost of rubber, Traditional crops, cash crops cultivation, self-employment investment, livestock rearing as well as natural resources extraction (6 variables). The last two variables include average value of livestock rearing and average value of natural resource extraction products. A total of 17 activity variables has been used to do cluster analysis. Variables regarding labor are measured by family labor working days. Expenditure indicators calculate the cost spent on material and for hiring labor by activity.

After activity variables being confirmed, a hierarchical agglomerative cluster analysis based on ward linkage (Garson,2012) is applied to decide the number of clusters and profile livelihood strategies. The optimum number of livelihood clusters is obtained from the Calinski & Harabatz criterion value (Caliński & Harabasz. ,1974). This method is a highly flexible and intuitive method to assign a large number of

observations into a smaller number of distinct clusters (Savath et al.,2014). It's less arbitrary when assigning observations into different groups compared with k-means method which requires number of clusters to be specified beforehand. Compared with latent cluster analysis, this method does not need to make any assumptions about the underlying distribution of the data and furthermore, it can demonstrate changes over years.

2.4.2. Comparing income level of livelihood strategies

In this section, we rank the returns of a livelihood strategy in terms of average per capita income and compare which livelihood strategy has (i) generated higher income, hereby we assume that average income can reflect the expected outcome of a chosen strategy; and (ii) greater probability of earning higher income in comparison with other strategies. Households choose a livelihood strategy with less expected income or less likelihood to obtain a higher income could indicate entry barriers that constrain the choice of livelihood strategies (Nielsen et al,2013). Hence, a stochastic dominance analysis is used to order livelihood strategies to compare household welfare (Barrett & Donald, 2003). It also allows to compare income distributions attributed to different livelihood strategies. The null hypothesis that choice of livelihood strategy a dominates b, can be rejected when p-value$_{a,b}$ $< \alpha$, α is the significance level at 0.1, 0.05 and 0.01. To obtain a conclusive decision that choice a dominates b, p-value$_{a,b}$ $> \alpha$ and p-value $_{b,a}$ $< \alpha$ are needed simultaneously (Schaub et.al.,2020). Besides stochastic dominance, Bonferroni pairwise tests are applied to examine the statistical difference of income composition between strategies.

2.4.3. Identifying the determinants of livelihood strategy choices

After applying a hierarchical cluster analysis, we are able to classify livelihood strategies which are nominal. Hence, a multinomial logit regression (MLR) is applied in order to investigate the determinants of the choices of livelihood strategy. It is the most widely used model when a dependent variable takes on more than two, unordered and concrete responses (Wooldridge, 2002). It is assumed that livelihood a strategy choice is the function of livelihood strategies in previous periods, subject to household and village characteristics. The formulation can be specified as:

$$Prob\left(y_{it} = j \middle| y_{it-1}, x_{it}\right) = \frac{\exp(\beta_j x_{it} + \alpha_j y_{it-1})}{\sum \exp(\beta_k x_{it} + \alpha_j y_{it-1})}$$

Where, y_{it} is livelihood strategy in the latter years (2014 or 2018) while y_{it-1} represents livelihood strategy in the previous years (2012 or 2014 and 2012). x_{it} are the vectors of explanatory variables, including household capitals (human, natural, physical, financial, social capitals) and village characteristics. α_j and β_j are the associated coefficients explaining the probability of a household to be part of identified cluster other than base group.

2.4.4. Identifying the determinants of livelihood strategy mobility

In the last step, a total of three categories of mobility are identified, namely: (i) upward mobility occurs when households shift from a strategy with a lower income level to an economically more attractive livelihood strategy, while (ii) downward mobility refers to the opposite case when a household moves into a lower income level strategy and (iii) no mobility represent when household remains in the same income level. In order to assess the determinants that explain the motilities among livelihood strategies, an ordered logit regression is employed. Following Cameron & Trivedi (2005), the equation can be specified with a single latent variable:

$$y_i^* = \beta x_{it-1} + u_i$$

In general, for an m-alternative ordered model, y_i defines as:

$y_i = j \;\; if \; c_{j-1} < y_i^* < c_j$, where $c_0 = -\infty$ and $c_m = \infty, j = 1, 2, 3, 4, \ldots, N$; $c_1, c_2, c_3 \ldots$ are the cut off points

Then, the probability of outcome *j* can be defined as:

$$\Pr(y_i = j \mid x_{it-1}) = \Pr(c_{j-1} < y_i^* < c_j)$$

$$= \Pr(c_{j-1} < \beta x_{it-1} + u_i < c_j)$$

$$= \Pr(c_{j-1} - \beta x_{it-1} < u_i < c_j - \beta x_{it-1})$$

$$= F(c_j - \beta x_{it-1}) - F(c_{j-1} - \beta x_{it-1})$$

Where, y_i is the categories of movement of livelihood strategy with ordinal values of 0, 1, 2 which stand for downward mobility, no mobility and upward mobility separately. x_{it-1} is the vector of independent variables in previous reference period. β are the associated regression coefficients. F is cdf of u_i. The regression coefficients β and $(j-1)$ unknown cut off points can be obtained by maximizing log likelihood.

2.4.5. Specification of model variables

The dependent variables used in multinomial logit regression (MLR) are also included in ordered logit regression (OLR). Variables regarding household and village characteristics which are hypothesized to explain the choices of certain livelihood strategy, are included in the analysis. An overview of all variables included is described in table 2.1. Specifically, household characteristics consist of human capital, natural capital, financial and social capital. Human capital includes household head information, labor size, dependency ratio, average household age and education, ethnicity, has worked on. Since livelihood activity decisions are mostly decided by a household head in a rural society, we have taken female household headship, household head age and major occupation household head works on into consideration. Labor size and dependency ratio are important factors to diversify livelihood strategies. Reardon (1997) had observed that family size influences a household to supply labor to farming activities. In a household with large labor size, some members could remain engaged in traditional farming while others could opt for off-farm activities (Khatun & Roy, 2012). Natural capital is represented by household altitude, land area, rubber cultivation and harvesting area household owns and the percentage of arable and forest land to be certified with land certification. Major income source differs from the altitude households reside in. Households with more land may engage in farming activities, e.g. crop cultivation. Altitudes can correlate with household's decision into different income-generating activities, for example, from Jin et al (2020), we know that there is a U-shape relationship between elevation and land rental decisions in XSBN. Financial capital includes whether households lend or owe money or receive public transfer from

government. Social capital is the membership family members of a social society which can increase access to government schemes. In addition, number of shocks households have suffered from can force farmers to diversify livelihood strategies or remain in the same strategy. Physical capital, like household wealth, is not included in the analysis due to it is more likely to be the results rather than the cause of choices of livelihood strategies.

At the village level, the following variables are included: average rubber price, whether access to two-lane high-quality road, the distance to the center of township, minimum one-way transportation cost to township and regional dummy. Since rubber price has made rubber cultivation profitable, the decline of rubber price could be the incentives for smallholder rubber farmers to diversify livelihood strategy. Regional dummy variables can capture regional differences on livelihood strategy classification. The rest variables indicate how accessible a specified village is to township where local labor market is advanced.

The only differences of those variables in these two models are: (i) variables in current reference period included in MLR whereas variables in the previous reference period included in OLR; besides, (ii) initial livelihood strategies in previous periods are included when doing MLR.

Table 2.1 Description of the variables included in the model

Variables	Type	Description
Household characteristics		
Female household head	Dummy	If household head is female; 1= yes;0 = Otherwise
Household head age	Continuous	Age of household head
HHD's major job types		
Own farming	Dummy	Engaging owning farming
Self-employment	Dummy	Self-employment
Agricultural wage employment	Dummy	Being employed in agricultural sector
Non-farming wage employment	Dummy	Being employed in non-farming sector
No. of labor	Continuous	No. of labor in a household
Dai ethnicity	Dummy	If a household is Dai ethnic group (1=yes; 0=otherwise)
Dependency ratio	Continuous	No. of dependents aged 0-14 and > 65 relative to No. of population aged 15-64
HH average age	Continuous	Average age in a household
HH average education	Categorical	Education attainment in a household
HH altitude	Continuous	Household altitude
Total land area	Continuous	Total land area; in Mu

Rubber area	Continuous	Total rubber cultivation area; in Mu
Rubber harvesting area	Continuous	Total rubber harvesting area; in Mu
Certified arable land	Continuous	The % of land in a HH is certified as cultivation land
Certified forest land	Continuous	The % of land in a HH is certified as forest land
Lending	Dummy	If household has lent money to others; (1=yes; 0=otherwise)
Loan	Dummy	If household has debt; (1=yes; 0=otherwise)
Public transfer received	Dummy	If household has received public transfer; (1=yes; 0=otherwise)
SPO	Dummy	If any household members have joined a social organization
No. of shocks	Continuous	No. of shocks household has suffered from
Village characteristics		
Rubber price	Continuous	Weighted average farm gate price of rubber of latex and dry rubber; in '1000 USD dollar
Two-lane road	Dummy	If household have access to high-quality two-lane road
Distance to the center of township	Continuous	The distance to the center of township; in km
Minimum one-way transportation cost to township	Continuous	The minimum one-way transportation cost to the center of township; in '1000 USD dollar
Jinghong	Dummy	Jinghong township; (1=yes; 0=otherwise)
Menghai	Dummy	Menghai township;(1=yes; 0=otherwise)
Mengla	Dummy	Menghai township; (1=yes; 0=otherwise)

Note: Mu is a metric unit used to measure land area in China. 1 mu equals to 666.67 square meters or 1 hectare equals to 15 mu. Source: Survey data

2.5 Descriptive statistics

2.5.1. Major variables of the sample

In table 2.2, summary statistics of the independent variables included in the models defined in the previous section (table2.1) are presented. The data in table 2.2 offer an overview of characteristics in terms of household, farm and village aspects in the panel dataset.

We can see that only 10% of households in XSBN is female head-led. Major occupation of household head is engaged in their own farming with a decreasing trend from 90% in 2012, to 70% in 2018, while the proportion of household head working on wage employment has been increasing from 3% in 2012 to 12% in 2018. It is assumed that major occupation of household head can influence resource allocation into income-generating activities. Average labor size per household is close to 4 people whereby the dependency ratio is around 40%, indicating that majority of household members are at working age and their average age is 35 years old. 60% of households is from Dai ethnic groups the majority group in

XSBN. Average altitude is around 750 meters above sea level. It is slightly different over periods due to the different tools (paper questionnaire in the first two waves, and tablet in the third wave) used for data collection. In terms of land area, on average, total land area a household own is about 70 mu. Majority of land is used to cultivate rubber with an average area of 50 mu. However, remarkably, only in about half of the rubber areas the trees are tapped. This is either because the plantation is still in gestation phase, especially in 2012 or because farmers have stopped tapping latex as a result of low rubber price which has decreased from 9.03 RMB (1.4 USD dollar) in 2012 to 3.95 RMB (0.6 USD dollar) in 2018 at the village level. It is noted that more than 40% of household are indebted. At the village level, the share of access to a high-quality two-lane road has doubled from 19 % in 2012 to 39 % in 2018 which indicates that infrastructure in the village has improved.

Table 2.2 Descriptive Statistics comparison of the variables included in the model

Variables	Unit	2012		2014		2018	
		Mean	Std.Dev.	Mean	Std.Dev.	Mean	Std.Dev.
Household characteristics							
Female household head	(0,1)	0.1	0.3	0.1	0.3	0.1	0.3
Household head age	Years	48.0	10.6	47.8	10.6	50.0	10.5
HHD's major job types							
Own farming	(0,1)	0.9	0.3	0.8	0.4	0.7	0.4
Self-employment	(0,1)	0.02	0.14	0.04	0.19	0.04	0.20
Agricultural wage employment	(0,1)	0.01	0.09	0.05	0.21	0.04	0.19
Non-farming wage employment	(0,1)	0.02	0.14	0.06	0.23	0.08	0.27
No. of labor	No.	3.8	1.2	3.9	1.2	3.7	1.2
Dai ethnicity	(0,1)	0.6	0.5	0.6	0.5	0.6	0.5
Dependency ratio	%	0.4	0.4	0.4	0.4	0.4	0.5
HH average age	Years	35.1	8.0	34.1	7.8	37.6	8.6
HH average education	Years	4.8	2.6	4.8	2.5	6.6	6.3
HH altitude	Meter	755.9	160.8	756.8	165.5	741.9	166.1
Total land area	Mu	68.3	67.8	72.5	76.2	66.7	63.6
Rubber area	Mu	53.1	58.8	54.2	64.5	45.6	54.7
Rubber harvesting area	Mu	23.3	39.8	25.0	41.1	24.0	39.4
Certified arable land	%	36.8	42.3	37.0	35.8	46.6	40.1
Certified forest land	%	55.2	43.8	55.0	40.0	55.3	40.0
Lending	(0,1)	0.15	0.36	0.18	0.39	0.11	0.32
Loan	(0,1)	0.42	0.49	0.41	0.49	0.47	0.50
Public transfer received	(0,1)	0.67	0.47	0.34	0.47	0.73	0.45
SPO	(0,1)	0.33	0.47	0.40	0.49	0.38	0.49

No. of shocks	No.	0.54	0.66	0.61	0.77	0.37	0.60
Village characteristics							
Rubber price	1000 USD dollar	0.0014	0.001	0.0008	0.0004	0.001	0.0004
Two-lane road	(0,1)	0.19	0.39	0.15	0.36	0.39	0.49
Distance to the center of township	km	11.6	11.6	11.3	11.6	12.1	11.8
Minimum one-way transportation cost to township	1000 USD dollar	0.002	0.0018	0.0013	0.0012	0.001	0.001
Jinghong	(0,1)			0.14	0.34		
Menghai	(0,1)			0.45	0.50		
Mengla	(0,1)			0.41	0.49		
Observation		**605**		**605**		**605**	

Source: own calculations

2.5.2. Changes of household's income-generating activities

The three pie charts in Figure 2.2 show income compositions in terms of per capita net income and the income changes for the three survey periods separately. We can see that household income source is diverse which consists of farming activities, like rubber, Traditional crops and some other cash crops cultivations, and non-farming activities, e.g., self-employment and wage employment. Correspondingly, rubber farming is an important income source for farmers albeit with a decreasing share from 41% in 2012 to 15% in 2018 due to the drop of rubber price. While other cash crops, like tea or tropical fruit cultivation increased in intensity during 2014 and decreased in 2018 once again. Remarkably, the share of off farming wage employment has demonstrated a gradual increasing trend as a result of labor reallocation. In 2012, it accounted for around 10 % of the household income but has increased to 32 % in 2018. Therefore, it could compensate for the income loss from rubber to some extent. Even though majority of households has reared livestock, income share of it only makes up 1% - 4% within the three periods. Income earned from renting out land is stable over time, approximately 11% of total income. It is also interesting to note that the income shares from non-farm self-employment and from natural resource extraction have declined in the next two periods. In general, annual household income in 2014 has dropped to 12917 RMB, nearly 26% less than the income in 2012 and in 2018, it was 14813 RMB, around 15% less compared with 2012(See

appendix of the absolute value of income changes). Those pie charts, we can conclude that smallholder rubber farmers have adjusted their income earning activities in response to the decline of rubber price.

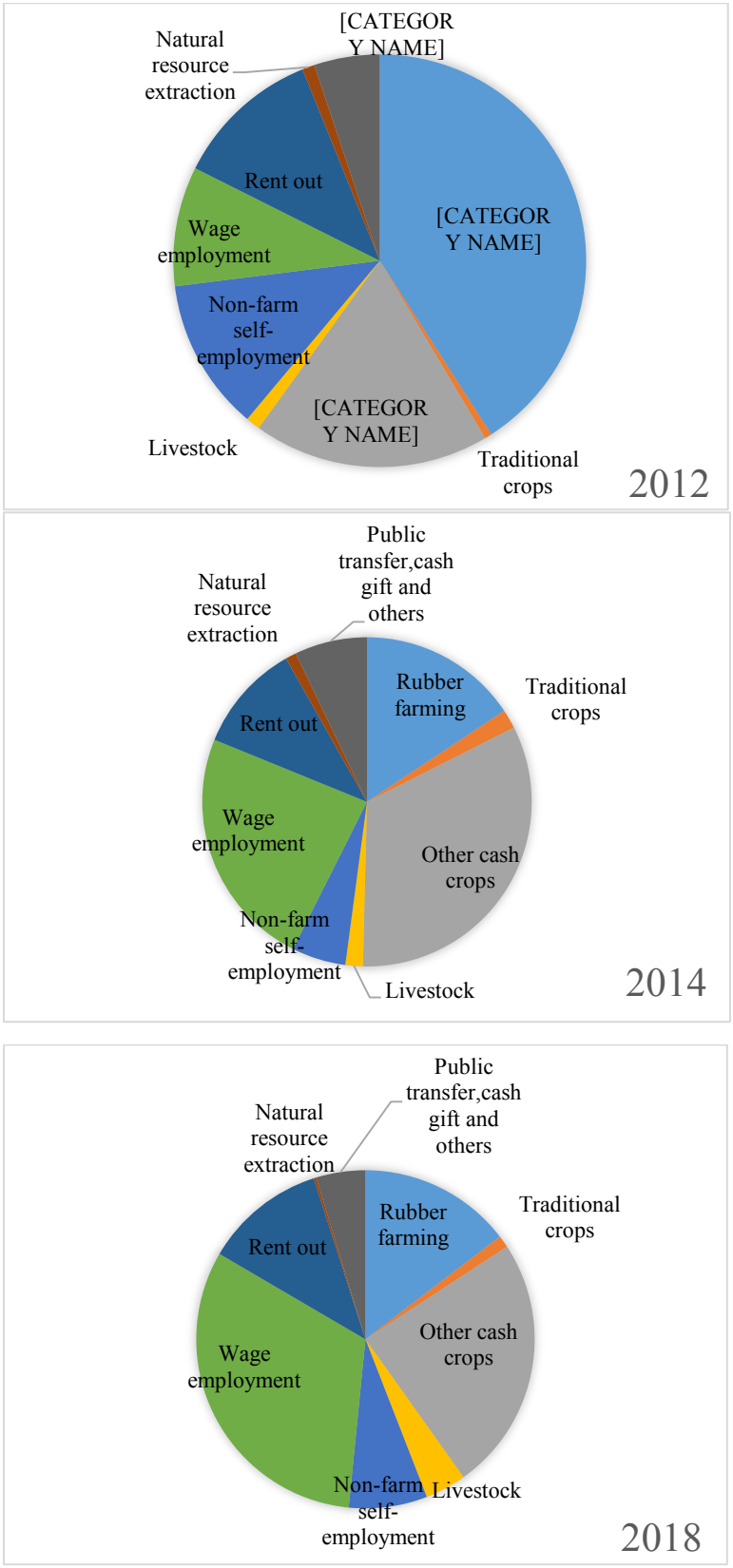

Figure 2.2 Income composition and changes in 2012 2014 and 2018

Source: own calculations

2.6 Model results

2.6.1 Livelihood strategy classification

A total of five livelihood strategy clusters has been classified in 2012, 2014 and 2018 in XSBN by applying cluster analysis. Generally, households with similar asset allocation choices are grouped together into the same and exclusively unique livelihood cluster. The statistics of activity variables is summarized in table 2A.2 and the comparison of them based on Bonferroni comparison test is shown in table 2A.3 – 2A.5 in the appendix.

In table 2.3, five livelihood clusters can be identified as follows: (1) Traditional crops (rice and maize) plus wage workers, (2) multiple livelihood strategy including traditional and cash crops as well as off farm employment, (3) Rubber dominant, wage workers plus renting out land, (4) cash crops dominated cultivation, including rubber, tea and fruit trees, (5) self-employed and wage workers plus renting out land. Actually, based on the statistics of activity variables (see appendix table 2A.2), all identified clusters are common in rubber cultivation which remains a major source of livelihood strategy in all livelihood groups, albeit at different levels of intensity. For instance, in the third cluster, rubber cultivation has accounted for an absolutely dominant place with highest percentage of asset allocation compared with other clusters. In order to stress it, we have included rubber when the third livelihood cluster is labeled. However, other clusters, is named after other dominant activities in addition to rubber cultivation.

There is approximately 20% in 2012, 23% in 2014 and 15% in 2018 of all households who is grouped into cluster 1. It is characterized by, high input into rubber cultivation, highest Traditional crops input among all clusters and relatively high expenditure spend on off farm wage employment. Livelihood strategy 2 is labeled as multiple strategy as assets are allocated into diverse activities, with less households adopting this strategy, from 23% in 2012 to 12.6% in 2018. In livelihood strategy 3, majority of all input is allocated into rubber cultivation which is the highest over five clusters. Besides investment into rubber cultivation, farmers devote most of the remaining labor assets to wage employment. Hence, it's called rubber dominant, wage workers plus renting out land. Livelihood strategy 4 is called cash crops-

dominated due to the high input into cash crops cultivation, including rubber, tea and fruit trees. The last livelihood strategy presents the group of households who have engaged in self-employment, wage employment, and rent out land. Our findings are consistent with previous researches that diverse activities smallholder farmers have practiced can secure income (Ellis,2000; Winters et al., 2001; Wan et al.,2016)

Table 2.3 Livelihood strategies and distribution of households in each strategy

Clusters	Categories	2012	2014	2018
LS1	Traditional crops plus wage workers	123	137	90
LS2	Multiple livelihood strategy	141	88	76
LS3	Rubber dominant, wage workers plus renting out land	181	207	245
LS4	Cash crops-dominated cultivation	113	142	106
LS5	Self-employed and wage workers plus renting out land	47	31	88
Total		**605**	**605**	**605**

Source: own calculations

2.6.2 Livelihood strategies transition

Between periods, households adjust their asset allocation in response to socioeconomic and ecological changes in XSBN, e.g., rubber price fluctuations. In return, livelihood strategy clusters to which households are assigned, differ over the periods. Hence, mobility of livelihood strategy clusters occurs. Tables 2.4 and 2.5 have shown the transition matrix of households between different livelihood strategies on the short term between 2012-2014; and on the medium term between 2012-2018.

As Table 2.4 shows, in 2012, LS3 is the major strategy accounting for 29.9%, following by LS2, LS1. While the primary livelihood strategies become LS3, LS4 and LS1 in 2014. In terms of the transition of livelihood strategies, among the 20% of households with LS1 in 2012, nearly 2%, 5%,3% and 1% of them has separately moved to LS2, LS3 LS4 and LS5 in 2014. In total, almost 11% of households who falls into LS1 in 2012 has been grouped into other strategies in 2018 due to their adjustments of asset allocation. 13.5% of households has transited from LS2 in 2012 to another four livelihood categories in 2014. 8.93% of LS3 households between 2012 and 2014 has moved out. The transitions from LS4 and LS5 in the 2 years' gap is 7.77% and 5.95%. Therefore, to sum up, in the short term, a total of 46.78% of households

have modified their livelihood strategies in order to adapt contextual factors changes, especially the decline of rubber price. From table 2.5, we can see that LS3, LS4 and LS1 are still the primary livelihood strategies in 2018. A total of 64.79% of households have shifted their livelihood strategies within six-years periods which is higher than the amount of mobility in the short term. It indicates that majority of households have adjusted their resource allocation into diverse activities in response to rubber price changes in XSBN.

Table 2.4 Livelihood strategy transition matrix (%) between 2012-2014

	Categories	2014					Total in 2012	Move-out
		Traditional crops plus wage workers (LS1)	Multiple livelihood strategy (LS2)	Rubber dominant, wage workers plus renting out land (LS3)	Cash crops-dominated cultivation (LS4)	Self-employed and wage workers plus renting out land (LS5)		
2012	Traditional crops plus wage workers (LS1)	9.75	1.98	4.46	3.31	0.83	20.33	10.58
	Multiple livelihood strategy (LS2)	7.27	9.75	1.49	4.63	0.17	23.31	13.55
	Traditional crops plus wage workers (LS3)	2.31	0.99	20.99	3.80	1.82	29.92	8.93
	Cash crops-dominated cultivation (LS4)	1.49	1.65	4.13	10.91	0.50	18.68	7.77
	Self-employed and wage workers plus renting out land (LS5)	1.82	0.17	3.14	0.83	1.82	7.77	5.95
Total in 2014		22.64	14.55	34.21	23.47	5.12	100.00	
Move-in		12.89	4.79	13.22	12.56	3.31		46.78

Source: own calculations

Table 2.5 Livelihood strategy transition matrix (%) between 2012-2018

	Categories	2018					Total in 2012	Move -out
		Traditional crops plus wage workers (LS1)	Multiple livelihood strategy (LS2)	Rubber dominant, wage workers plus renting out land (LS3)	Cash crops-dominated cultivation (LS4)	Self-employed and wage workers plus renting out land (LS5)		
2012	Traditional crops plus wage workers (LS1)	3.14	2.64	10.08	2.64	1.82	20.33	17.19
	Multiple livelihood strategy (LS2)	7.44	4.79	3.97	4.96	2.15	23.31	18.51
	Traditional crops plus wage workers (LS3)	1.49	2.81	17.85	2.15	5.62	29.92	12.07
	Cash crops-dominated cultivation (LS4)	2.31	1.65	5.62	7.60	1.49	18.68	11.07
	Self-employed and wage workers plus renting out land (LS5)	1.82	0.17	3.14	0.83	1.82	7.77	5.95
Total in 2018		16.20	12.07	40.66	18.18	12.89	100.00	
Move-in		13.06	7.27	22.81	10.58	11.07		64.79

Source: own calculations

2.6.3 Determinants of livelihood strategy choices

The estimation results from multinomial logit regression are presented in Table 2.6 which demonstrates the factors determining the choices of livelihood strategy in 2014. LS4 is the base group for this analysis. The coefficients explain the likelihood of smallholder rubber farmers undertake other livelihood strategies relative to the choice of cash-crop dominated livelihood strategy (base group).

From the results we can see that the initial livelihood strategies in 2012 is correlated with the choices in 2014. A female-headed household is more likely to practice cash crops-based livelihood strategy (LS4) than LS1. This is probably because households with female headship have less male labor. Furthermore, the conservative outlook of female household head has led them to prefer farming activities. This finding is different from the analysis from Van den Berg (2010). It is likely that households with more certified arable land are opt for LS4 than LS1 as well. At the village level, shorter distance and lower transport cost to the center of township can prompt farmers to adopt LS4 than LS1. In terms of multiple livelihood strategy (LS2), major occupation of household head and dependency ratio are negatively correlated with the choice of it. Specifically, a household head being employed in agricultural sectors is less willing to adopt a multiple livelihood strategy. Higher dependency ratio means less available labor to do multiple income earning activities. However, the finding that rubber price is significantly correlated with LS2 relative to LS4 which is quite surprising. The possibility to be in LS3 and LS5 is negatively correlated with household altitude and total land area, while positively associated with total rubber area. LS3 and LS5 has non farming activities involved. Households in higher altitude and more land area can be constraint to undertake non farming activities. Higher rubber area that increases the possibility in LS3 and LS5 is plausible. LS3 is originally rubber dominant livelihood strategy. LS5 mainly involves in non-farming activities. Even though households own large rubber area, when income from rubber cultivation is less profitable, households will not allocate labor or investment to manage and harvest it. The statistics of activity variables of labor and expenditure also correspond to this situation (in Appendix Table 2A.2), that is, even though the land area allocated is LS5 is relatively higher, labor and expenditure is smallest over all clusters. Transport cost to the center of township decreases the possibility to be in cluster 5. Lower

transport cost represents the center of township is easily accessible where the economic growth is more developed with better wage-rated non-farm opportunities. Household who lends money to others are better off which can invest more into off farm activities. Meanwhile, indebted household is also more likely to undertake LS5 compared with base group on the short term. Mainly because the startup of non-farm business and wage employment activities needs capitals. The debt in the short run could has an active impact on off farm activities.

The determinants of choice in 2018 from multinomial logit regression results is shown in Table 2A.6 in the appendix. We find some new variables which have substantial influence on the choice of strategies on the medium term compared with short term. A female-head household is less likely to be in LS1, which is the same as the result in the short term. In the medium term, the occupation type of household head is an influential factor for the choice of livelihood strategies. For instance, household head engaging into own farming is more likely to practice cash crops-based livelihood strategy rather than Traditional crops-based (LS1). The household head who is self-employed is likely to choose livelihood strategy 5 with less farming activities whereas less likely to choose LS1 and LS3 which involves farming activities. Dai ethnic group is less likely to practice LS3 this is due to Dai group resides in lowland area with more high quality arable land and which enables them easily access to land rental and labor market.

In the medium term, household altitude and total land area negatively correlate with LS3 and LS5 in 2018. Furthermore, altitude is negatively associated with LS2 in 2018. Being contrary with the results in 2014, the debt household own decrease the possibility to be LS5 and LS2. This implies that long term debt which beyond farmers' affordability can constrain the choice of LS5 and LS2. Household with social group membership is less likely to take on LS3. LS3 yields least income for smallholder rubber farmers based on the following analysis. Social ties can help households to access to better career information and resources. The number of shocks a household suffers from increases the possibility to undertake diverse livelihood strategies (LS2). Access to good quality two-lane road has a strong influence on LS3 than LS4. The probability to be in LS2 is negatively affected by longer distance to the center of township.

Table 2.6 The determinants of livelihood strategy choices in 2014 by MLM regression

Variables	Traditional crops plus wage workers (LS1)		Multiple livelihood strategy (LS2)		Rubber dominant, wage workers plus renting out land (LS3)		Self-employed and wage workers plus renting out land (LS5)	
	Coef.	S.D	Coef.	S.D	Coef.	S.D	Coef.	S.D
Household strategies in 2012								
LS1: Traditional crops plus wage workers	2.90 ***	0.54	1.29 **	0.56	0.67	0.43	0.65	0.83
LS2: Multiple livelihood strategy	2.04 ***	0.5	2.58 ***	0.46	0.36	0.53	-0.14	1.59
LS3: Rubber dominant, wage workers plus renting out land	1.91 ***	0.58	0.61	0.66	1.95 ***	0.41	1.38 *	0.73
LS5: Self-employed and wage workers plus renting out land	3.1 ***	0.77	0.97	1.11	1.49 **	0.58	3.37 ***	0.88
Household characteristics								
Female household head	-1.47 **	0.7	-0.93	0.62	-0.06	0.5	-0.98	0.88
HD age	0.03	0.08	0.15	0.14	0.13	0.08	0.26	0.2
HD age2	-9.96e-05	0.0008	-0.001	0.001	-0.009	0.001	-0.002	0.002
HD's major job types								
Own farming	-0.28	1.25	-1.3	1.06	-0.41	0.98	-1.91	1.22
Self-employment	1.29	1.81	-0.05	1.76	1.61	1.42	2.3	1.62
Agricultural wage employment	-0.88	1.37	-2.57 **	1.31	-0.31	1.1	-1.27	1.65
Non-farming wage employment	-1.11	1.42	-1.76	1.35	-0.18	1.15	-1.37	1.4
No. of labor	0.06	0.16	-0.17	0.17	0.08	0.15	0.24	0.31
Dai ethnicity	-0.49	0.36	0.07	0.42	-0.23	0.35	0.74	0.75
Dependency ratio	-0.024	0.46	-0.86 *	0.45	-0.004	0.4	0.014	0.88
HH average age	-0.015	0.022	0.017	0.022	-3E-04	0.019	-0.089 **	0.038
HH average education	0.014	0.065	-0.006	0.077	0.007	0.068	0.092	0.077
HH altitude	0.0004	0.0012	-0.001	0.001	-0.005 ***	0.0015	-0.005 **	0.002
Total land area	-0.011	0.01	0.0074	0.0084	-0.066 ***	0.0148	-0.098 ***	0.028

Rubber area	0.014		0.01	-0.016		0.012	0.061	***	0.0148	0.091	***	0.028
Rubber harvesting area	-0.006		0.0051	0.005		0.0075	0.003		0.0053	0.0082		0.008
Certified arable land	-0.014	*	0.007	-0.002		0.0087	0.002		0.0064	0.0066		0.013
Certified forest land	-0.005		0.006	-0.004		0.0073	-0.004		0.0053	-0.008		0.012
Lending	-0.64		0.45	-0.23		0.44	0.35		0.36	1.2	**	0.6
Loan	0.47		0.33	0.23		0.35	0.22		0.32	0.92	*	0.53
Public transfer received	-0.44		0.33	-0.21		0.35	-0.34		0.32	0.07		0.49
SPO	0.39		0.33	0.46		0.36	0.16		0.29	0.27		0.56
No. of shocks	0.06		0.19	0.01		0.2	-0.45	**	0.21	0.13		0.39
Village characteristics												
Rubber price	390.6		412.78	1,453.3	***	449.5	-172.2		401.9	-460.1		879.2
Two-lane road	-0.68		0.44	0.62		0.44	-0.41		0.47	-1.11		1.00
Distance to township	0.03	*	0.02	0.004		0.02	0.01		0.02	0.02		0.05
Minimum transport cost	-370.2	*	205	-59.97		133.2	140.6		137.3	-912.1	***	344.7
Menghai	-1.98	***	0.54	-1.09	*	0.66	-0.20		0.50	-2.05	**	1.02
Jinghong	-2.50	***	0.37	-0.75	*	0.40	-0.09		0.37	-0.60		0.65
Constant	-0.82		2.92	-3.63		3.49	0.94		2.68	-1.90		5.96

*** p<0.01, ** p<0.05, * p<0.1; Source: own calculations

2.6.4 Ordering livelihood strategies based on return

As figure 2.3 shows, per capita income among the five livelihood strategies ranges largely in 2012, 2014 and 2018. For instance, in 2012, it ranges from 18395 RMB for LS3 to 94710 RMB for LS5 while in 2014, it varies from 13223 RMB for LS3 to 54968 RMB for LS5, and in 2018, it changes from LS3 with 15629 RMB to LS5 with 38561 RMB. Therefore, the LS5 (Self-employed and wage workers plus renting out land) is found to be the most beneficial strategy in terms of the highest per capita income it yielded, whereas LS3 (Rubber dominant, wage workers plus renting out land) has the lowest per capita income. Furthermore, the pairwise comparison of LS3 and LS5 in per capita income shows they are significantly different (As appendix table 2A.7 and table 2A.8 show). Stochastic dominance analysis[1](Sergei et al., 2020; Marrit van den Berg,2010) further confirms the findings, since it provides a more comprehensive information with low, medium and high-income livelihood strategy by considering income distribution at all moments than not just compare mean levels of income at certain points. As revealed in table 2.7, livelihood strategy 5 is the dominant strategy which brings highest return for rubber farmers. Contrarily, livelihood strategy 3 is the one with low income. Income derived from the remaining three livelihood strategies (LS1/LS2/LS4) are at medium level. What's more, the results from stochastic dominance analysis are in accordance with average per capita income comparisons.

Our findings indicate that livelihood strategy with off farm employment involvement have yielded relatively higher income compared with strategy with farming.

What's more, table 2.8 shows the upward and downward movements of households between different income levels. In the short term, there is 73.5% of households who remain in the same income groups. 16% has moved upward into relatively profitable income strategies in 2014 while 10.4% has moved downward into fewer beneficiary activities. Surprisingly, on the medium term, the figure shows that more households, accounting for 24%, have moved downward into groups with less income level in 2018 whereas 17.5% has transited into ecologically attractive strategies.

[1] Following Sergei et al., (2020), Kolmogorov-Smirnov equality-of-distributions test is applied to conduct stochastic dominance analysis

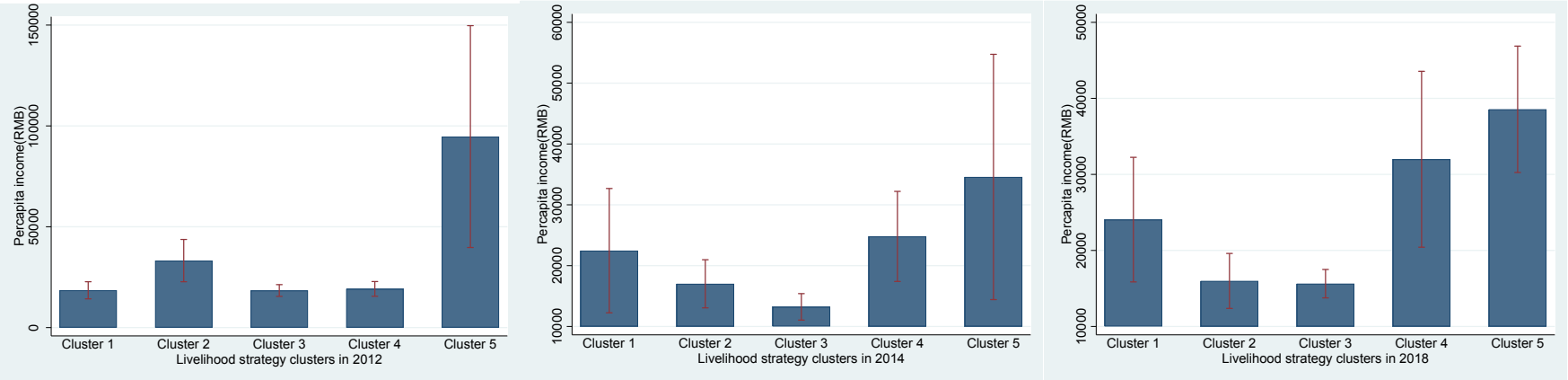

Figure 2.3 Average per capita income and standard deviation among clusters over years

Table 2.7 Overview of second order stochastic dominance between livelihood strategies

Livelihood strategies	2013		2015		2019	
	Dominant	Dominated	Dominant	Dominated	Dominant	Dominated
High-income strategy						
Self-employed and wage workers plus renting out land (LS5)	4	0	2	0	4	0
Medium-income strategy						
Traditional crops plus wage workers (LS1)	0	2	1	1	1	1
Multiple livelihood strategy (LS2)	3	1	1	0	0	2
Cash crops-dominated cultivation (LS4)	0	2	1	0	2	0
Low-income strategy						
Rubber dominant, wage workers plus renting out land (LS3)	0	3	0	4	0	4

Source: own calculations

Table 2.8 Transition matrices for income groups of rural livelihood strategies (%)

	2014			2018		
2012	Low	Middle	High	Low	Middle	High
Low	20.99	7.11	1.82	17.85	6.45	5.62
Middle	10.08	50.74	1.49	19.67	37.19	5.45
High	3.14	2.81	1.82	2.98	1.32	3.47

Source: own calculations

2.6.5 Determinants of livelihood strategy mobility between different income levels

An ordered logit model was used to estimate the factors that were expected to be correlated with the determinants of downward and upward mobility. As table 2.9 presents, in the short term, we can see that a household with female headship is more likely to move downward, i.e. to relatively less beneficial livelihood strategy. This may indicate that female headship can be a constraint for households due to a number of limitation in a male dominated society. Household average education is negatively correlated with downward mobility which implies that households with higher educated members are less likely to move to strategies with lower income. Households with debt, in the short term, are less likely to move downwards. It is plausible if a household borrows money to invest into off farm activities which could yield highest income among all income generating activities. The coefficient for "Menghai" implies that households in this county experience a higher probability to move downwards. In the medium term (as Table 2A.9 in the appendix shows), some coefficients can explain the mobility in different directions. For instance, depending on the kind of major occupation of a household head the coefficient can be positive or negative. If household head is employed in the non-farm sector, the household is more likely to move upward while the opposite is the case if major occupation is in own farming. Rubber area is negatively correlated with upward mobility, indicating that a larger rubber area constrains a shift into more beneficial livelihood strategies which is due to sunk cost and government restriction of converting rubber to other land use. When rubber price is higher, farmers allocate more labor and time into rubber cultivation and less labor is allocated into labor market participation. Households with access to high quality two-lane roads are less likely shift their livelihood strategy into less beneficial ones.

Table 2.9 Estimations of ordered logit regression between 2012 and 2014

Variables	Ordered logit		Marginal effect					
			Downward mobility		No mobility		Upward mobility	
	Coef	S.D	Coef	S.D	Coef	S.D	Coef	S.D
Female household head	-1.158***	0.364	0.144***	0.045	-0.038**	0.0191	-0.106***	0.035
HD age	0.056	0.055	-0.007	0.007	0.002	0.002	0.005	0.005
HD age2	-0.001	0.001	0.0001	0.0001	-0.00002	0.00002	-0.00006	0.0001
HD's major job types								
Own farming	0.211	0.634	-0.026	0.079	0.007	0.021	0.019	0.058
Self-employment	-0.834	0.941	0.104	0.117	-0.028	0.033	-0.076	0.086
Agricultural wage employment	-1.809	1.122	0.225	0.138	-0.060	0.042	-0.165	0.105
Non-farming wage employment	0.565	0.871	-0.070	0.109	0.019	0.031	0.052	0.079
No. of labor	-0.040	0.103	0.005	0.013	-0.001	0.0034	-0.004	0.009
Dai ethnicity	0.259	0.229	-0.032	0.029	0.009	0.008	0.024	0.021
Dependency ratio	0.007	0.260	-0.001	0.032	0.0002	0.009	0.001	0.024
HH average age	0.001	0.014	-0.0001	0.002	0.0000	0.001	0.0001	0.001
HH average education	0.052*	0.031	-0.006*	0.004	0.00171	0.001	0.005	0.003
HH altitude	0.0002	0.001	-0.00001	0.0001	0.00001	0.0000	0.00001	0.0001
Total land area	0.0004	0.003	-0.0001	0.0004	0.00001	0.0001	0.00004	0.0003
Rubber area	-0.006	0.005	0.0008	0.0006	-0.0002	0.0002	-0.0006	0.0004
Rubber harvesting area	-0.002	0.003	0.0003	0.0004	-0.0001	0.0001	-0.0002	0.0003
Certified arable land	-0.005	0.004	0.0007	0.0005	-0.0002	0.0002	-0.0005	0.0004
Certified forest land	-0.001	0.004	0.0001	0.0005	-0.00005	0.0001	-0.0001	0.0004
Lending	0.020	0.270	-0.002	0.034	0.0007	0.009	0.002	0.024
Loan	0.339*	0.202	-0.042*	0.025	0.011	0.008	0.031	0.019
Public transfer received	-0.114	0.245	0.014	0.030	-0.004	0.008	-0.010	0.023
SPO	0.292	0.221	-0.036	0.028	0.01	0.008	0.027	0.020
No. of shocks	0.002	0.157	-0.0002	0.020	0.0001	0.005	0.0001	0.014
Village characteristics								

Rubber price	30.065	141.703	-3.737	17.602	0.997	4.712	2.740	12.91
Two-lane road	-0.177	0.236	0.022	0.029	-0.006	0.007	-0.016	0.022
Distance to township	0.011	0.009	-0.001	0.001	0.0004	0.0003	0.001	0.001
Minimum transport cost	29.306	63.839	-3.642	7.929	0.972	2.144	2.671	5.826
Menghai	-1.034***	0.344	0.129***	0.042	-0.034*	0.018	-0.094***	0.033
Jinghong	-0.137	0.236	0.017	0.029	-0.005	0.008	-0.013	0.022
cut1	-0.559	1.637						
cut2	3.521**	1.648						
Observations	605		605		605		605	

*** p<0.01, ** p<0.05, * p<0.1; Source: own calculations

2.7 Summary, conclusions and policy implications

In this study, we have investigated the livelihood strategies pursued by smallholder rubber farmers in XSBN. We especially analyzed the changes over a seven-year period, applying a framework of dynamic of livelihood strategy in XSBN. A multinomial and an ordered logit model were employed to estimate the determinants of the households' livelihood choices over time. A three-wave panel dataset of 612 households were used.

Overall, our results demonstrate that even though rubber cultivation still plays a major role in all livelihood strategies in rural XSBN, diversifying the income portfolio is taking place which confirms the observation of other authors, e.g. Davis et al., (2010). Rubber farmers in XSBN have adjusted resource reallocations in response to changing socioeconomic conditions. The main findings of this paper are as follows. First, a total of five livelihood strategies have been classified. From the activity variables, it was derived that all the 612 households in our panel are in effect part-time farmers with varying degrees of income shares from own agriculture and non-agricultural sources respectively. Second, the majority of households are found having changed their livelihood strategy over the seven-year observation period. There were 47% between 2012 and 2014 and 65% of households between 2012 and 2018 who transited to other strategies. Third, the livelihood strategy involving activities of self-employment, wage employment and renting out land yields the highest income, whereas following a rubber-dominated strategy results in the low-income category. Fourth, some factors are significantly correlated with the choices of a livelihood strategy. For instance, households with female headship are more likely to adapt subsistence farming. Households with more dependent members are less likely to be found adopting a multiple income source livelihood strategy. Also, transportation costs to the township center, altitude and total land area, are the factors which constrain households to adopt a livelihood strategy which yields higher income. Belonging to the Dai ethnicity and access to good quality two-lane roads is positively associated. Furthermore, the more shocks a household has experienced, the more she is likely to diversify her income generating activities. Fifth, since a livelihood strategy corresponds with high, medium and low-income levels, the transitions of households between different income levels were observed in the study. Finally, average

education of household members and household debt and female household headship are correlated with downward mobility on the short term, while household head occupation, membership in a social group and access to good-quality roads are significant on the medium term.

Our findings have some implications for rural development policies. First, since diversification continues to take place among rubber farmers, there is a need to focus on farming transitions towards different livelihood strategies, rather than promoting a fixed farming model, e.g. intercropping in rubber, as currently the case in XSBN. Improving skills and capacities of rural household members, e.g. through adult education should be undertaken by the Government. This will make household members better prepared for the requirements of the off-farm labor market. Furthermore, promoting village-based small and medium size enterprises, the advancement of land rental markets and promoting more sustainable farming practices should be components of such policies. With the outbreak of Covid-19 in China, and the on-going "Zero Covid" policy of the national Government, support for the adjustment of livelihood strategies are needed in order minimize economic losses arising from strict quarantine regulations.

References

Ansoms A., McKay, A. (2010). A quantitative analysis of poverty and livelihood profiles: the case of rural Rwanda. *Food Policy*, *35*(6), 584-598.

Babulo, B., Muys, B., Nega, F., Tollens, E., Nyssen, J., Deckers, J., & Mathijs, E. (2008). Household livelihood strategies and forest dependence in the highlands of Tigray, Northern Ethiopia. *Agricultural Systems*, *98*(2), 147-155.

Barrett, C. B., Reardon, T., & Webb, P. (2001a). Nonfarm income diversification and household livelihood strategies in rural Africa: concepts, dynamics, and policy implications. *Food policy*, *26*(4), 315-331.

Barrett, C. B., Bezuneh, M., Clay, D. C., & Reardon, T. (2001b). *Heterogeneous Contraints, Incentives, and Income Diversification Strategies in Rural Africa* (No. 642-2016-43959).

Barrett, G. F., & Donald, S. G. (2003). Consistent tests for stochastic dominance. *Econometrica*, *71*(1), 71-104.

Caliński, T., & Harabasz, J. (1974). A dendrite method for cluster analysis. *Communications in Statistics-theory and Methods*, *3*(1), 1-27.

Cameron, A. C., & Trivedi, P. K. (2005). *Micro econometrics: methods and applications*. Cambridge university press.

Campos, M., Velázquez, A., & McCall, M. (2014). Adaptation strategies to climatic variability: A case study of small-scale farmers in rural Mexico. *Land Use Policy*, 38, 533-540.

Chambers, R. and Conway, G. (1992). *Sustainable Rural Livelihoods: Practical Concepts for the 21st Century*, IDS Discussion Paper 296, Institute of Development Studies, University of Sussex, Brighton.

Davis, B., Winters, P., Carletto, G., Covarrubias, K., Quiñones, E. J., Zezza, A., ... & DiGiuseppe, S. (2010). A cross-country comparison of rural income generating activities. *World development*, 38(1), 48-63.

Ellis, F., 2000. Rural Livelihoods and Diversity in Developing Countries. Oxford University Press, New York.

Fan, S., Brzeska, J., Keyzer, M., & Halsema, A. (2013). *From subsistence to profit: Transforming smallholder farms* (Vol. 26). Food policy report. Washington, D.C.: International Food Policy Research Institute (IFPRI). http://dx.doi.org/10.2499/9780896295582

Garson, G. D. (2012). Testing statistical assumptions. Asheboro, NC: *Statistical Associates Publishing*.

Jansen, H. G., Pender, J., Damon, A., Wielemaker, W., & Schipper, R. (2006). Policies for sustainable development in the hillside areas of Honduras: A quantitative livelihoods approach. *Agricultural economics*, *34*(2), 141-153.

Jiao, X., Pouliot, M., & Walelign, S. Z. (2017). Livelihood strategies and dynamics in rural Cambodia. *World Development*, *97*, 266-278.

Jin, S., Huang, J., & Waibel, H. (2020). Location and economic resilience in rubber farming communities in southwest China. *China Agricultural Economic Review*.

Khatun, D., & Roy, B. C. (2012). Rural livelihood diversification in West Bengal: determinants and constraints. *Agricultural Economics Research Review*, *25*(347-2016-16910), 115-124.

Liu,W., Li, J., Lu,H., et.al (2013). Vertical patterns of soil water acquisition by non-native rubber trees (Hevea brasiliensis) in Xishuangbanna, Southwest China. *Ecohydrology*, *7*, 1234–1244.

Min, S., Waibel, H., Cadisch, G., Langenberger, G., Bai, J., & Huang, J. (2017a). The Economics of Smallholder Rubber Farming in a Mountainous Region of Southwest China: Elevation, Ethnicity, and Risk. *Mountain Research and Development, 37*(3), 281.

Min, S., Huang, J., Bai, J., & Waibel, H. (2017b). Adoption of intercropping among smallholder rubber farmers in Xishuangbanna, China. *International Journal of Agricultural Sustainability, 15*(3), 223–237.

Nielsen, Ø. J., Rayamajhi, S., Uberhuaga, P., Meilby, H., & Smith-Hall, C. (2013). Quantifying rural livelihood strategies in developing countries using an activity choice approach. *Agricultural economics, 44*(1), 57-71.

Paudel Khatiwada, S., Deng, W., Paudel, B., Khatiwada, J. R., Zhang, J., & Su, Y. (2017). Household livelihood strategies and implication for poverty reduction in rural areas of central Nepal. *Sustainability*, 9(4), 612.

Reardon, T. (1997). Using evidence of household income diversification to inform study of the rural nonfarm labor market in Africa. *World development*, *25*(5), 735-747.

Schaub, S., Buchmann, N., Lüscher, A., & Finger, R. (2020). Economic benefits from plant species diversity in intensively managed grasslands. *Ecological Economics*, 168, 106488.

Savath, V., Fletschner, D., Peterman, A., & Santos, F. (2014). *Land, assets, and livelihoods: Gendered analysis of evidence from Odisha state in India* (Vol. 1323). Intl Food Policy Res Inst.

Scoones, I., (1998). *Sustainable rural livelihoods: A framework for analysis*. IDS Working Paper No. 72, Institute of Development Studies, University of Sussex, Brighton.

Scoones, I. (2009). Livelihoods perspectives and rural development. *The journal of peasant studies*, *36*(1), 171-196.

Soltani, A., Angelsen, A., Eid, T., Naieni, M. S. N., & Shamekhi, T. (2012). Poverty, sustainability, and household livelihood strategies in Zagros, Iran. *Ecological Economics*, *79*, 60-70.

Van den Berg, M. (2010). Household income strategies and natural disasters: Dynamic livelihoods in rural Nicaragua. *Ecological Economics*, *69*(3), 592-602.

Walelign, S. Z., Pouliot, M., Larsen, H. O., & Smith-Hall, C. (2017). Combining household income and asset data to identify livelihood strategies and their dynamics. *The Journal of Development Studies*, *53*(6), 769-787.

Winters, P., Corral, L., Gordillo, G., 2001. *Rural livelihood strategies and social capital in Latin America: Implications for rural development projects*. Working Paper Series No. 2001-6, School of Economics, University of New England, Armidale.

Wan, J., Li, R., Wang, W., Liu, Z., & Chen, B. (2016). Income diversification: A strategy for rural region risk management. *Sustainability*, 8(10), 1064.

Wooldridge, J. M. (2002). Econometric analysis of cross section and panel data MIT press. *Cambridge, MA*, *108*(2), 245-254.

Xu, J., (2006). The political, social, and ecological transformation of a landscape. *Mountain Research and Development, 26*(3), 254-262.

Xu, J., Grumbine, R. E., & Beckschäfer, P. (2014). Landscape transformation through the use of ecological and socioeconomic indicators in Xishuangbanna, Southwest China, Mekong Region. *Ecological Indicators*, 36, 749-756.

Zhang, J., Mishra, A. K., & Zhu, P. (2019). Identifying livelihood strategies and transitions in rural China: Is land holding an obstacle? *Land Use Policy*, *80*, 107-117.

Appendix

Table 2A.1 Average net income and income source in 2012,2014,2018

	2012			2014			2018		
Income sources classification	No.	Mean	%	No.	Mean	%	No.	Mean	%
Total net income	**605**	**17363.2**	**100.0**	**605**	**12917.3**	**100.0**	**605**	**14813.8**	**100.0**
Rubber farming	605	7183.4	41.4	598	2025.7	15.7	599	2165.7	14.6
Traditional crops	236	-97.8	-0.6	241	241.6	1.9	233	171.2	1.2
Other cash crops	257	3248.7	18.7	235	4242.1	32.8	304	3612.7	24.4
Livestock	546	197.1	1.1	540	221.0	1.7	518	582.1	3.9
Non-farm self-employment	67	2094.3	12.1	59	686.6	5.3	99	1109.2	7.5
Wage employment	143	1647.2	9.5	211	3066.8	23.7	298	4718.5	31.9
Rent out	163	2018.8	11.6	289	1376.8	10.7	334	1720.7	11.6
Natural resource extraction	447	170.8	1.0	337	137.8	1.1	90	36.2	0.2
Public transfer, cash gift and others	444	900.7	5.2	451	919.0	7.1	458	697.4	4.7

Source: own calculations; Unit: RMB/population

Table 2A.2 Average value of activity variables in each livelihood strategies over years

Activity variables	All			Traditional crop plus wage workers (LS1)			Multiple livelihood strategy (LS2)			Rubber dominant, wage workers plus renting out land (LS3)			Cash crops-dominated (LS4)			Self-employed and wage workers plus renting out land (LS5)		
	2012	2014	2018	2012	2014	2018	2012	2014	2018	2012	2014	2018	2012	2014	2018	2012	2014	2018
Land shares (%)																		
Rubber	79.4	73.9	66.2		78.1	60.1	62.3	60.7	69.2	90.5	80.3	71.0	72.9	66.5	59.1	92.8	84.5	65.4
Traditional crops	6.0	4.1	5.2	13.3	11.2	8.3	12.6	10.1	14.7	0.0	0.1	3.3	0.0	0.1	0.6	5.0	0.0	4.5
Other cash crops	8.7	9.7	13.7	0.0	5.6	23.6	19.9	18.1	7.2	0.1	0.2	5.7	21.9	24.4	30.7	0.0	0.3	10.7
Rent-out	5.8	12.3	14.7	3.0	5.1	8.1	5.3	11.1	8.9	9.4	19.4	20.0	5.2	9.1	9.6	2.3	15.2	18.2
Labor shares (%)																		
Rubber	59.9	58.0	42.0	65.2	61.3	35.6	43.4	49.6	44.7	78.4	68.0	50.5	53.9	51.2	35.9	39.4	32.2	30.2
Traditional crops	6.7	2.9	1.8	16.3	9.2	8.9	13.8	5.7	2.6	0.0	0.0	0.2	0.0	0.0	0.0	2.2	0.0	0.8
Other cash crops	11.2	6.3	6.9	0.0	0.1	10.5	25.1	14.9	7.2	0.0	0.0	0.8	28.7	17.4	22.5	0.0	0.0	1.0
Off-farm wage employment	11.1	21.7	30.0	11.3	18.0	28.2	9.7	19.0	32.8	13.3	26.8	38.0	8.1	20.6	18.5	13.1	16.1	21.3
Off-farm self-employment	4.1	4.7	6.7	0.0	4.0	1.2	1.7	3.6	2.6	0.9	0.6	0.0	2.8	3.0	3.0	37.2	47.0	39.4
Expenditure share (%)																		
Rubber	65.2	66.3	40.1	64.2	64.9	31.3	48.6	68.2	52.4	90.9	72.5	52.1	64.9	66.8	34.9	19.8	22.5	11.1
Traditional crops	10.9	3.0	5.3	27.9	8.9	32.1	21.2	6.4	2.6	0.0	0.0	0.2	0.0	0.0	0.0	3.3	0.0	0.8
Other cash crops	10.0	3.3	5.1	0.0	0.1	2.6	21.5	8.4	15.1	0.0	0.0	0.9	26.8	8.7	12.8	0.0	0.0	1.1
Livestock rearing input	4.6	12.4	30.2	6.2	14.3	29.9	4.3	10.1	20.7	5.6	11.7	35.6	3.1	13.9	41.2	1.8	8.4	10.6
Self-employment input	7.6	6.6	11.5	0.0	6.1	0.8	3.4	3.8	2.3	1.1	0.9	0.0	3.4	4.0	1.8	75.0	66.6	73.8
Natural resource input	1.2	4.0	1.3	1.5	4.4	0.0	0.8	2.3	0.8	1.2	4.8	0.6	1.7	4.2	5.2	0.1	0.4	0.1
Other activities																		
Average value of livestock assets	280.8	169.9	235.4	213.7	275.7	334.4	547.0	216.4	129.6	154.9	108.6	239.8	269.1	143.2	198.3	170.8	101.3	257.8
Average value of natural resource extraction	832.7	684.6	155.5	988.7	1115.5	3.9	1143.6	1156.7	220.2	619.2	324.3	142.1	709.2	613.7	285.8	610.7	171.3	135.0
No. of observations	**605**	**605**	**605**	**123**	**137**	**90**	**141**	**88**	**76**	**181**	**207**	**245**	**113**	**142**	**106**	**47**	**31**	**88**

Source: own calculations

Table 2A.3 Pairwise comparison of activity variables using Bonferroni method in 2018

Comparison	Land allocated to... (%)				Family labor allocated to… (%)					Expenditures spent on... (%)						Average livestock value	Natural resource value
	Rubber	Traditional crops	Cash crops	Renting out	Rubber	Traditional crops	Cash crops	Wage employment	Self-employment	Rubber	Traditional crops	Cash crops	Livestock rearing	Self-employment	Natural resource extraction		
1 *VS 2*		-6.5 (0.0)	16.5 (0.0)			6.3 (0.0)				-21.1 (0.0)	29.5 (0.0)	-12.5 (0.0)					
1 *VS* 3	-10.9 (0.0)	4.9 (0.0)	17.9 (0.0)	-11.9 (0.0)	-15.0 (0.0)	8.7 (0.0)	9.7 (0.0)			-20.8 (0.0)	31.9 (0.0)						
1 *VS* 4		7.7 (0.0)	-7.1 (0.05)			8.9 (0.0)	-11.9 (0.0)				32.06 (0.00)	-10.2 (0.0)			-5.2 (0.01)		
1 *VS* 5		3.7 (0.06)	12.9 (0.0)	-10.2 (0.01)		8.1 (0.0)	9.5 (0.00)		-38.16 (0.0)	20.2 (0.0)	31.3 (0.0)		19.3 (0.0)	-73.1 (0.0)			
2 *VS* 3		11.4 (0.0)		-11.1 (0.0)		2.4 (0.02)	6.5 (0.01)					14.2 (0.0)	-14.9 (0.01)				
2 *VS* 4	10.1 (0.1)	14.2 (0.0)	-23.5 (0.0)			2.6 (0.03)	-15.3 (0.0)	14.3 (0.06)		17.5 (0.01)			-20.5 (0.0)		-4.5 (0.02)		
2 *VS* 5		10.2 (0.0)		-9.4 (0.03)	14.5 (0.04)		6.3 (0.06)		-36.8 (0.0)	41.3 (0.0)		13.9 (0.0)		-71.57 (0.0)			
3 *VS* 4	11.9 (0.0)	2.8 (0.08)	-25.0 (0.0)	10.3 (0.00)	14.6 (0.0)		-21.7 (0.0)	19.5 (0.0)		17.2 (0.0)		-11.9 (0.0)	-5.6 (1.00)		-4.6 (0.0)		
3 *VS* 5					20.3 (0.0)			16.72 (0.001)	-39.4 (0.0)	41.01 (0.0)			24.9 (0.00)	-73.82 (0.0)			
4 *VS* 5		-4.0 (0.02)	20.0 (0.0)	-8.6 (0.03)			21.5 (0.0)		-36.4 (0.0)	23.81 (0.0)		11.7 (0.0)	30.6 (0.0)	-71.98 (0.0)	5.2 (0.0)		

Source: own calculations

Table 2A.4 Pairwise comparison of activity variables using Bonferroni method in 2014

Comparison	Land allocated to... (%)				Family labor allocated to… (%)					Expenditures spent on... (%)						Average livestock value	Natural resource value
	Rubber	Traditional crops	Cash crops	Renting out	Rubber	Traditional crops	Cash crops	Wage employment	Self-employment	Rubber	Traditional crops	Cash crops	Livestock rearing	Self-employment	Natural resource extraction		
1 *VS* 2	17.4 (0.0)		-12.5 (0.0)			3.5 (0.02)	-14.9 (0.0)					-8.4 (0.0)					
1 *VS* 3		11.1 (0.0)	5.4 (0.0)	-14.3 (0.0)		9.2 (0.0)					8.9 (0.0)			5.2 (0.08)		167.2 (0.0)	791.2 (0.06)
1 *VS* 4	11.7 (0.0)	11.1 (0.0)	-18.8 (0.0)			9.2 (0.0)	-17.3 (0.0)				8.9 (0.0)	-8.6 (0.0)				132.6 (0.01)	
1 *VS* 5		11.2 (0.0)		-10.1 (0.0)	29.1 (0.0)	9.2 (0.0)			-43.0 (0.0)	42.4 (0.0)	8.9 (0.0)			-60.5 (0.00)			
2 *VS* 3	-19.6 (0.0)	10.0 (0.0)	18.0 (0.0)	-8.3 (0.0)	-18.5 (0.0)	5.7 (0.0)	14.9 (0.0)				6.4 (0.0)	8.42 (0.0)					
2 *VS* 4		10.0 (0.0)	-6.3 (0.0)			5.7 (0.0)					6.4 (0.0)						
2 *VS* 5	-23.8 (0.0)	10.1 (0.0)	17.8 (0.0)			5.7 (0.0)	14.9 (0.0)		-43.3 (0.0)	45.7 (0.0)	6.4 (0.01)	8.4 (0.004)		-62.8 (0.00)			
3 *VS* 4	13.8 (0.0)		-24.2 (0.0)	10.3 (0.0)	16.9 (0.0)		-17.3 (0.0)					-8.7 (0.0)					
3 *VS* 5					35.80 (0.0)				-46.4 (0.0)	50.01 (0.0)				-65.7 (0.0)			
4 *VS* 5	-18.0 (0.0)		24.1 (0.00)		18.9 (0.05)		17.4 (0.0)		-43.9 (0.0)	44.3 (0.0)		8.7 (0.001)		-62.6 (0.0)			

Source: own calculations

Table 2A.5 Pairwise comparison of activity variables using Bonferroni method in 2012

Comparison	Land allocated to... (%)				Family labor allocated to… (%)					Expenditures spent on... (%)						Average livestock value	Natural resource value
	Rubber	Traditional crops	Cash crops	Renting out	Rubber	Traditional crops	Cash crops	Wage employment	Self-employment	Rubber	Traditional crops	Cash crops	Livestock rearing	Self-employment	Natural resource extraction		
1 *VS 2*	21.5 (0.0)		-19.9 (0.0)		21.8 (0.0)		-25.1 (0.0)			15.5 (0.0)	6.7 (0.0)	-21.5 (0.0)					
1 *VS* 3	-6.8 (0.0)	13.3 (0.0)		-6.5 (0.0)	-13.2 (0.00)	16.3 (0.0)				-26.8 (0.0)	27.9 (0.0)						
1 *VS* 4	10.9 (0.0)	13.3 (0.0)	-21.9 (0.0)		11.3 (0.06)	16.3 (0.0)	-28.8 (0.0)				27.88 (0.0)	-26.8 (0.0)					
1 *VS* 5	-9.0 (0.01)	8.3 (0.0)			25.8 (0.00)	14.2 (0.0)			-37.2 (0.0)	44.4 (0.0)	24.6 (0.0)			-75.0 (0.0)			
2 *VS* 3	-28.3 (0.0)	12.6 (0.0)	19.8 (0.0)	-4.2 (0.02)	-34.9 (0.00)	13.8 (0.0)	25.1 (0.0)			-42.3 (0.0)	21.2 (0.0)	21.5 (0.0)				392.1 (0.03)	
2 *VS* 4	-10.6 (0.0)	12.6 (0.0)			-10.4 (0.09)	13.8 (0.0)				-16.3 (0.0)	21.2 (0.0)	-5.3 (0.09)					
2 *VS* 5	-30.5 (0.0)	7.7 (0.0)	19.8 (0.0)			11.6 (0.0)	25.1 (0.0)		-35.6 (0.0)	28.8 (0.0)	17.9 (0.0)	21.5 (0.0)		-71.6 (0.0)			
3 *VS* 4	17.6 (0.0)		-21.9 (0.0)	4.2 (0.04)	24.5 (0.0)		-28.8 (0.0)			26.1 (0.0)		-26.8 (0.0)					
3 *VS* 5		-4.9 (0.0)		7.2 (0.0)	39.0 (0.0)				-36.3 (0.0)	71.1 (0.0)				-73.9 (0.0)			
4 *VS* 5	-19.9 (0.0)	-5.0 (0.0)	21.9 (0.0)		14.5 (0.08)		28.7 (0.0)		-34.4 (0.0)	45.1 (0.0)		-26.8 (0.0)		-71.6 (0.0)			

Source: own calculations

Table 2A.6 The determinants of livelihood strategy choices in 2018 by MLM regression

Variables	Traditional crops plus wage workers (LS1)			Multiple livelihood strategy (LS2)			Rubber dominant, wage workers plus renting out land (LS3)			Self-employed and wage workers plus renting out land (LS5)		
	Coef.		S.D	Coef.		S.D	Coef.		S.D	Coef.		S.D
Household strategies in 2012												
LS1: Traditional crop plus wage workers	0.64		0.52	0.46		0.58	0.75	*	0.45	1.48	*	0.85
LS2: Multiple livelihood strategy	1.12	**	0.51	1.46	***	0.56	0.64		0.51	2.21	***	0.78
LS3: Rubber dominant, wage workers plus renting out land	0.79		0.64	1.07		0.7	0.82		0.52	2.14	***	0.82
LS5: Self-employed and wage workers plus renting out land	1.91	*	1.12	1.33		1.24	1.65	*	0.93	4.02	***	1.16
Household strategies in 2014												
LS1: Traditional crop plus wage workers	1.65	***	0.54	1.75	***	0.61	1.69	***	0.5	1.3	*	0.67
LS2: Multiple livelihood strategy	1.4	***	0.5	1.39	**	0.6	-0.11		0.56	0.48		0.65
LS3: Rubber dominant, wage workers plus renting out land	0.33		0.61	1.26	**	0.54	1.52	***	0.41	1.09	*	0.6
LS5: Self-employed and wage workers plus renting out land	1.76		1.53	2.61		1.59	1.27		1.34	3.3	**	1.32
Household characteristics												
Female household head	-2.62	**	1.21	-1.04		0.91	-0.03		0.61	-0.1		0.67
HD age	0.22		0.14	0.15		0.13	0.07		0.1	0.13		0.13
HD age2	-0.0025	*	0.0014	-0.0017		0.0013	-8E-04		0.001	-0.002		0.0014
HD's major job types												
Own farming	-1.22	*	0.74	-0.52		0.89	-0.85		0.63	-0.61		0.74
Self-employment	-17.27	***	1.23	-0.31		1.96	-17.2	***	1.56	2.75	**	1.32
Agricultural wage employment	-14.75	***	1.12	1.02		1.34	0.11		1.09	-0.89		1.37
Non-farming wage employment	-1.51		1.15	-0.18		1.25	0.21		0.91	1.05		1.01
No. of labor	0.19		0.19	0.26		0.19	0.11		0.18	0.06		0.19

Dai ethnicity	1.42	***	0.38	1.12	**	0.45	0.97	***	0.34	1.02	**	0.44
Dependency ratio	0.03		0.41	0.18		0.45	-0.57		0.35	-0.7		0.47
HH average age	0.0097		0.022	0.015		0.0235	-0.004		0.020	0.0004		0.028
HH average education	0.0032		0.025	0.0026		0.0313	0.004		0.024	-0.018		0.032
HH altitude	-0.0018		0.0015	-0.003	*	0.0015	-0.006	***	0.0017	-0.005	**	0.0019
Total land area	0.0007		0.0062	-0.006		0.0069	-0.012	*	0.0064	-0.01	*	0.0059
Rubber area	0.0039		0.0082	0.0074		0.0098	0.012		0.008	0.005		0.0092
Rubber harvesting area	-0.013	*	0.0079	0.0025		0.0073	0.002		0.0064	0.0016		0.0093
Certified arable land	0.0069		0.017	0.0017		0.0105	-0.009		0.0084	-0.007		0.01
Certified forest land	0.0007		0.018	0.0017		0.0106	-0.006		0.0086	-0.004		0.0097
Lending	0.13		0.61	-0.38		0.59	-0.38		0.59	0.77		0.61
Loan	-0.25		0.35	-0.85	**	0.37	-0.42		0.31	-1.06	***	0.41
Public transfer received	0.67		0.48	1.73	***	0.53	0.16		0.39	0.49		0.48
SPO	-0.49		0.4	0.02		0.41	-0.63	*	0.36	-0.18		0.43
No. of shocks	0.39		0.28	0.87	***	0.29	0.24		0.25	-0.19		0.36
Village characteristics												
Rubber price	256.99		564.77	113.17		573.87	-284.1		458.63	-240.3		542.22
Two-lane road	0.41		0.47	0.7		0.47	1.24	***	0.39	0.31		0.48
Distance to township	-0.01		0.02	-0.04	*	0.02	-0.02		0.02	-0.01		0.02
Minimum transport cost	-106.63		190.38	8.15		197.4	-45.54		173.74	187.71		211.65
Menghai	-0.27		0.65	1.47	*	0.62	-0.37		0.53	0.74		0.63
Jinghong	0.14		0.48	0.53	**	0.54	0.06		0.44	-0.04		0.56
Constant	-6.21	*	3.73	-6.54	*	3.65	3.59		2.82	-0.99		4.17

*** p<0.01, ** p<0.05, * p<0.1; Source: own calculations

Table 2A.7 Per capita income distributions of livelihood strategies

Year	All		Traditional crops plus wage workers (LS1)		Multiple livelihood strategy (LS2)		Rubber dominant, wage workers plus renting out land (LS3)		Cash crops-dominated cultivation (LS4)		Self-employed and wage workers plus renting out land (LS5)	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
2012	27947.2	65630.3	18498.8	23771.9	33217.3	62978.7	18395.9	19793.8	19186.1	19588.6	94710.3	187334.1
2014	19680.1	40112.8	22466.5	60467.2	17014.2	18675.3	13223.7	15867.3	24803.5	44628.3	34577.0	54968.2
2018	23130.1	35668.5	24052.8	39117.5	15989.8	15813.8	15629.4	14851.0	31991.3	60065.4	38561.9	39221.7

Unit: RMB; Source: own calculations

Table 2A.8 One-way ANOVAS of livelihood strategies (Bonferroni comparison test)

2012

	Traditional crops plus wage workers (LS1)	Multiple livelihood strategy (LS2)	Rubber dominant, wage workers plus renting out land (LS3)	Cash crops-dominated cultivation (LS4)
Multiple livelihood strategy (LS2)	14718.5			
	(0.572)			
Rubber dominant, wage workers plus renting out land (LS3)	-102.878	-14821.4		
	(1.00)	(0.355)		
Cash crops-dominated cultivation (LS4)	687.377	-14031.2	790.255	
	(1.00)	(0.764)	(1.00)	
Self-employed and wage workers plus renting out land (LS5)	76211.6	61493	76314.4	75524.2
	(0.00)	(0.00)	(0.00)	(0.00)

2014

	Traditional crops plus wage workers (LS1)	Multiple livelihood strategy (LS2)	Rubber dominant, wage workers plus renting out land (LS3)	Cash crops-dominated cultivation (LS4)
Multiple livelihood strategy (LS2)	-5452.25			
	(1.00)			
Rubber dominant, wage workers plus renting out land (LS3)	-9242.81	-3790.56		
	(0.354)	(1.00)		
Cash crops-dominated cultivation (LS4)	2337.04	7789.3	11579.9	
	(1.00)	(1.00)	(0.078)	
Self-employed and wage workers plus renting out land (LS5)	12110.5	17562.8	21353.4	9773.5
	(1.00)	(0.351)	(0.055)	(1.00)

2018

	Traditional crops plus wage workers (LS1)	Multiple livelihood strategy (LS2)	Rubber dominant, wage workers plus renting out land (LS3)	Cash crops-dominated cultivation (LS4)
Multiple livelihood strategy (LS2)	-8062.93			
	(1.00)			
Rubber dominant, wage workers plus renting out land (LS3)	-8423.4	-360.469		
	(0.492)	(1.00)		
Cash crops-dominated cultivation (LS4)	7938.5	16001.4	16361.9	
	(1.00)	(0.022)	(0.001)	
Self-employed and wage workers plus renting out land (LS5)	14509.1	22572	22932.5	6570.6
	(0.054)	(0.00)	(0.00)	(1.00)

Source: own calculations

Table 2A.9 Estimations of ordered logit regression between 2012 and 2018

Variables	Ordered logit		Marginal effect					
			Downward mobility		No mobility		Upward mobility	
	Coef	S.D	Coef	S.D	Coef	S.D	Coef	S.D
Female household head	-0.507	0.357	0.088	0.062	-0.018	0.014	-0.070	0.050
HD age	-0.015	0.044	0.003	0.008	-0.001	0.002	-0.002	0.006
HD age2	3.77E-05	0.0005	-6.5E-06	0.0001	0.00000134	0.00002	0.00000518	0.0001
HD's major job types								
Own farming	0.068	0.525	-0.012	0.0910	0.002	0.019	0.009	0.072
Self-employment	-0.141	0.961	0.025	0.167	-0.005	0.034	-0.019	0.132
Agricultural wage employment	-0.490	1.391	0.085	0.241	-0.017	0.050	-0.068	0.191
Non-farming wage employment	1.473*	0.764	-0.255*	0.133	0.052	0.036	0.203*	0.104
No. of labor	0.036	0.087	-0.006	0.015	0.001	0.003	0.005	0.012
Dai ethnicity	0.306	0.218	-0.053	0.038	0.011	0.0089	0.042	0.030
Dependency ratio	0.296	0.255	-0.051	0.044	0.011	0.010	0.041	0.035
HH average age	0.007	0.012	-0.001	0.002	0.0003	0.000	0.001	0.002
HH average education	0.028	0.029	-0.005	0.005	0.0010	0.001	0.0039	0.004
HH altitude	0.000	0.001	-0.0001	0.000	0.00001	0.0000	0.00005	0.0001
Total land area	0.002	0.003	-0.0004	0.0005	0.00009	0.0001	0.0003	0.0004
Rubber area	-0.006	0.004	0.001	0.0006	-0.0002	0.0002	-0.0008*	0.0005
Rubber harvesting area	-0.001	0.003	0.0002	0.0005	-0.00004	0.0001	-0.0001	0.0004
Certified arable land	-0.000	0.004	0.00001	0.001	-0.000003	0.0001	-0.00001	0.001
Certified forest land	0.002	0.004	-0.0004	0.001	0.0001	0.0001	0.0003	0.001
Lending	0.062	0.231	-0.011	0.0400	0.002	0.008	0.009	0.032
Loan	0.173	0.169	-0.030	0.029	0.006	0.007	0.024	0.023
Public transfer received	-0.004	0.202	0.0007	0.035	-0.0001	0.007	-0.0006	0.028

SPO	0.314	0.192	-0.055	0.033	0.011	0.008	0.043*	0.026
No. of shocks	-0.041	0.119	0.007	0.021	-0.001	0.004	-0.006	0.017
Village characteristics								
Rubber price	-228.08*	124.174	39.51*	21.3385	-8.120	5.2704	-31.39*	17.20
Two-lane road	0.369	0.227	-0.0640*	0.0388	-0.0132	0.0088	0.051	0.032
Distance to township	0.014	0.009	-0.00235	0.0015	0.000483	0.0004	0.002	0.001
Minimum transport cost	10.580	45.317	-1.833	7.8511	0.377	1.6250	1.456	6.233
Menghai	0.203	0.302	-0.0352	0.0523	0.00724	0.0111	0.028	0.042
Jinghong	0.548**	0.217	-0.0950**	0.0376	0.0195*	0.0111	0.076**	0.030
cut1	-0.556	1.367	0.129***	0.042	-0.034*	0.018	-0.094***	0.033
cut2	2.317*	1.368	0.017	0.029	-0.005	0.008	-0.013	0.022
Observations	605		605		605		605	

*** p<0.01, ** p<0.05, * p<0.1; Source: own calculations

CHAPTER 3: PARTICIPATION IN OFF-FARM LABOR MARKETS: A GOOD STRATEGY FOR FARMERS IN SOUTHWEST CHINA TO COPE WITH DECLINING RUBBER PRICES?

Previous version of this paper is presented and published as proceedings at: Tropentag2020 conference. Food and nutrition security and its resilience to global crises, 9 -11, September 2020, Germany (online)

Abstract

The development of labor markets has contributed to poverty reduction and income increase in China. In this paper, we (1) investigate the factors explaining the participation of off farm wage employment and its intensity by using random and fixed effect models; (2) extend the analysis to the dynamics of labor market participation strategies over time by means of a multinomial logit model; (3) employ a multinomial endogenous switching model along with counterfactual analysis to estimate the impacts of off farm participation and its transition on smallholder rubber farmers' income. Moreover, instrumental variables are used to address potential self-selection and endogeneity problems. Our analysis is based on a representative three wave socio-economic panel dataset collected in the Xishuangbanna Dai Autonomous Prefecture in the southwest China. Results show that 48% of households had at least one member engaged in wage employment. Average treatment effects show that household income would decrease by 60% to 90% if households did not participate in the labor market. At the same time, income of households who continuously participate in the labor market would decrease by more than 50% if they did otherwise.

Keywords: Off farm wage employment, Labor market, Smallholder rubber farmers, Southwest China

3.1 Introduction

Past economic growth in China was largely fueled by the transfer of workers from agriculture to the industrial and service sectors. For a long time, rural areas offered an almost unlimited source of labor. Although, there is still some controversy among researchers and policy makers whether or not China has reached the "Lewis turning point" (Cui et al., 2018; Qiao, 2017), continuous structural changes have brought about the end of "cheap labor" (Cai & Du, 2011; Li et al., 2012).

The development of labor markets facilitates the reallocation of rural labor resources in China, especially, the transfer of labor from farm to non-farm sectors, contributing to reducing poverty and lowering the vulnerability to agricultural shocks (de Brauw et al. 2002, de Janvry, et al., 2005; Huang et al., 2009). With the increase in off-farm employment, the marginal product of labor in agriculture will rise and eventually compete with the secondary and tertiary sectors for labor, i.e. when agriculture has reached the commercialization point (Ranis and Fei, 1961). This is especially relevant for agricultural systems in which perennial cash crops, like oil palm or natural rubber are dominant. This is the case for this study on off-farm labor market participation of rubber farming households in Southwest China. The study looks at the interrelationship between agricultural shocks, off farm labor supply and income of rural households and hereby complements research that have investigated the implications of the escalating labor shortage for overall economic growth and the development of China's agriculture (Cui et al., 2018; Qiao 2017; Choi & Peng, 2015). In the context of structural transformation of the economy, it is important to recognize that rural development is not a straightforward and continuous process. As demonstrated, for example, during the financial crisis of 2008, shocks can severely disrupt the transformation process and can cause significant downside effects for the well-being of the rural population. This is because laborers from the agricultural sector are often in vulnerable and unstable employment conditions with little social protection. The recent Covid-19 pandemic was a typical example of a shock that significantly impacted on off farm labor markets in many Asian countries, although in China this was only of a short-term nature, so far.

In this paper, we investigate the implications of the decline in rubber prices for rubber farmers' labor supply response in Southwest China. The economic and environmental conditions in Xisuangbanna (XSBN), Dai Autonomous Prefecture, in Southern Yunnan, make this study an interesting case. The area is marked by high ethnic diversity with a rich cultural heritage. This has made XSBN a preferred location for domestic tourism, and hereby contributing to a growing off farm job market. As shown by Ahlheim et al., (2013 & 2018), consumers in other parts of China express a positive willingness to pay for maintaining and improving the local environment in XSBN.

Our study adds to the literature on rural development and structural transformation in three aspects. Firstly, natural rubber, as a perennial crop with high initial investment, can lead to sunk costs and path dependency. This hinders the participation of farmers in off farm labor markets, even when profitability in agriculture is declining. For example, as shown by Min et al (2018). When confronted with the hypothetical question of a possible 50 % decline in the price of rubber, almost half (45 %) of the smallholder rubber farmers did not respond with any changes in their cropping system. Secondly, the possibility for small holder farmers to respond to declining prices of rubber with shifting labor to off-farm occupations is dependent on farm characteristics and location factors. For example, Jin et al. (2020), found that farmers with a high share of rubber in their crop portfolio and those in locations with lower access to land and labor markets, are less likely to engage in off-farm employment. Thirdly, policy constraints hinder farmer's permanent exit from unprofitable and in some locations also environmentally damaging rubber cultivation because natural rubber is considered a strategic crop in China. The Government has defined a strategic minimum rubber area of 5 million mu (333,333 ha). Consequently, rubber farmers must obtain permission if they want to cut down rubber trees and replace them by another crop (State Bioindustry Office, 2018).

In this study, we make use of a three-period household panel data collected from some 612 rubber farmers in XSBN in 2012, 2014 and 2018. Our data allow to analyze the role of labor market participation as a response to declining rubber prices for income and well-being on the longer term. The main hypothesis of this paper is that households who continuously participated in the labor market will be better able to cope

with declining rubber prices than households who did so discontinuously or those who solely relied on agriculture alone.

Our results show that participation of households in off farm wage employment has increased significantly between 2012 and 2018. While in 2012 some 23 % of households had at least one member in wage employment, in 2018 this share had increased to 48 %. The most prominent employment type is in the service sector, followed by working on other farms, in the construction and manufacturing sector. Mostly, household members with off-farm employment are in full-time jobs but recently part-time employment has been on the rise. Interestingly also, none of our panel households had left farming altogether during the 7-year observation period, i.e. all keep their farm as a baseline income source.

By means of three models we generate a better understanding for the impact of labor market participation on household wellbeing. First we use a logit model to identify factors that are responsible for a household's decision to engage in off farm employment. Results show that household characteristics and location factors are significant. Extending the analysis to the dynamics of labor market participation strategies over time by means of a multinomial logit IV model, we find that different variables are responsible for the choice between a continuous and a discontinuous wage employment, namely labor capacity for the former and altitude for the latter. Next, we employed an endogenous switching regression model to assess the impact of labor market participation on household income. There is significant average treatment effects (ATT), ranging from 60 % to 90 % for the three survey years. In all cases ATT exceeds ATU by a factor of 2 to 4. This suggests that household would have lost substantially, had the not participated in off farm labor markets. This result is confirmed by our third model, a multinomial endogenous switching regression with instrumental variable specification. The model suggests that household income would decrease by 97 % and 65% if continuous employment households would switch to non-participating and discontinuous employment. Household income would decrease by 19% if household with variable employment would drop out of the labor market. Conversely, income of households without labor market participation would increase by 77 % if they would be continuously employed.

Although the model results must be treated with care it seems sound to conclude that participation in off farm labor markets is an effective coping strategy against shocks in agriculture for small scale rubber farmers. However, not all households have the possibility to do so and there are other factors in a rubber farmer household's utility function that make labor market participation not beneficial or unattractive. Sunk costs of rubber plantations, poor access to labor markets, household demographics and education are among these variables. Hence, supplementing income from farming through off farm wage employment can be a good long-term strategy. On the other hand, our results also show that engagement in off-farm wage employment is not a pathway out of agriculture. Rural households remain their livelihood base in farming but increasingly supplement their income by off farm sources.

The paper is structured as follows. In the next section, we describe the study area and the data collection approach. In section three, we introduce our conceptual framework derived from household theory. In section four we explain the empirical strategy and the models used to answer the research question. Section five describes our panel data including some descriptive statistics. In section 6, we report and discuss model results and in section 7, we conclude.

3.2 Research area and data collection

This section presents the study area, its development conditions and the strategy to draw a representative sample of rubber farmers in XSBN. First, we give a brief overview of the study area including geographic, administrative and socioeconomic aspects. Second, the procedure of data collection has been explained in detail.

3.2.1 Research area

Xishuangbanna (XSBN), called the Dai Autonomous Prefecture and located in the south of Yunnan province, China, is bordering Myanmar to the west and Laos to the south (see Figure 1.2). XSBN covers an area of slightly over 19,000 km^2, wherein over 95% of it is mountainous region with altitude ranging from 475 to 2430 meters above the mean sea level (Min et al., 2017a). The area is characterized by tropical climate and is of outstanding natural beauty and can be considered to be China's most prominent

biodiversity hotspot. In addition, XSBN is home of at least a dozen different ethnic groups who are indigenous to the area but are minorities in China as a whole. As the name of the prefecture suggests, the dominant group in XSBN are the "Dai" who predominantly live in the valleys, while other ethnicities like the Hani, Yao, Lahu, or Bulang live in upland and mountain areas (Xu,2006). The different ethnic groups have practiced location and culture-specific, multiple livelihoods (Min et al. 2017b).

The administrative set-up of XSBN, includes the city (and county) of Jinghong and the counties Menghai and Mengla. The next administrative level are townships of which there are 32 (see Figure 1.2). In the past, forest was the dominant land use in XSBN. Deforestation and conversion of forest land to agricultural land has been ongoing during the past decades. Hence, forest reform has been implemented whereby communal forestland plots were contracted or leased to individual households for planting rubber (Guo and Padoch,1995). Encouraged by more flexible land use policies, new technologies and government support, rubber cultivation therefore has expanded rapidly in XSBN. While in 1976, rubber area was less than 25 000 ha, it has increased to over 225 000 ha in 2007 (Li et al., 2006). Rubber area almost doubled again by 2010, reaching over 424 000 ha (Xu et al.,2014), almost one fifth of the total land area of XSBN. Rising prices made rubber highly profitable. Especially in the favorable production locations rubber has become the dominant crop, accounting for approximately 30% of regional economy in 2008 (Hu et al., 2008).

After 2011, the rubber price started to decline, reducing profitability and increasing uncertainty of the farm incomes. In Figure 1A.1 (Appendix) the long-term trend in global rubber prices from 2001 to 2021 is shown. This reveals that prices had reached a peak in 2011 and thereafter declined following the global trend (Jin et al. 2020)

3.2.2 Data collection

The data used in this study are from a three-wave socioeconomic panel survey carried out in 2013, 2015 and 2019 from some 612 rubber farmers in XSBN. Sample selection followed a stratified random

sampling approach based on the density of rubber cultivation in 42 villages, 8 townships in counties (city) of Jinghong, Menghai and Mengla (see Figure 1.2).

A total of 612 households were initially interviewed in March 2013, using the preceding year as the reference period. The same households have been revisited again in March 2015 and during the same period in 2019. Attrition was low with only one household missing. As survey instruments, a standardized household and a village head questionnaire were used. The household questionnaire contained information about household characteristics, land use and land use history as well as all income-generating activities, i.e. from rubber and other crops but also from livestock, natural resources extraction and income from wage and self-employment plus income from other sources. Other modules of the questionnaire referred to information on household finance and shocks experienced during the past five years as well as risks expected by the respondents in the future. In the village head questionnaire information on village infrastructure, demography and labor profiles were asked. These data can serve for the specification of instrumental variables in household models.

Since the panel data span over a period of 7 years, the short-and medium term reactions of rubber farmers to the decline in rubber prices between 2012 and 2014 and again until 2018, can be identified and quantified. The consistency of data collected allows to assess farmers labor supply response as well as the changes in household income and its composition.

3.3 Conceptual framework

To model participation in off-farm labor markets we refer to household theory assuming a utility maximizing, risk-neutral, single-family farm household with on-farm and off farm income sources (Ellis, 1993; Ellis, 1998) allocate their resources e.g. time and labor on diverse livelihood activities. The model provides a basic theoretical framework for hypothesizing a rural household's labor allocation decision for on-farm and off farm work.

Following this model, total time endowment (T) is the household's major constraint which can be distributed among farm work (T_f), off-farm (wage) work (T_w) or leisure time (T_l):

$$T = T_f + T_w + T_l \quad (3.3.1)$$

The rural household's utility is maximized by an optimal allocation of household time among these three options, subject to a leisure-income indifference curve. Household income (H_i) is determined by the net revenue from farm production function, earnings in off farm wage employment and other incomes That is, total household income (H_i) is then the sum of farm income, wage income and other income (see equation 2). For households who do not engage in wage employment $T_w * w$ is omitted from equation 2.

$$(P_Q * Q - P_I * Q_I) + T_w * W + I_o + H_i \quad (3.3.2)$$

Farm output (Q) is determined by the production function (equation 3), market prices for outputs is (P_Q) (rubber). Farm function is:

$$Q = (T_f, Q_I; \tau_2) \quad (3.3.3)$$

whereby (T_f) is farm labor, (Q_I) are purchased external farm inputs (e.g. fertilizer) and (τ_2) are other parameters of the production function.

To illustrate the conditions of small holder rubber households in XSBN and to develop our study hypotheses we refer to Figures 3.1-3.3

In Figure 3.1, we depict a rubber farming household who does not participate in off farm labor markets under two scenarios, namely high and low rubber prices. In the first case, the household achieves income HI_H and allocates L_H of his time to farm work based on his individual leisure-income indifference curve (I_1) . When rubber prices go down, household income declines to HI_L and optimal labor input is reduced depending on the degree of path dependency of rubber farming. This is the basis for our first hypothesis, i.e. farmers who do not engage in off farm wage employment will experience income loss and may be triggered to engage in off farm activities if their household conditions (e.g. education, access to labor market) allow them to do so.

In Figure 3.2, we depict the situation of a household who distributes his time between farm labor and wage employment. Income is generated by farm and off-farm sources. Under the condition of high rubber

prices, more labor will be allocated to farm work. Labor input for farming (point A) is determined by the off farm wage which represents the opportunity cost of farm labor. The intensity of off farm work is determined by the households' indifference curve as indicated in tangential point B in Figure 3.2. Under a situation of lower rubber prices, farmers will reduce on-farm work and expand the time spend for off farm work. At the same time, it can be expected that household income will decline in the short run as further adjustment of labor allocation will take time and is subject to other constraints.

Figure 3.3 depicts how a household reallocates his time spent on farming and off farm wage employment when wage in the labor market declines and rubber price remains unchanged. Off farm labor supply is quite sensitive to wage rate (Sumner,1982). Under the condition of high rubber price and lower wage level, labor supply for farming will increase. As point A in Figure 3.3 shows, the farming labor, representing by $LF_{H,}$ is greater than it in Figure 3.3 shows. The intensity of off farm work will reduce accordingly which is indicated by the tangential point B in Figure 3.3. Under the scenario of low rubber price and lower wage level, the intensity of on-farm and off-farm work is determined by the marginal value of these two activities. Further adjustment of labor allocation will be made as the off farm labor market wage declines. Farmers will reduce their time spent on labor market and reallocate labor into farming activities.

In summary, based on the theoretical model, we expect that when rubber price is low (for some period of time), farmers will tend to allocate more labor (time) to off farm wage employment. If rubber prices rise again and/or other attractive on-farm options will become available, the marginal product of labor in agriculture will increase and farmers may intensify labor in agriculture again. Thus, over time, we can expect a variable pattern of on-farm and off-farm labor allocation, depending on the elasticity of agricultural labor supply and the demand for labor in off farm labor markets.

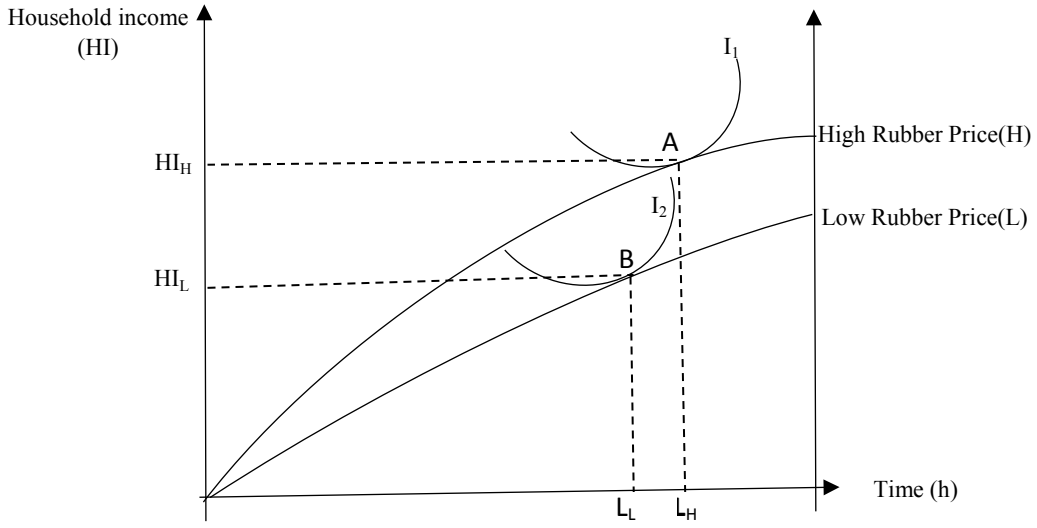

Figure 3.1 Household Labor Allocation and Income without access to Off-Farm Labor Markets under High(H) and Low(L) Rubber Price

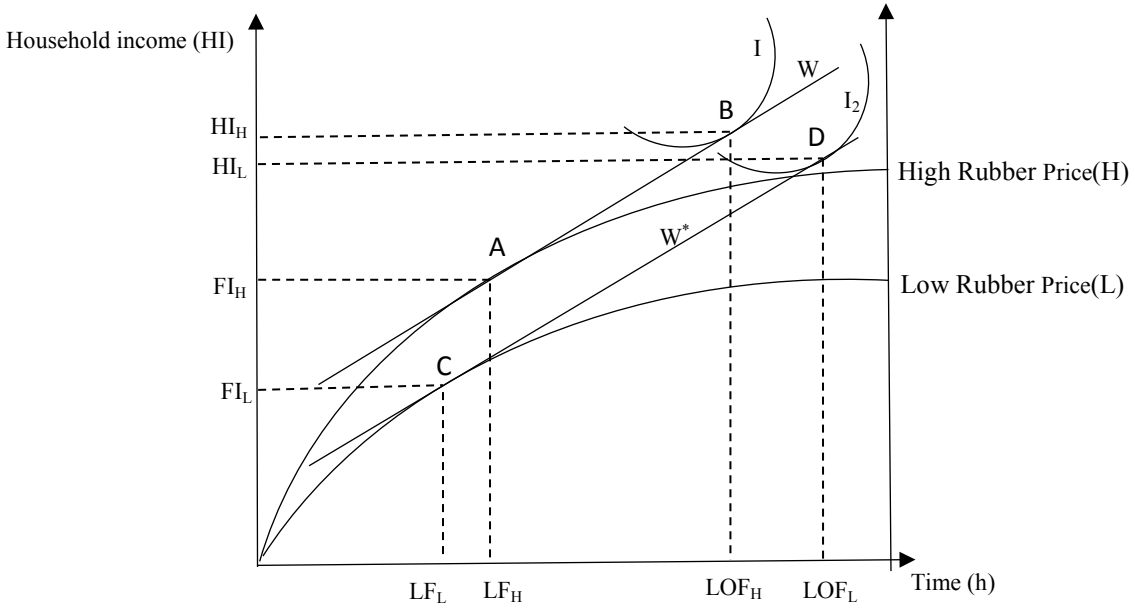

Figure 3.2 Household Labor Allocation and Income with participation in Off-Farm Labor Markets under High (H) and Low (L) Rubber Price

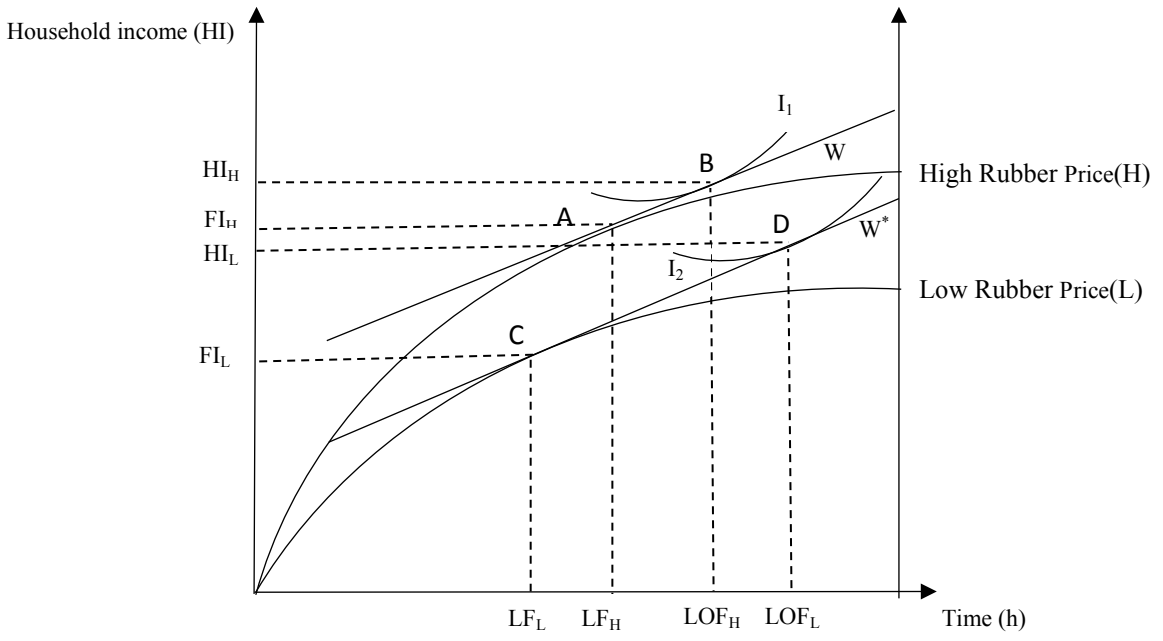

Figure 3.3 Household Labor Allocation and Income with participation in Off-Farm Labor Markets under High (H) and Low (L) Rubber Price and lower wage level.

3.4 Empirical strategy

In this section, we introduce our empirical strategy to investigate the factors which are expected to influence rubber farmers' off-farm labor market participation and examine to what extent different off-farm participation strategies contribute to the income of rubber farmers in XSBN, on the short and on the medium term. We have developed three models: (i) two-stage least squares to identify factors of labour market participation and participation intensity, (ii) an endogenous switching regression (ESR) model to estimate the overall impact of labour market participation on household income and (iii) an ESR in the form of a multi-nominal model in order to capture the income effects of labour market participation over time.

3.4.1 Modelling the participation of labor market

Following previous studies (e.g. Manning et al.,1981; Duan et al.,1983; Olsen & Schafer, 2001, Han et al., 2019), Two-stage least squares have been employed to analyze the determinants of off farm labor market participation and its participation intensity.

The first step is to estimate the factors which determine the labor market participation choice.

$$Participation^{*}_{ijt} = a_0 + a_1 X_{ijt} + a_2 V_{jt} + a_3 C + a_4 T + U_{ij} + \varepsilon_{ijt} \quad (3.4.1\text{-}1)$$

$$Participation_{ijt} = \mathrm{I}\,(Participation^{*}_{ijt} > 0) \quad (3.4.1\text{-}2)$$

Where, $Participation^{*}_{ijt}$ is a latent variable which represents the labor market participation choice. $Participation_{ijt}$ is a binary variable denoting household's participation choice which is determined through the value of $Participation^{*}_{ijt}$. a_i is a vector of unknown parameters. X_{ijt} refers to a vector of household demographic and socio-economic characteristics of the i_{th} household in village j at period t; V_{jt} presents the characteristics of j_{th} village; C is the regional fixed effects which are used to capture unobservable factors but might be correlated with off-farm labor market participation at the county level. T captures the fixed time effect (i.e., year dummy). The descriptive and summary statistics of these variables are shown in next section. U_{ij} are random effects which capture time-invariant unobserved heterogeneity; ε_{ijt} is the error term that is independently and identically distributed and assumed to be independent of $X_{ijt}, V_{jt}, C,$ and U_{ij}.

In part two, in order to investigate the intensity of off farm employment, a generalized linear mixed model (GLMM) in log scale represents part II of our model:

$$log(I_{it} \mid I_{it} > 0) = \beta_0 + \beta_1 X_{ijt} + \beta_2 V_{jt} + \beta_3 C + \beta_4 T + \mu_{ij} + \sigma_{ijt} \quad (3.4.1\text{-}3)$$

where I_{it} captures off farm wage of a household earned from labor market in XSBN. Covariates of X_{ijt}, V_{jt}, C in Eq.(3.4.1-3) are following the same settings as Eq.(3.4.1-1); μ_{ij}, σ_{ijt} denote the unobserved random components of the intensity of labor market participation. For both models, a fixed and a random-effects variant were run. Since farmers may self-select and voluntarily decide whether involving into labour market, the participation of wage labour market is considered as potentially endogenous. Failure to take selectivity bias and endogeneity into account can obscure the true effects of off farm participation and lead to biased estimation results, selection instruments have to be decided which will affect the participation of labor market but don't influence participation intensity. According to this concept, the the

percentage of off farm participants in the village who work outside and don't commute every day (Jin et al.,2021) and off farm wage level in the village are chosen as instrument variables in our analysis.

3.4.2 Impact of off farm employment participation on household income

The interest in this part is to estimate the overall income impact of off farm wage employment participation on smallholder rubber households. In order to account for the issues of selectivity bias and potential endogeneity, following the existing literatures (Di,Falco et al.,2011; Huang et al. 2015;Tesfaye, W., & Tirivayi, N. ,2018) on endogeneity and selection bias correction, endogenous switching regression methodology (ESR) (Lohshin & Sajaja,2004; Malikov & Kumbhakar,2014) has been utilized in this section.

ESR model is based on the theoretical assumption that farmers only decide to participate when the expected profit brought by participation in the labor market is higher than non-participation. Participation status is indicated by a dummy variable P_i which equals to 1 when there is labor market participation, 0 otherwise.

$$P_i^* = \gamma z_i + \varepsilon_i \; with \; P_i = \begin{cases} 1 \;\; if \; P_i^* > 0 \\ 0 \; otherwise \end{cases} \qquad (3.4.2\text{-}1)$$

Conditional on labor market participation, income effects can be modified based on the two regimes households have faced:

Regime1 (with labor market participation): $Y_{wi} = \beta_1 X_{wi} + u_{wi} \; if \; P_i = 1$ (3.4.2-2a)

Regime2 (without (w/o) labor market): $Y_{w/o\,i} = \beta_2 X_{w/oi} + u_{w/oi} \; if \; P_i = 0$ (3.4.2-2b)

z is a vector of variables which captures the decision to participate in the labor market.Y is the outcome variable, which represents by household per capita income of households with and without off farm participation respectively in this analysis. x is a vector of weakly exogenous explanatory variables which may impact the income impact. Furthermore, variables of z and x are allowed to be overlap or the same. γ, β_1 and β_2 are the coefficients need to be estimated. ESR estimates rubber farmers' participation selection

and two income impact equations simultaneously using the full information maximum likelihood estimation (Di,Falco et al.,2011; Lokshin & Sajaja,2004, 2011) by plugging inverse Mills ratios $\lambda_{w/oi}$, λ_{wi} and covariance terms $\sigma_{w\varepsilon}$ and $\sigma_{w/o\,\varepsilon}$ into the outcome equations(3.4.2-2a/3.4.2-2b). In this way, the selection bias arising from both observable and unobservable factors are addressed (Ma and Abdulai, 2016).

After estimating the model's coefficients, the actual expected outcomes along with counterfactual effects, i.e. participation and non-participation, can be compared so that all treatment and heterogenous effects can be calculated as Table 3.1 shows.

Table 3.1 Conditional expectations, treatment effects and heterogenous effects

Households	Decision status		Treatment effects
	To participate	Not to participate	
Participants	$(a)\ E(Y_{wi}\|P_i=1)$	$(b)E\left(Y_{w/o\,i}\middle\|P_i=1\right)$	TT
Non-participants	(c) $E\left(Y_{w\,i}\middle\|P_i=0\right)$	$(d)\ E\left(Y_{w/oi}\middle\|P_i=0\right)$	TU
Heterogeneity effects	BH_1	BH_2	TH

Source: Di Falco et al., 2011

By following Heckman et al (2001), the treatment effect of participation on the treated (ATT) is calculated by comparing the differences between expected outcome of households with actual labor market participation (a) and the counterfactual scenario if households had decided not to participate (b). Similarly, the treatment effect on the untreated (ATU) households, i.e. those who did not participate in the employment market had they decided to participate.

Moreover, based on the studies from Carter and Milon (2005) and Di Falco et al. (2011), households with wage employment participation may have better outcome than those without participation due to unobservable characteristics rather than the facts of their participation or not. The "effect of base heterogeneity" is defined to capture those outcome differences. Therefore, for the households who participated in the labor market, the "effect of base heterogeneity" (BH_1) is the difference between (a) and

(c), denoting as BH_1. Likewise, the "effect of base heterogeneity" (BH_2) of households without labor market participation can be calculated as well

Finally, "transitional heterogeneity effect" (TH) is the term used to assess whether the income effect of labor market participation is larger or smaller for households with actual participation compared to households who did not participate, i.e. in the counterfactual scenario had they decided to participate.

3.4.3 The income effects of labour market participation over time

In response to rubber price fluctuations, farmers have selected to participate in the labor market whose impacts has been investigated in the previous section. In addition, rubber farmers have adjusted their participation status over a period as well. Based on the dynamics of smallholder rubber farmers' wage employment status in 2012, 2014 and 2018, diverse employment transition typologies can be identified. We have categorized all households into 3 groups on the basis of their wage employment dynamic typologies in 2012, 2014 and 2018. Specifically, they are households with: (1) continuously employment participation (C); (2) a discontinuous employment (V); (3) no-employment (N) whereby (1) + (2) are labeled as dynamic employment typology. Therefore, in addition to the assessment of the impact of labor market participation, we further investigate the determinants of wage participation strategies over time and their corresponding influence on household wealth.

A multinomial endogenous switching model, along with counterfactual analysis, is used in this section. Based on utility theory, household *i* would select dynamic employment typology *t* over alternatives when the expected welfare is highest.

The estimation procedure follows several steps. First, drawing on the basis of the research from McFadden (1973), a multinomial logit model is applied to estimate the factors which may correlate with a households' choice into dynamic wage employment dynamic typologies.

$$(Probility\ of\ household\ i\ selected \text{ dynamic typology t}) = \frac{\exp(\beta_t \chi_i)}{\sum_{r=c,v}^{u} \exp(\beta_r \chi_i)} \qquad (3.4.3\text{-}1)$$

Second, based on Dubin and McFadden (1984) and Bourguignon et al., (2007), we employ the multinomial endogenous switching regression to estimate the impacts of a specific labor market typology on income. This model helps to correct for self-selection bias. An income equation has been estimated for each of the typology showing as follows:

$$Y_{ic} = Q_i a_c + \mu_c \quad \text{if } Y_{ic}^* > \max_{s \neq c}(Y_{is}^*) \qquad (3.4.3\text{-}2a)$$

$$Y_{iv} = Q_i a_v + \mu_v \quad \text{if } Y_{iv}^* > \max_{s \neq v}(Y_{is}^*) \qquad (3.4.3\text{-}2b)$$

$$Y_{in} = Q_i a_n + \mu_n \quad \text{if } Y_{in}^* > \max_{s \neq in}(Y_{is}^*) \qquad (3.4.3\text{-}2c)$$

Q_i refers to all the explanatory variables included in χ_i, Y_{ic} $Y_{iv} and$ Y_{in} represent income brought by taking different labor market dynamic strategy. μ_c μ_v, μ_n, they are the error terms distributed with zero mean and equal variance. In order to get the consistent estimation of α_t, selection correction terms generated from the selection equation (3.4.3-1) needed to be included. Therefore, the Normalized Dubin McFadden (DMF2) model is applied which allows for linearity of errors in the outcome equation and makes the errors ε's and μ's independent. Covariance between ε's and μ's, the inverse mills ratios and error terms drawing from the DMF2 model of Bourguignon et al (2007) are included into (3.4.3-2) equations. By means of bootstrapping, the standard errors in equation (3.4.3-2a), (3.4.3-2b) and (3.4.3-2c) separately, heteroscedasticity, derived from the generated regressors can be accounted for.

After investigating the correlation factors, the average treatment effects can be obtained by estimating actual and counterfactual scenarios of wage employment dynamic typology (as shown in Table 3.2 and 3.3) drawn from Carter and Milon (2005), Di Falco and Veronesi (2014) following the same logic in section 3.4.2 which extend the scenarios into 3 categories.

Table 3.2 Average treatment effects on the treated (ATT) of dynamic wage employment typology

Actual categories		Counterfactual categories	
Employed->Employed	$E(Y_{ic}\|Y_i = C) = Q_i a_c + \delta_c \gamma_c$	Employed->Unemployed	$E(Y_{in}\|Y_i = C) = Q_i a_n + \delta_n \gamma_c$
Employed->Employed	$E(Y_{ic}\|Y_i = C) = Q_i a_c + \delta_c \gamma_c$	Employed->Variable	$E(Y_{in}\|Y_i = C) = Q_i a_n + \delta_n \gamma_c$
Variable->Variable	$E(Y_{iv}\|Y_i = v) = Q_i a_v + \delta_v \gamma_v$	Variable->Unemployed	$E(Y_{in}\|Y_i = v) = Q_i a_n + \delta_n \gamma_v$

Source: own compilation

Table 3.3 Average treatment effects on the untreated (ATU) of dynamic wage employment typology

Counterfactual categories		Actual categories	
Unemployed->Employed	$E(Y_{ic}\|Y_i = C) = Q_i a_c + \delta_c \gamma_c$	Unemployed-> Unemployed	$E(Y_{in}\|Y_i = C) = Q_i a_n + \delta_n \gamma_c$
Unemployed->Variable	$E(Y_{ic}\|Y_i = C) = Q_i a_c + \delta_c \gamma_c$	Unemployed-> Unemployed	$E(Y_{in}\|Y_i = C) = Q_i a_n + \delta_n \gamma_c$
Variable->Employed	$E(Y_{iv}\|Y_i = v) = Q_i a_v + \delta_v \gamma_v$	Variable->Variable	$E(Y_{in}\|Y_i = v) = Q_i a_n + \delta_n \gamma_v$

Source: own compilation

3.4.4 Specification of model variables

As suggested by various literatures (e.g., Weersink, 1998; Van den Broeck, & Kilic, 2019) labor market participation of rural farm households is conditional to a number of factors. These include accessibility to regional labor markets as well as household and village level characteristics such labor capacity and labor constraints of households (e.g. Grabowski & Kerr, 2014; Min et al., 2017b), also the characteristics of potential labor market participants such as age and educational attainment (Behrman & Wolfe, 1984). For example, the more members in a household are at the working age (16 and 60 years) and the better educated, the higher likelihood of participation in off-farm employment. Furthermore, household head characteristics like age and gender can play a role as well since she/he is vital in the decision of a household member to work outside the farm (e.g. Abdulai, & Delgado, 1999; Beyene, 2008).

Furthermore, the characteristics of rubber plantations such as altitude and other location factors, total size, age and growth stage of rubber plantations determine rubber profitability and together with income from other farm and non-farm sources are likely to influence labor allocation decisions. Moreover, village level variables such as road conditions and proximity to urban centers can play a role. What's more, adopting off farm wage employment is often mentioned as a coping measure in many literatures (Bezu et al., 2012; Gao & Mills,2018).

Besides, village level variables like type and quality of roads in the village and the distance to the workplace in the township or city was included. These variables show accessibility to labor markets and are a proxy for transportation and transactions costs.

In table 3.4, a definition and description of the variables included in the models described in the previous section are given. Since different variables have been included in analysis 1,2 and analysis 3, the differences have been pointed out in the last column in table 3.

Table 3.4 Definition and description of the variables in the three models

Variables	Types	Definition	Included in which model
Dependent variables			
Off-farm wage employment	Dummy	A household member involved in off farm wage employment (1=yes; 0=no)	1
Household wage income	Continuous	Gross income earned from labor market	1
Independent variables			
Household and Farm Characteristics			
HH Labor size	Continuous	No. of working age members (16- 64) per household	1/2/3
Dependency ratio	Percentage	The ratio of household member < 16 and > 16 relative to working age members	1/2/3
Age	Continuous	Average age of working household members	1/2/3
Female head	Dummy	Household head is female (1=yes; 0=otherwise)	1/2/3
Education	Categorical	Highest average education attainment of a household member	1/2/3
Total land area	Continuous	Total land area(in hectare)	3
Share of rubber land	Continuous	Share of rubber land in a household	1/2/3
Share of harvesting land	Continuous	Share of harvesting rubber land in a household	1/2/3
Age of rubber plantations	Continuous	The average age of a household's rubber plantation in years	1/2
Other area	Continuous	Other crop area other than rubber	1/2
Share of tea area	Continuous	Share of tea land in a household	3
Altitude	Continuous	Altitude of household location in m.a.s.l.	1/2/3
Public transfers	Continuous	Money received by household from public sources (in 1000RMB)	1/2
No. of motor cycle	Continuous	No. of motorcycle owned by households	1/2/3
No. of mobile phone	Continuous	No. of mobile phone owned by households	1/2/3
Shock	Continuous	No. of shocks experienced during past 5 years	1/2
Insurance	Dummy	Household has any insurance (1=yes;0=otherwise)	3
Loan	Dummy	Household has borrowed money from others (1=yes;0=otherwise)	3
Lend	Dummy	Household has lent money from others (1=yes;0=otherwise)	3
Transfer	Dummy	Households has received money from public sources (1=yes;0=otherwise)	3
Rubber Price	Continuous	Weighted average farm gate price of rubber of latex and dry rubber	1/2/3
Village characteristics			
Road condition	Dummy	Village has a two-lane road(1=yes; 0=otherwise)	1/2/3
Travel Costs	Continuous	Cheapest possibility to travel to township (in 1000RMB)	1/2
Distance	Continuous	Distance to the center of township; in km	1/2/3
Regions			
Jinghong	Dummy	Jinghong township(1=yes; 0=otherwise)	1/2/3
Menghai	Dummy	Menghai township(1=yes; 0=otherwise)	1/2/3
Mengla	Dummy	Mengla township(1=yes; 0=otherwise)	1/2/3

Source: own compilation

3.5 Descriptive statistics

In the following, we describe our panel data by means of the usual statistical parameters like frequencies, means and standard deviation. Whenever meaningful, we performed parametric statistical tests, for example to compare income among households who participate in wage employment and those who do not. The descriptive analysis is focused on two issues, namely (i) household income over time and its sources and (ii) labor market participation the three panel periods. The descriptive analysis is believed to form a good basis for the subsequent econometric models.

3.5.1 Major variables of the sample

In table 3.5, summary statistics of the independent variables used in the models as defined in table 3.4 in the previous section are presented. Dependent variables are not included but are presented in subsequent tables as part of the descriptive statistics. The data in table 3.5 provide a first insight into household, farm and village characteristics of the panel dataset. As shown, average household size is close to 5 persons whereby the dependency ratio of around 40% indicates that majority of household members are at working age. It is also worth noting that the share of rubber in agricultural land use has been declining between 2012 and 2018 from over 80 % to around 65 % while other crop area has slightly increased. Remarkably, only about half of the rubber areas are harvested, either because the plantation is still in gestation phase or because farmers have stopped tapping latex as a result of low price which has declined from 9.03 RMB in 2012 to 3.95 RMB in 2018 in the village level.

Village variables show that infrastructure has improved during the panel period as the share of good roads doubled from 19 % in 2012 to 38 % of the villages in 2018. The average distance of the sampled villages to the center of township is 12 km which costs farmers minimum 10 RMB to travel in a single way.

Table 3.5 Descriptive statistics of the sample, major variable

Independent Variables	Unit	2012		2014		2018	
		Mean	SD	Mean	SD	Mean	SD
Household and Farm Characteristics							
HH population	No.	5.11	1.46	5.26	1.48	5.08	1.49
HH Labor size	No.	3.80	1.18	3.85	1.18	3.69	1.14
Dependency ratio	%	40.42	38.91	43.56	40.75	44.26	45.10
Age	Years	35.07	7.95	34.03	7.83	37.51	8.35
Female head	(0,1)	0.07	0.26	0.08	0.27	0.08	0.26
Education	Years	9.27	2.62	9.36	2.63	8.93	2.82
Total land area	Mu	66.41	67.59	72.05	74.68	68.32	65.32
Share of rubber land	%	81.02	19.05	74.37	23.06	65.27	23.94
Share of harvesting land	%	41.14	32.45	39.39	33.68	38.31	33.06
Age of rubber plantations	Years	10.46	5.90	12.39	6.06	16.13	6.12
Other area	Mu	2.41	8.92	3.49	16.03	4.04	15.58
Share of tea area	%	5.56	13.36	5.91	13.23	7.02	14.61
Altitude	m.a.sl (m)	756.11	160.27	756.84	164.99	756.11	165.65
Public transfers	`1000RMB	1.31	3.30	0.66	2.20	1.51	3.88
Transfer	(0,1)	0.67	0.47	0.34	0.47	0.73	0.44
No. of motor cycle	No.	0.99	0.15	1.21	0.70	1.47	1.20
No. of mobile phone	No.	0.98	0.17	1.27	0.92	1.03	1.34
Shock	(0,1)	0.45	0.50	0.46	0.50	0.31	0.46
Insurance	(0,1)	0.11	0.31	0.45	0.50	0.69	0.46
Borrowing	(0,1)	0.41	0.49	0.41	0.49	0.47	0.50
Lending	(0,1)	0.15	0.35	0.18	0.38	0.11	0.32
Village characteristics							
Road condition	(0,1)	0.19	0.39	0.15	0.35	0.38	0.49
Travel Costs	`1000RMB	0.01	0.01	0.01	0.01	0.01	0.01
Distance	km	11.48	11.58	11.22	11.54	12.10	11.82
Rubber Price	RMB	9.03	5.48	4.65	2.69	3.95	2.66
Observations		612		611		609	

Source: own calculations

3.5.2 Household Income and its composition

Table 3.6 reports the average annual net household income for the three survey years respectively. In 2012 income reached 77.000 RMB per household (~ 11 000 USD). Considering an average household size of 5 to 6 persons shows that on average rubber farming households are well above the poverty line. On the other hand, they may rarely have passed the middle income level which still makes them vulnerable to

shocks. The influence of lower rubber prices is obvious from table 3.6. Annual household income has dropped by about 22 % in 2014 and by around 18 % in 2018 when compared to 2012. Correspondingly, the share of rubber in household income fell from almost 50 % in 2012 to 16.6 % and to 15.2 % in 2014 and 2018 respectively. While other crops, like tea or maize increased in intensity during 2014, these could not compensate for the income loss from rubber. The dependency on rubber becomes obvious by the fact that also raising livestock makes up only a minor share of household income although in relative livestock has increased by a factor of 5 between 2014 and 2018. The major substitution for labor allocation has occurred with off-farm wage employment. In 2012, this was just little more than 10 % of the household income but has increased to 36 % in 2018. It is also interesting to note that the income shares from non-farm self-employment and from natural resource extraction has declined. The latter may be an indication of a further deterioration of the environment in the rubber dominated landscape.

Table 3.6 Annual Household net income (in 1000 RMB) and income shares in %

Income sources classification	2012		2014		2018	
	Mean	SD	Mean	SD	Mean	SD
Total Net income (1000 RMB)	77.3	178.7	63.6	187.3	64.9	130.3
Rubber (%)	46.9	71.6	16.6	24.2	15.2	91.2
Other crops (%)	20.3	100.3	41.9	180.2	26.7	66.9
Livestock (%)	1.2	48.6	3.0	30.2	7.4	58.3
Natural resource extraction (%)	1.0	1.8	1.0	2.9	0.2	1.0
Non-farm self-employment (%)	13.9	89.9	6.0	25.1	9.6	31.2
Wage employment (%)	10.8	20.4	24.2	28.8	36.0	35.2
Others (incl. transfers & gifts) (%)	5.9	11.6	7.3	10.0	4.9	7.8

Source: own calculations based on three panel waves, SURUMER and DFG Project

Note: income is in nominal values; CPI changed only slightly between 2012 and 2018 (source: XSBN State Statistics Bureau). SURUMER is the abbreviation of the joint project named "Sustainable Rubber Cultivation in Mekong Region: Development of an integrative land-use concept in Yunnan Province, China" with Hohenheim University during 2011-2017.

3.5.3 Comparing households with and without labor market participation

Table 3.7 shows the absolute number and the share of households engaged in off farm wage employment during the observation period. While in 2012, less than one fourth of our panel households had at least one member in wage employment, seven years later it was almost one half (48.1%).

Table 3.7 Participation in off farm wage employment during the panel period

Households with…	2012		2014		2018	
	No.	%	No.	%	No.	%
Participants	143	23.4	214	35	294	48.1
Non-participants	469	76.6	394	64.5	317	51.9
Total	**612**	**100**	**611**	**100**	**611**	**100**

Source: own calculations based on three panel waves, SURUMER and DFG Project.

In table 3.8, we compare average annual gross income for both groups of households. Gross income of households with labor market participants has declined by almost 20 % while income of households without labor market participants have reduced by 30% between 2012 and 2018. Overall those with household members in wage employment were slightly better off, in relative terms. However, participating households already had a statistically significantly higher income 2018. This is not the case in 2012 and 2014. Those results leave room for interpretation as one could expect labor market participants to do better. However, it is possible that several substitution effects took place. On the one hand households who did not join the labor market may have found some good on-farm alternatives (e.g. tea) while those who joined did jobs worse than those who were already in the labor market. Obviously, there is a wide range of adjustment measures by rubber farming households that can have effects on income, indicated by the high standard deviations, all being well above the mean. This issue demands further scrutiny in the econometric analysis.

Table 3.8 Comparing household gross income between labor market participants and non-participants over time

	2012		2014		2018		
Households with…	Mean	SD	Mean	SD	Mean		SD
Participants	119.5	149.0	91.2	119.4	99.6		88.7
Non- Participants	98.8	283.9	68.9	226.5	69.6		162.1
diff.	20.6		22.3		30.0	***	

Source: own calculations based on three panel waves, SURUMER and DFG Project.

Note: *** = significant at 1 % level, based on t-test; Unit: `1000 RMB

3.5.4 Characteristics of wage employment

In this section we describe the characteristics of wage employment by members of rubber farming households who participate in the labor markets during the 7-year observation period. Describing the types of wage employment will help to better understand whether wage employment can be a sustainable complementary source of household income for rubber farmers or will even be a pathway out of agriculture. At the same time, we can identify important variables to be included in our models.

As shown in table 3.9, most wage employment is in the service sector, followed by agriculture and industry. While the pattern practically did not change between 2012 and 2018, wage employment on other farms has been steadily declining while jobs in the service sector increased in 2018. On the other hand, jobs in the industrial sector (construction, factories) had increased in 2014 but went down again in 2018, indicating a gradual economic slow-down in China in 2018[2]. Remarkably, over 25 % of the employments in the service sector are public sector jobs. Such jobs can be assumed to provide a stable source of income. Other services (e.g. transportation, taxi by car and motorcycle) have been growing fastest from 5 % in 2012 to 14.3 % in 2018. Also, in 2018, 18 % of all jobs were in the construction which is perhaps the least decent wage employment due to its demanding work environment.

Table 3.9 Wage employment by sector in %

Wage employment activities by sector	2012 %	2014 %	2018 %
Agriculture, Forestry and Fisheries	**37.4**	**30**	**29.8**
Industry	**22**	**29.7**	**23.2**
Construction	15.9	15.2	18
Manufacturing	6	14.5	5.3
Service	**40.7**	**40.3**	**46.9**
Tourism	10.4	9.7	11.2
Trading	11.5	9.4	8.1
Public sector	13.7	13	13.4
Others	5	8.2	14.3
Total	**100**	**100**	**100**

Source: own calculations based on three panel waves, SURUMER and DFG Project…

[2] in 2018, China experienced its lowest GDP growth rate in 28 years with 6.8 % p.a. (National Bureau of Statistics in China)

Table 3.10 reveals that most wage employments by members of rubber farming households are full-time jobs. These have decreased slightly in 2018 as compared to 2012 and especially when compared to 2014, again, indicating the slower growth of the Chinese economy. As expected, most part-time jobs are in agriculture which is plausible, given its seasonality of labor. Furthermore, full-time wage employment has decreased most strongly in agriculture, i.e. from 28 to 12.7 %. This may also be a reflection of the declining attractiveness of rubber, whereby larger rubber farmers can release full-time agricultural laborers as they may stop tapping rubber temporarily.

Table 3.10 Full- time and part-time wage employments (in %)

	2012	2014	2018
Categories	**%**	**%**	**%**
Full time*	**79.1**	**82.1**	**74.8**
Agriculture	28.0	17.9	12.7
Non-agriculture	51.1	64.2	62.1
Part time	**20.9**	**17.9**	**25.2**
Agriculture	8.8	10.6	16.7
Non-agriculture	12.1	7.3	8.5
Total	**100**	**100**	**100**

Source: own calculationa, based on three panel waves, SURUMER and DFG Project…
* Following Quiñones et al. (2009), Van den Broeck & Kilic (2019) and Messinis (2013), full time is defined as a labor market participant who has worked at least 125 hours in a calendar month.

Table 3.11 shows the locations of wage employment. Location affects costs and time of transportation and therefore the flexibility to combine on-farm and off-farm work. We use three location categories, namely (i) within the township, (ii) outside the township but within Xisuangbanna (XSBN) Prefecture and (iii) outside XSBN. Jobs within the same township allows people to come home in the evening as their work place can be reached by motorcycle, for example. For jobs outside the township but within XSBN, sleeping away from the household but coming home on weekend may be the most likely pattern while employment outside XSBN usually requires migration. Not surprisingly, most wage employment is within the township. This holds for both full-time and part-time jobs but much more for the latter. In 2018, over 85 % of part-time employment is in the township, up from 60% in 2012. On the other hand, for full-

time employment, changes over the three periods can be observed with employment outside XSBN reaching almost 40% in 2018, up from 28.5 % and 15.5% in 2012 and 2014 respectively. The rising trend of migrant labor indicates that there will be profound changes in farm organization on the longer term.

Table 3.11 Location of full-time and part-time employment

Type of Employment by Location	2012 %	2014 %	2018 %
Full time			
Within township	36.8	53.1	45.8
Outside township	34.7	31.4	16.4
Outside XSBN	28.5	15.5	37.8
Part time			
Within township	60.5	81.4	85.2
Outside township	21.1	13.5	3.5
Outside XSBN	18.4	5.1	11.3

Source: own calculations, based on three panel waves, SURUMER and DFG Project

A last point which will help to better understand rubber farmer labor allocation strategies is to identify changes in labor market participation over time. This allows some initial conclusions about the longer term development of rubber farming households as well as for structural change and agricultural transformation in rubber producing areas in Southwest China and perhaps also in the wider Mekong region. We therefore report the dynamics of labor market participation during the three panel waves. In table 3.12 we have defined five categories of labor market participation over time, namely (1) always in the labor market or (5) never participating. Categories (2), (3), and (4) refer to the entry or exit year in the labor market by the household, i.e. getting in after 2012, getting out after 2012 and finally, in and out. As shown in table 3.12, the majority of our panel households have been in the labor market at some point in time during the 7-year observation period but only 10.7% have always been there. The single largest share, with 36 % goes to non-participants, followed by those who joined in either in 2014 or 2018. The smallest group are those who joined the labor market at any point but got out afterwards, while another 12 % get in and out.

Table 3.12 Dynamics of Labor Market Participation

Group No.	Strategy	No.	%
1	Always in	65	10.7
2	Get in after 2012	201	33.0
3	Get out after 2012	51	8.6
4	In and out	73	12.0
5	Never in	219	36.0
Total		609	100.0

Source: own compilation
* Households with at least a member employed in wage employment.
** households without any members involving in wage employment

Overall, this behavioral pattern indicates that the majority of rubber farmers in XSBN react flexible to changing farming and labor market conditions and participate in off farm labor markets. However, over one third of our panel households do not but remain on farm completely. One the other hand, none of the households gave up farming altogether and completely switched to non-farm employment. This suggests that farmers remain their basis in farming while trying to supplement their income through income diversification in including wage employment. The question of the relative success of these strategies will be tackled in the subsequent econometric analysis.

3.6 Model results

In this section, we present the results of our three models as outlined in section 3.4. First, the results of the logit model with two variants, namely a random effects model and a fixed effect with instrumental variable (IV) model, are presented in section 3.6.1. The model can help to identify the factors related to labor market participation. Second, an endogenous switching regression (ESR) model which simultaneously estimates the effect of labor market participation on household income, presented in section 3.6.2. Third, in section 3.6.3 we present the results of exploring the dynamics of rubber farmers' labor market participation over time by means of a multi-nominal ESR model which gives an assessment of the relative success of rubber farmers' alternative labor allocation strategies in terms of household income.

3.6.1 Factors related to labour market participation

It can be seen from table 3.13 that most of the statistically significant coefficients in the two models have the expected signs. Significant variables, positively correlated with labour market participation in both the random and fixed effects models are: (i) the number of household members in working age (labour size), (ii) the level of education of the household as measured by the member with the highest educational attainment and (iii) the amount of public transfers received. While the first two variables are plausible, (iii) is less clear. One possibility is that receipt of public transfers is a proxy for better access to public institutions and hereby job market information. Variables significantly negatively correlated are: (i) dependency ratio, (ii) share of rubber land, (iii) area devoted to other crops, (iii) shocks and (iv) distance to township. All signs are plausible. For example, a higher dependency ratio ultimately means that less labour is available for outside work, given that own farming remains the backbone of the households' livelihood. This is underlined by the coefficients for rubber and other crops area indicating the association with faming. The same could be true for shocks, especially health shocks, although especially agricultural shocks can also induce households to cope by means of adopting outside jobs in order to compensate for income loss and to smooth consumption. The household's location relative to wage employment opportunities which are in urban environments is underlined by the variables "distance" and "travel costs". The general trend towards labour market participation over time, is underpinned by the positive and significant year dummies of 2014 and 2018. In addition to those coefficients in both models, some of significant coefficients of the random effects model are confirmed, e.g. female head, residing in Jinghong are positivity correlated with labour market participation, while the share of rubber area, distance to the centre of township are negatively correlated.

Unfortunately, regarding the participation intensity, both model variants did not improve the quality of the model in terms of significant coefficients.

Overall, the regression equations shed some light on factors that drive off farm labour market participation of rubber farming households. Although the individual household's farm gate price of rubber is not

significant in the model, the general trend towards wage employment is likely to have something to do with the decreasing economic attractiveness of rubber. On the other hand, on-farm activities compete with off farm work as long as rural households keep their base in farming.

Table 3.13 Determinants of off farm labor market participation by using random effects and fixed effects with IV model

Explanatory variables	Random effects with IV model						Fixed effects with IV model					
	(1)			(2)			(1)			(2)		
	Wage employment participation			Participation intensity (log(off farm income))			Wage employment participation			Participation intensity (log(off farm income))		
	Coef		RSE	Coef		RSE	Coef		RSE	Coef		RSE
Independent variables												
Household level characteristics												
Labor size	0.039	***	0.012	0.066	*	0.039	0.042	*	0.025	0.104		0.071
Dependency ratio	-0.001	***	0.000	0.000		0.001	-0.0001		0.001	0.001		0.001
Age	0.005		0.008	-0.003		0.009	0.026		0.017	0.018		0.049
Age2	-0.0001		0.0001	0.0001		0.0001	-0.0003		0.0002	-0.0002		0.001
Female head	0.0748	*	0.0407	-0.0526		0.131	-0.055		0.098	-0.378	*	0.208
Education	0.030	***	0.004	0.009		0.027	0.061	***	0.014	0.077		0.096
Share of rubber land	-0.001	**	0.001	0.0003		0.001	-0.001		0.001	0.001		0.002
Share of harvesting land	-0.001	*	0.000	-0.001		0.001	-0.001		0.001	-0.003		0.002
Other crop area	-0.003	***	0.001	-0.0003		0.002	-0.002	*	0.001	-0.002		0.003
Altitude	-0.00001		0.0001	-0.0002		0.0001	0.000		0.000	0.001		0.000
Public transfer	0.007	**	0.003	-0.003		0.007	0.005		0.003	0.001		0.008
No. of motor cycle	0.007		0.014	0.031		0.021	-0.008		0.015	0.007		0.029
No. of mobile phone	0.009		0.012	-0.010		0.022	0.014		0.014	0.006		0.031
Shock	-0.061	***	0.021	-0.012		0.070	-0.041	*	0.025	-0.060		0.070
Village characteristics												
Distance to township	-0.004	***	0.001	0.0002		0.003	0.001		0.002	0.007		0.006
Road condition	-0.001		0.027	-0.052		0.046	0.002		0.033	-0.086		0.074
Rubber price	-0.330		2.713	-4.092		4.107	1.918		4.152	-1.292		8.991
Jinghong	0.088	**	0.034	0.091		0.120			(omitted)			
Mengla	-0.023		0.034	0.061		0.047			(omitted)			
Year2014	0.084	***	0.029	0.032		0.078	0.125	***	0.033	0.180		0.183
Year 2018	0.206	***	0.037	0.038		0.193	0.265	***	0.051	0.344		0.361
Constant	-0.072		0.185	-0.242			-0.981	**	0.461	-1.878		1.685
IVs												
Wage in village level	0.001		0.001				-0.001		0.001			
The percentage of migration	0.004	**	0.002				0.006		0.005			
Wald test	478			32686			8.040			9577		
Prob > chi2	0.00			0.00			0.000			0.000		

Control variables							
Travel cost	-4.432	***	1.267	1.287	1.532	4.124	3.099
Age of rubber plantations	-0.002		0.002	0.002	0.006	0.007	0.008

***significance at 1% level, **significance at 5% level, * significance at 10% level. Robust standard errors in parentheses Note: The variance inflation factor(VIF) has been used to check whether variables are collinear. The results are shown in Table 3A.4. in appendix. Coefficient correlation are estimated to make a second examination as well.
Source: own calculations

Further insights into the wage employment of rubber farming households, are obtained by investigating the dynamics of labour market participation by means of a multinomial selection model as introduced in section 3.4. Model results are shown in table 3.14. The dependent variables are the labour market participation strategies over the three observation periods referring to table 3.12 in the previous section. Hereby, we collapse the five groups of table 3.12 into three, whereby households that have stayed out of the labour market in all three periods ("never in") is defined as the base group. Hence, two groups remain, i.e. those who were "always in" which we call "continuous participation" and those who either joined or left after 2012 which we call "discontinuous participation".

Interpretation of the results of the multinomial selection model is different from the model above as the coefficients must be compared to the base group. By doing so, we gain additional insights into the factors that drive labour market participation strategies. For example, as shown in table 3.14, household labour size significantly increases the likelihood of a continuous participation which seems plausible as these households may re-allocate excess labour to off farm wage employment. A higher dependency ratio reduces the likelihood of both continuous and discontinuous participation. This also makes sense because the more dependents a rural household has, the stronger the need of working age members to stay with the household. On the other hand, higher education significantly increases the likelihood to be in either group. The significant coefficient for gender of household head is interesting as female headed households are more likely to be in either continuously or variably participate. Possibly, female heads are more open to work off farm and demand for female jobs may be higher, for example, in the tourism sector of XSBN. Furthermore, households located around Jinghong, the capital of XSBN increases the probability of continuous participation. Similarly, distance from labour markets reduces the likelihood to be in either group. Some of the "agricultural variables" such as area for rubber and tea or the share of rubber land

under harvest is significantly and negatively correlated. Households who own insurance are more likely not to be employed over time. This is mainly because insurance has provided a kind of guarantee for farmers to mitigate potential risks. Farms located in higher altitudes are more likely to be discontinuous labour market participants relative to non-participants which is not so plausible at a first glance and deserves more investigation. It is probably because farmers who live in higher altitudes more likely to have less diversify income portfolios, for example, tea or other cash crops cultivation which is highly vulnerable to market price. Once the current income source farmers are relying on becomes less beneficiary, farmers are pushed to find alternatives. Then, wage employment is a good choice for them. Furthermore, paved high quality road and motorbike add more changes even though it is still subject to some actual constraints.

Summing up the results, we can conclude that analysing the dynamics of wage employment has clarified the factors that can be related to rubber farmers' decision to engage some of their household members in the labour market.

Table 3.14 Dynamics estimation results of dynamic employment by multinomial logit regression

Variables (base: No-employment)	(1) Continuously employed			(2) Discontinuous employment		
Labor size	0.42	***	0.101	0.042		0.061
Dependency ratio	-0.01	***	0.004	-0.007	***	0.001
Age	0.020		0.070	0.018		0.042
Age2	-3.99e-05		0.001	-0.0001		0.001
Education	0.24	***	0.035	0.122	***	0.021
Female head	1.08	***	0.311	0.532	**	0.215
Land area	-0.0003		0.002	0.0001		0.001
Share of rubber land	-0.01	**	0.005	-0.001		0.003
Share of harvesting land	-0.01	**	0.004	0.001		0.002
Share of tea area	-0.006		0.007	-0.013	***	0.005
Altitude	-0.0001		0.001	0.002	***	0.0004
No. of motorcycle	0.143		0.113	0.069		0.071
No. of mobile phone	0.068		0.091	0.006		0.062
Insurance	-0.47	**	0.219	-0.232	*	0.126
Borrowing	-0.127		0.180	0.105		0.111
Lending	-0.197		0.259	0.005		0.156
Public transfer	0.183		0.210	0.007		0.126
Distance to township	-0.06	***	0.016	-0.019	***	0.005
Road condition	0.207		0.215	0.108		0.137
Rubber price	-9.107		26.16	-20.26		15.39
Jinghong	1.50	***	0.399	0.184		0.184
Mengla	0.79	*	0.424	-0.662	***	0.190
Selected instruments						
Wage in village level	7.768		5.365	1.407		
The percentage of migration	0.03	**	0.015	0.012		0.01
Constant	-5.59	***	1.775	-1.774	*	0.95
Wald test on selected instruments	6.82 with prob.== 0.033	**		1.390 with prob.== 0.5000		
Wald chi2	317.35					
Pseudo R2	0.115					

*** p<0.01, ** p<0.05, * p<0.1; Source: own calculations

3.6.2 Impact of labor market participation on household income

Turning to the second objective of this study, we explore the impact of labor market participation on household income, by employing endogenous switching analysis with counterfactual analysis. First, the determinants of participation choice and two income equations are estimate. Results of the participation and income model are presented in appendix Table 3A-5. In order to account for possible selection and

endogeneity biases. Hereby, labour market participation is instrumented by using the average off-farm wage at village level and the percentage of household members per village who are wage employed outside but do not commute back and forth daily (Jin et al.,2021). A falsification test is employed to confirm the validity of these two instruments which satisfy the exclusion restrictions (Table 3A-6).

In the following we present the results of the counterfactual analysis with treatment effects on the treated (ATT) and the untreated (ATU) as well as the heterogeneity effects by survey year and for the entire sample on household income per capita in logarithmic terms (see table 3.15).

The treatment effects are significant showing that the estimated income per capita of households who participated in the labor market in 2012 (ATT) is significantly higher by 61.7 %. The counterfactual analysis (ATU) suggests that if non-participating households had participated their estimated income (ATU) would have increased significantly by a sound 17.2%. The results remain consistent for the following survey years and the aggregated sample. The ATTs are 79.5 %, 92.6 % and 81.5% for 2014, 2018 and the aggregate sample respectively, while the corresponding ATUs are 32.7 %, 51.5 % and 31.6 %. Interestingly both ATT and ATU increase over time. These results shows that in all cases ATT exceeds ATU by a factor of 2 to 4. This is underlined by the positive signs of the transitional heterogeneity effects which indicates that the impact is larger for rubber farm households with wage employment compared to those without. In other words, participants would lose more if they would not participate compared to the gain of non-participants if they would do otherwise

From an economic point of view, our results suggest that households who join labor market could lose a lot if they get out again. However, results must be treated with care as the income model may incompletely capture all important factors as underlined by the base heterogeneity effects, that consider unobservable characteristics in the differences between participants and non-participants. Besides non-economic factors such as tradition among the ethnically highly diverse population and the challenging natural environment in XSNB cannot be fully accounted for in this model.

Table 3.15 Average expected household per capita income(log-transformed),treatment and heterogneity effects

Subsamples	To participate		Not to participate		Treatment effects	
2012	Mean	SE	Mean	SE	Mean	SE
Households with wage employment participation(ATT)	9.654	0.189	9.037	0.045	0.617***	0.035
Households w/o wage employment participation(ATU)	9.117	0.012	8.944	0.020	0.172***	0.017
Heterogeneity effects(TH)	0.537		0.093		0.445	
2014						
Households with wage employment participation (ATT)	9.456	0.020	8.670	0.034	0.795***	0.026
Households w/o wage employment participation(ATU)	8.981	0.018	8.653	0.025	0.327***	0.018
Heterogeneity effects(TH)	0.475		0.008		0.468	
2018						
Households with wage employment participation (ATT)	9.596	0.015	8.667	0.030	0.926***	0.023
Households w/o wage employment participation in (ATU)	9.154	0.022	8.638	0.033	0.515***	0.023
Heterogeneity effects(TH)	0.442		0.029		-1.271	
Whole samples						
Households with wage employment participation (ATT)	9.562	0.011	8.747	0.021	0.815***	0.016
Households w/o wage employment participation (ATU)	9.081	0.350	8.765	0.015	0.316***	0.011
Heterogeneity effects(TH)	0.481		-0.018		0.499	

*** p<0.01, ** p<0.05, * p<0.1; Source: own calculations

3.6.3 Impact of dynamics of off farm employment on household income

In the last step, we repeat the impact analysis for the dynamics of labor market participation taking into account the three age employment strategies, namely continuous, discontinuous and no participation.

Table 3.16 shows the ATT effects of transition for the respective actual and counterfactual scenarios, i.e. actual per capita income of households' who continuously employed over 7-year span to the counterfactual effects if households would have been employed variably or they would have never been employed. ATT results of income reveals that the income of households with continuous labor market participation would experience a decrease by 96.7% and 65% respectively had they adopted no or discontinuous participation. Likewise, income of discontinuous participation will decrease by 19% if they had never participated. From the ATT results, we could conclude that discontinuous employment or never being employed can lead to a decrease in household income.

The lower panel of table 3.17 shows the ATU impacts of labor market participation transitions. ATU results show the impact on income if non participating households would have switch to continuous or discontinuous employment and if discontinuous would switch to continuous. For the first case, per capita income non-participant farmers would increase by 77% and 11.4% respectively relative to the base year of 2012, had they switched to continuous or discontinuous participation. Furthermore, income of households who are discontinuous participants in the labor market would increase their income by 71.6% had they switched to continuous wage employment.

Table 3.16 ATT estimation of dynamics of off farm employment (log per capita income)

Actual			Counterfactual			ATT	
Categories	Mean	SE	Categories	Mean	SE	Mean	SE
Employed->Employed	9.73	0.03	Employed->unemployed	8.77	0.06	0.97***	0.04
Employed->Employed	9.73	0.03	Employed->Flexible	9.08	0.04	0.65***	0.03
Flexible->Flexible	9.02	0.02	Flexible->unemployed	8.83	0.02	0.19***	0.02

*** p<0.01, ** p<0.05, * p<0.1; Source: own calculations

Table 3.17 ATU estimation of dynamics of off farm employment (log per capita income)

Counterfactual			Actual			ATU	
Categories	Mean	SE	Categories	Mean	SE	Mean	SE
Unemployed->Employed	9.66	0.02	Unemployed->Unemployed	8.89	0.02	0.77***	0.02
Unemployed->Flexible	9.00	0.02	Unemployed->Unemployed	8.89	0.02	0.11***	0.02
Flexible->Employed	9.74	0.01	Flexible->Flexible	9.02	0.02	0.72***	0.01

*** p<0.01, ** p<0.05, * p<0.1; Source: own calculations

3.7 Summary and conclusions

The aim of this paper was to investigate the determinants and the impact of off farm labor market participation of small-scale rubber farmers in XSBN after they were confronted with a decline in the price of rubber. A three-wave, comprehensive socioeconomic panel dataset of some 612 rubber farmers in XSBN has been used in this analysis. By means of household theory, as a conceptual basis, we first hypothesize that the wage for off-farm employment, productivity and profitability (rubber prices) of agriculture as well as household preferences determine labor market participation. By means of two logit models, we identify factors significantly correlated with wage employment and hereby largely confirm this hypothesis. We also find that over time, households employ different labor market participation

strategies, depending on socioeconomic circumstances. Our second hypothesis is that participation in wage employment will have a positive effect on household income. By employing an endogenous switching model with instrumental variables, we can confirm this hypothesis. Combining farm work with off farm work significantly increase income and conversely households who decide against or are unable to join the labor market are much worse off in terms of household income. The model also shows that staying engaged in the labor market continuously is economically superior to a "in-and-out" strategy.

While overall, our study suggests that off farm labor market participation is a good strategy to cope with decreasing profitability in rubber farming due to lower rubber prices, this does not support the notion that rural households in Southwest China are likely to get out of farming and rely on wage employment in the industry and service sector. Farming remains the backbone of rural households and a combination of on farm and off farm labor allocation is the utility maximizing strategy. This is indicated by the fact that none of our 612 panel households has left farming altogether, despite the economic decline in rubber faming over a seven-year observation period. Off-farm wage employment is not a panacea either as the competitiveness of rural household member in the labor market is often limited. More often than not, they are engaged in rather indecent employment conditions and get jobs with poor social protection.

Our study also raises the question, how rural labor markets should be developed in Southwest China and elsewhere in the Mekong Basin countries, in order to facilitate off-farm employment in combination with farming. The rural population is generally not well prepared to engage in jobs that require high qualification and that would offer enough income for making a living without farming. Hence, it is unlikely that the politically envisaged transformation of small scale agriculture towards large-scale farming and corporate agribusiness is still a far way to go. In all likelihood, and based on observations in other Asian countries, majority of small-scale farmers will not sell or rent out their land on a large scale and on the short run. Rather they would follow a strategy of income combinations are in effect what is called "part-time farmers" in European agriculture (Schmitt 1984). Therefore, our main policy recommendation is that rural development must be more than just providing more jobs in the non-farm sector. Instead, what is needed, is a well-planned and stable rural development policy that facilitates a

sustainable transformation process, ecologically and economically balanced, and which primarily strengthens the resilience of rural households. This could include elements of the traditional self-sufficiency economy as well as making more use of the possibilities of rural digitalization. The recent Covid-19 pandemic with ongoing Covid-19 related restrictions in China, is a strong reminder in this direction.

A possible expansion of the analysis which was carried out in this paper, should look at other indicators beyond income such as wealth, coping capacity and resilience.

References

Abdulai, A., & Delgado, C. L. (1999). Determinants of nonfarm earnings of farm-based husbands and wives in northern Ghana. *American Journal of Agricultural Economics*, *81*(1), 117-130.

Ahlheim, M., Frör, O., Jing, L., Pelz, S., & Tong, J. (2013). How do Beijing residents value environmental improvements in remote parts of China. *Advances in Climate Change Research*, 4(3), 190-200.

Ahlheim, M., Neidhardt, J., Siepmann, U., & Yu, X. (2018). WeChat-using social media for the assessment of tourist preferences for environmental improvements in China (No. 09-2018). Hohenheim Discussion Papers in Business, Economics and Social Sciences.

A D Beyene (2008) Determinants of off-farm participation decision of farm households in Ethiopia, *Agrekon: Agricultural Economics Research, Policy and Practice in Southern Africa,* 47:1, 140-161, DOI:10.1080/03031853.2008.9523794

Behrman, J. R., & Wolfe, B. L. (1984). Labor force participation and earnings determinants for women in the special conditions of developing countries. *Journal of Development Economics*, *15*(1-3), 259-288.

Bezu, S., Barrett, C. B., & Holden, S. T. (2012). Does the nonfarm economy offer pathways for upward mobility? Evidence from a panel data study in Ethiopia. *World Development*, 40(8), 1634-1646.

Carter, D. W., & Milon, J. W. (2005). Price knowledge in household demand for utility services. *Land Economics*, 81(2), 265-283.

Choi, Susanne YP, and Yinni Peng. "Humanized management? Capital and migrant labour in a time of labour shortage in South China." *Human Relations* 68.2 (2015): 287-304.

Cui, Y., Meng, J., & Lu, C. (2018). Recent developments in China's labor market: Labor shortage, rising wages and their implications. *Review of Development Economics*, *22*(3), 1217-1238.

Cai, F., & Du, Y. (2011). Wage increases, wage convergence, and the Lewis turning point in China. *China Economic Review* 22 (4), 601-610.

Duan, N., Manning, W. G., Morris, C. N., and Newhouse, J. P. (1983), "A Comparison of Alternative Models for the Demand for Medical Care," *Journal of Business and Economic Statistics*, 1, 115-126.

De Brauw, A., Huang, J., Rozelle, S., Zhang, L., & Zhang, Y. (2002). The evolution of China's rural labor markets during the reforms. *Department of Agricultural and Resource Economics, UC Davis Working Paper*, (02-003).

Di Falco, S., Veronesi, M., & Yesuf, M. (2011). Does adaptation to climate change provide food security? A micro-perspective from Ethiopia. *American Journal of Agricultural Economics*, 93(3), 829-846

De Janvry, A., Sadoulet, E., & Zhu, N. (2005). The role of non-farm incomes in reducing rural poverty and inequality in China (No. 1557-2016-133197).

Ellis, F., (1993). *Peasant Economics: Farm Households and Agrarian Development*. Cambridge University Press, 2nd edn.

Ellis, F., (1998). Survey Article: Household Strategies and Rural Livelihood Diversification, *Journal of Development Studies*, 35(1), 1-38

Guo, H., & Padoch, C. (1995). Patterns and management of agroforestry systems in Yunnan: an approach to upland rural development. *Global Environmental Change*, *5*(4), 273-279.

Gao, J., & Mills, B. F. (2018). Weather shocks, coping strategies, and consumption dynamics in rural Ethiopia. *World Development*, 101, 268-283

Grabowski, P. P., & Kerr, J. M. (2014). Resource constraints and partial adoption of conservation agriculture by hand-hoe farmers in Mozambique. *International Journal of Agricultural Sustainability*, *12*(1), 37-53.

Han, D., Liu, L., Su, X., Johnson, B., & Sun, L. (2019). Variable selection for random effects two-part models. *Statistical methods in medical research*, 28(9), 2697-2709.

Hu, H., Liu, W., & Cao, M. (2008). Impact of land use and land cover changes on ecosystem services in Menglun, Xishuangbanna, Southwest China. *Environmental monitoring and assessment*, *146*(1), 147-156.

Huang, J., Wu, Y., & Rozelle, S. (2009). Moving off the farm and intensifying agricultural production in Shandong: a case study of rural labor market linkages in China. *Agricultural Economics, 40*(2), 203-218.

Huang, J., Wang, Y., & Wang, J. (2015). Farmers' adaptation to extreme weather events through farm management and its impacts on the mean and risk of rice yield in China. *American Journal of Agricultural Economics*, 97(2), 602-617.

Heckman, J., Tobias, J. L., & Vytlacil, E. (2001). Four parameters of interest in the evaluation of social programs. *Southern Economic Journal*, 68(2), 210-223.

Xu J. (2006). The political, social, and ecological transformation of a landscape. *Mountain Research and Development*, *26*(3), 254-262.

Xu, J., Grumbine, R. E., & Beckschäfer, P. (2014). Landscape transformation through the use of ecological and socioeconomic indicators in Xishuangbanna, Southwest China, Mekong Region. *Ecological Indicators*, 36, 749-756.

Jin, S., Huang, J., & Waibel, H. (2020). Location and economic resilience in rubber farming communities in southwest China. *China Agricultural Economic Review*.

Jin, S., Min, S., Huang, J., & Waibel, H. (2021). Falling price induced diversification strategies and rural inequality: Evidence of smallholder rubber farmers. *World Development*, 146, 105604.

Li, H.,Li, L., Wu, B., & Xiong, Y. (2012). The end of cheap Chinese labor. *Journal of Economic Perspectives*, 26(4), 57-74.

Li, Q., Huang, J., Luo, R., & Liu, C. (2013). China's labor transition and the future of China's rural wages and employment. *China & World Economy*, *21*(3), 4-24.

Lokshin, M., & Sajaia, Z. (2004). Maximum likelihood estimation of endogenous switching regression models. *The Stata Journal*, 4(3), 282-289.

Lokshin, M., & Sajaia, Z. (2011). Impact of interventions on discrete outcomes: Maximum likelihood estimation of the binary choice models with binary endogenous regressors. *The Stata Journal*, 11(3), 368-385.

Li H., Aide T.M., Ma Y., Liu W., Cao M. (2006) Demand for rubber is causing the loss of high diversity rain forest in SW China. In: Hawksworth D.L., Bull A.T. (eds) Plant Conservation and Biodiversity. Springer, Dordrecht. https://doi.org/10.1007/978-1-4020-6444-9_11

Malikov, E., & Kumbhakar, S. C. (2014). A generalized panel data switching regression model. *Economics Letters*, 124(3), 353-357.

Manning, W., Morris, C. N., Newhouse, J. P., Orr, L. L., Duan, N., Keeler, E. B., Leibowitz, A., Marquis, K. H., Marquis, M. S., and Phelps, C. E. (1981), "A Two-Part Model of the Demand for Medical Care: Preliminary Results from the Health Insurance Experiment," in *Health, Economics, and Health Economics*, eds. J. van der Gaag and M. Perlman, Amsterdam: North-Holland, pp. 103-104.

Ma, W., & Abdulai, A. (2016). Does cooperative membership improve household welfare? Evidence from apple farmers in China. *Food Policy*, 58, 94-102.

McFadden, D. (1973). Conditional logit analysis of qualitative choice behavior.

Messinis, G. (2013). Returns to education and urban-migrant wage differentials in China: IV quantile treatment effects. *China Economic Review*, 26, 39–55. doi:10.1016/j.chieco.2013.03.006

Min, S., Waibel, H., Cadisch, G., Langenberger, G., Bai, J., & Huang, J. (2017a). The Economics of Smallholder Rubber Farming in a Mountainous Region of Southwest China: Elevation, Ethnicity, and Risk. *Mountain Research and Development*, *37*(3), 281.

Min, S., Huang, J., Bai, J., & Waibel, H. (2017b). Adoption of intercropping among smallholder rubber farmers in Xishuangbanna, China. *International Journal of Agricultural Sustainability*, *15*(3), 223–237.

Min, S., Wang, X., Liu, M., & Huang, J. (2018). The asymmetric response of farmers to an expected change in the price of rubber: The roles of sunk costs and path dependency. *Land Use Policy*, 79, 585-594.

Olsen, M. K., & Schafer, J. L. (2001). A two-part random-effects model for semi continuous longitudinal data. *Journal of the American Statistical Association*, 96(454), 730-745.

Quiñones, E. J., de la O-Campos, A. P., Rodríguez-Alas, C., Hertz, T., & Winters, P. (2009). Methodology for Creating the RIGA-L Database. *Online at www. fao. org/es/ESA/riga/pdf/RIGA-L_Methodology. pdf*.

Qiao, F. (2017). Increasing wage, mechanization, and agriculture production in China. *China Economic Review*, 46, 249-260.

Ranis, G., & Fei, J. C. (1961). A theory of economic development. *The American economic review*, 533-565.

Sumner, D. A. (1982). The off-farm labor supply of farmers. *American Journal of Agricultural Economics*, *64*(3), 499-509.

Schmitt, Günther. "Part-time farming in the Federal Republic of Germany." *Land Use Policy* 1.2 (1984): 125-133.

Tesfaye, W., & Tirivayi, N. (2018). The impacts of postharvest storage innovations on food security and welfare in Ethiopia. *Food Policy*, 75, 52-67.

Van den Broeck, G., & Kilic, T. (2019). Dynamics of off-farm employment in Sub-Saharan Africa: A gender perspective. *World Development*, *119*, 81-99.

Weersink, A., Nicholson, C., & Weerhewa, J. (1998). Multiple job holdings among dairy farm families in New York and Ontario. *Agricultural Economics*, *18*(2), 127-143.

Appendix

Figure 3A.1. World rubber price changes

Description: Singapore Commodity Exchange, No. 3 Rubber Smoked Sheets (RSS3);
Source: Mundi Index, 2018 (https://www.indexmundi.com/commodities/?commodity=rubber&months=240)

Table 3A.1 Rubber price changes over the year at the county level in XSBN

Categories	2012		2014		2018	
	Latex	Dry rubber	Latex	Dry rubber	Latex	Dry rubber
Price(Unit: USD/kg)						
Menghai	1.795	2.693	0.432	1.267	0.941	0.796
	(1.260)	(0.832)	(0.187)	(0.225)	(0.429)	(0.246)
Jinhong	1.264	2.670	0.478	1.342	0.624	1.016
	(0.718)	(0.793)	(0.121)	(0.252)	(0.369)	(0.335)
Mengla	1.476	2.383	0.461	1.206	0.620	1.010
	(0.670)	(0.770)	(0.124)	(0.297)	(0.317)	(0.340)
Average	1.414	2.554	0.468	1.28	0.635	0.976
	(0.824)	(0.795)	(0.128)	(0.276)	(0.354)	(0.332)

Source: own calculations

Table 3A.2 Contract types of off farm wage employment participants

Categories (%)	2012	2014	2018
Written contract	13.2	27.9	34.9
Verbal agreement	52.7	33.9	23.9
Without contract	34.1	38.2	41.2
Total	100	100	100

Source: own calculations

This table reveals the contract types. Even though the awareness of using contract to guarantee their rights have grown, without signing any contract is dominant in 2018. Most employees have informal verbal contracts with their employers or do not have any warranty.

Table 3A.3 Working intensity in household level

Working intensity	2012	2014	2018
Total working hours	2794.4	3738.3	3279.4
Average working hours	2188.8	2463.4	2140.0

Source: own calculations

This table reveals that total and average household wage working hours have decreased in 2018 which is opposite with our assumption. The phenomena can be attribute to the following factors: (1). Rubber latex price has increased in 2018 which has attracted some famers transition out of wage employment. (2). More farmers engage in part time employment in 2018.

Table 3A.4 Multicollearity check

Variable	VIF	1/VIF
Mengla	2.9	0.34
Jinghong	2.81	0.36
Share of harvesting land	1.71	0.58
HH Altitude	1.58	0.63
Average rubber tree age	1.45	0.69
Distance to township	1.4	0.71
Head age	1.4	0.71
Total land area	1.35	0.74
Share of rubber land	1.35	0.74
Head education	1.35	0.74
Average age	1.32	0.76
Household size	1.24	0.81
Travel cost	1.18	0.85
Education attainment	1.16	0.86
Non-farm enterprise	1.12	0.89
Dependency ratio	1.11	0.9
Road condition	1.1	0.91
Female head	1.05	0.95
Shock	1.05	0.96
Public transfer	1.04	0.96
Mean VIF	1.35	

Source: own calculations

Table 3A.5 Endogenous switching regression estimates of off farm employment participation and corresponding income impacts

Variables	(1)			(2)			(3)		
	Participation (1/0)			Participation = 0 (HHs have not participated in wage employment)			Participation = 1 (HHs have participated in wage employment)		
				Household per capita income (log-transformed)					
	Coef.		Robust Std.Error	Coef.		Robust Std.Error	Coef.		Robust Std.Error
Household level characteristics									
Labor size	0.128	***	0.036	-0.191	***	0.045	-0.068		0.049
Dependency ratio	-0.004	***	0.001	-0.003	***	0.001	-0.005	***	0.002
Age	0.025		0.030	0.018		0.027	0.020		0.025
Age2	-0.000		0.000	-0.000		0.000	-0.000		0.000
Female head	0.215	*	0.121	0.267	*	0.146	-0.001		0.116
Education	0.096	***	0.013	0.040	**	0.019	0.052		0.033
Share of rubber land	-0.003	*	0.002	-0.002		0.002	-0.002		0.002
Share of harvesting land	-0.003	**	0.001	0.007	***	0.002	0.003	***	0.001
Other crop area	-0.010	***	0.003	0.010	***	0.002	0.010	*	0.006
Altitude	0.000		0.000	0.001	**	0.000	0.000		0.000
Public transfer	0.021	**	0.009	0.047	***	0.014	0.013		0.008
No. of motorcycle	0.009		0.040	0.061		0.055	0.028		0.037
No. of mobile phone	0.017		0.034	0.060		0.060	0.052	*	0.030
Shock	-0.187	***	0.069	-0.143	*	0.080	-0.130	*	0.071
Village characteristics									
Distance to township	-0.014	***	0.004	0.008	**	0.004	0.001		0.006
Road condition	0.009		0.081	-0.005		0.095	0.022		0.083
Travel cost	-12.079	**	5.606	-0.040		4.740	0.839		6.591

Age of rubber plantations	-0.005		0.006	0.015	**	0.007	-0.008		0.006
Rubber price	-4.264		9.599	25.306	**	10.177	12.679		10.041
Jinghong	0.200	*	0.116	-0.048		0.142	0.238	*	0.125
Mengla	-0.099		0.112	0.521	***	0.138	0.255	*	0.137
Year2014	0.299	***	0.099	-0.222	**	0.101	-0.024		0.148
Year2018	0.694	***	0.138	-0.340	**	0.142	0.161		0.248
Instruments									
Wage in village level	0.153		4.093						
The percentage of migration	0.009	*	0.006						
Constant	-1.886	**	0.735	7.568	***	0.654	8.215	***	1.216
σ_i				1.278	***	0.032	0.758	***	0.092
p_i				0.056		0.186	0.336		0.596
Log-likelihood				-3673.49					
Wald chi2(22)				171.76	***				
Observations	1826			651			1176		

*** p<0.01, ** p<0.05, * p<0.1; Source: own calculations

It is can be observed that both household and village characteristics affect smallholder rubber farmers' likelihood to participate in labour market. In terms of household characteristics, larger households with better education are more likely to enter labour market. This can be explained by larger household offers more labour endowments. Farmers with higher education attainment are often open-minded and are willingly to embrace new opportunities. On the contrary, some factors, like share of rubber land, share of rubber harvesting land, other crop area are negative correlated with the possibility of wage employment participation. This is because rubber and other crop cultivation are labour-intensive industries which acquire and utilize more labours which are supposed to engage in labour market. Households who have suffered from shocks are less willing to do wage employment. With respect to village characteristics, the farther distance to township, the less likelihood to participate in wage employment. HHs which resides in Jinghong are more likely to involve into wage employment market. This is due to Jinghong is the capital of XSBN which could offer more employment opportunities with relatively higher salary.

In terms of the income determinants, the estimated coefficients from the 2nd and 3rd columns reveal that there are some existing heterogeneity and differences between the two regimes of HHs with and without participation. Household per capita income of the household without participation increases with altitude. This could be correlated with the fact that HHs in a higher altitude cultivate some other cash crops which are also important income source.

Table 3A.6 Exogenous test on the validity of the selected instruments- Determinants of participation

Variables	(1)			(2)		
	Participation (0/1)			HH per capita income that didn't participate		
	Coef.		Std. Error	Coef.		Std. Error
Control for other variables	Yes			Yes		
Wage in village level	**6.769**	***	**2.152**	**-6.566**		**2.054**
The percentage of migration	**0.010**		**0.007**	**0.009**		**0.007**
Underidentification test						
Kleibergen-Paap rk LM statistic	41.31	***				
Weakidentification test						
Cragg-Donald Wald F statistic	21.09					
Kleibergen-Paap rk Wald F statistic	20.51					
Overidentification test of all instruments						
Hansen J statistic	0.661		0.4163			
Constant	-2.904	***	0.761	8.452	***	0.662
Wald chi2 (22)	183.19	***		251	***	
Wald test on the instruments	**40.5**	***		**4.1**		
Observations	1,827			1,168		

*** p<0.01, ** p<0.05, * p<0.1; Source: own calculations

A falsification test is used to check the validity of the instruments by following Di Falco et al. (2011). The estimation results are shown in Table 3A.6. As can be seen from table 3A.6, these two instruments are significantly correlated with smallholder rubber farmers' likelihood to participate labor market but they have no significant impact on the income outcome of households who didn't participate in the labor market. Hence, we couldn't reject their validity. Moreover, the results show that IV also pass the under-identification, weak identification and over-identification tests which have proven these two instruments are exogenous and efficient.

Table 3A.7 Selection bias correction based on the multinomial logit model

Dependent variables	(0)			(1)			(2)		
	No participation			Continuously employed			Discontinuous employment		
	Log per capita income								
	Coef.		Std.Error	Coef.		Std.Error	Coef.		Std.Error
Labor size	-0.118		0.120	0.105		0.288	-0.223	***	0.064
Dependency ratio	-0.010		0.008	-0.005		0.006	-0.008	**	0.003
Age	0.040		0.067	-0.031		0.123	0.049		0.039
Age2	-0.000		0.001	0.001		0.002	-0.001		0.001
Education	0.145		0.146	0.057		0.106	0.062		0.055
Female head	1.105		0.735	0.122		0.523	0.104		0.285
Land area	0.007	***	0.002	0.001		0.002	0.004	***	0.001
Share of rubber land	-0.006		0.005	-0.008		0.008	-0.000		0.003
Share of harvesting land	0.012	***	0.004	0.000		0.007	0.009	***	0.002
Share of tea area	0.002		0.017	0.021	**	0.010	0.007		0.007
Altitude	0.002		0.002	-0.002		0.002	0.001		0.001
No. of motorcycle	0.147		0.147	-0.011		0.122	0.020		0.069
No. of mobilephone	0.159		0.100	0.161		0.101	-0.045		0.054
Insurance	-0.235		0.307	0.133		0.287	0.213		0.131
Borrowing	0.168		0.207	-0.137		0.270	0.040		0.105
Lending	0.235		0.254	-0.142		0.327	0.263	**	0.131
Public transfer	-0.031		0.193	0.161		0.232	0.249	***	0.094
Distance to township	-0.022		0.025	-0.028		0.035	-0.006		0.010
Road condition	0.130		0.259	0.287		0.236	0.092		0.122
Rubber price	4.701		30.237	6.200		27.129	11.933		15.180
Jinghong	-0.042		0.376	0.817		0.837	0.258		0.187

Mengla	-0.476		0.928	1.173		0.984	0.117		0.379
Selection bias correlation terms									
_m0	-0.461		1.828	5.387	*	2.812	-0.595		2.651
_m1	2.062		2.348	2.039		1.636	-0.598		1.483
_m2	5.144		4.329	0.438		1.706	0.690		0.668
Constant	9.472	***	1.707	9.074	**	4.121	6.267	***	2.318

Standard errors is bootstrapped (1000 replications); Source: own calculations
*** p<0.01, ** p<0.05, * p<0.1

Table 3A.7 has presented multinomial endogenous switching regression results. It has displayed the factors which are correlated with per capita income under three different labor market participation transition over years.

Table 3A.8 Test on the Validity of the selection instruments –Determinant of employment dynamic typology

Variables	HH per capita income that keep unemployed		
	Coef.		Std. Error
Control for other variables	Yes		
Selected instruments			
Wage in village level	-5.721	*	-3.178
The percentage of migration	0.009		-0.01
Constant	9.375	***	-0.877
Wald test on selected instruments	2.21 with Prob.= 0.1105		
R-squared	0.213		

*** p<0.01, ** p<0.05, * p<0.1; Source: own calculations

Table 3A.8 has displayed the validity of the instruments. As can be seen from table 3-2, these two instruments are significantly correlated with smallholder rubber farmers' employment transition. Moreover, neither of these two instruments are correlated with household per capita income of those who were unemployed over years. Hence, we fail to reject their validity. Therefore, these two instruments are efficient.

CHAPTER 4: LAND RENTAL, OFF FARM EMPLOYMENT AND HOUSEHOLD INCOME GROWTH IN SOUTHWEST CHINA

Previous version of this paper is presented and published as proceedings at:
20th Annual World Bank Conference on Land and Poverty 'Catalyzing Innovation', 25-29, March 2019 Washington DC, USA

Abstract

With the development of land rental market in China, the impacts of land rental have attracted much attention. This paper empirically investigates the impacts of renting out land on off farm employment, household total income and income components, i.e. farm income, on- and non-farm wage employment income. Using a representative survey data in XSBN covering 600 smallholders, 2SLS regression, IvTobit model, and Propensity score matching approaches are used to estimate the impacts by taking potential endogeineity problem into consideration. Results demonstrate that smallholders' land rental is significantly positive correlated with household total income, non- farm wage income but negatively correlated with farm income. The average treatment effects show that renting out land can increase household total income by approximately 44% -60% and decrease farm income by 49% to 65% on the basis of different matching numbers. Furthermore, estimation results also show that renting out land is significantly correlated with wage employment participation and non-farm wage employment. Finally, a mediation analysis has proved labor market participation is a mediation variable, through which land rental affects household income.

Keywords: Renting out land, Household income, Income composition, Mediation analysis, China

4.1. Introduction

A well-functioning land rental market plays an essential role in rural development and household income increase ((Deininger & Feder, 2001; Deininger & Jin, 2005; Feng & Heerink,2008). First,

it allows farmers with high agricultural productivity to rent in more land plots which encourages long-term agricultural investment. Accordingly, these farmers are better able to engage in large scale farming and further improve agricultural productivity. Second, for the farmers with relatively low agricultural productivity, they can lease out their land, release their labor from farming, and then reallocate their labor into off farm employment activities, facilitating rural transformation by transferring surplus labor (Cheng at al.,2019). Furthermore, land transfer makes land a more valuable collateral asset, which allows landholders to get access to credit (Deininger, 2003a, b).

In the last decades, the Chinese government has launched a series of land use policies in order to promote the advancement of land rental markets, guarantee land tenure stability and facilitate land transferability. In 1979, the household responsibility system (HRS) was implemented, giving farmers some control over land allocated to them. Although the system intended to protect land use rights through a contractual framework, village authorities have occasionally reallocated land which has brought uncertainty in the duration of land contracts (Chang et al. ,2018). In 2002, the rural land contracting law (RLCL) was passed which eases the exchange of land use rights (Chang et al.,2018; Yan & Huo.,2016). Since 2008, the land titling project started, in order to strengthen the contractual management rights by legally ensuring the security of property rights (Hong et al., 2020). In 2018, the 'Three Rights Separation Policy' (TRSP) was announced which regulates 'three rights' which farmers have on their lands, namely, land ownership right, contract rights and management right (Xu et al.,2018).

As a result of legal permission and government policy encouragement, the rural land rental market has been growing rapidly in China. By 2008, the total area of land rented out reached 106 million mu (7.07 million hectares), accounting for 8.7% of the total land contracted to rural households. By 2013, the area of rented-out land has more than tripled, reaching 340 million mu (22.68 million hectares) or 26% of the total contracted land (Ye, 2015). By 2015, approximately

63 million rural households all over China have rented out their cultivatable farmland which accounts for nearly 33% of the total contracted farmland area, under the household responsibility system (HRS) (Committee of China Agriculture Yearbook, 2010–2016).

Against the background of land rental market and economic development, several studies that investigated the impacts of land rental in China have been conducted. Most researches focused on agricultural labor productivity and equity impacts (Jin and Deininger.,2009; Feng et al.,2010; Zhang et al., 2021;) and off farm labor markets and land rental (Kung,2002; Feng,2006; Su,2018). Several recent studies (Zhang et al.,2018; Peng et al.,2020) have examined the impacts of land rentals on rural household income and its composition with mixed estimation results.

This paper intends to examine whether renting out land, can increase rural household income in XSBN. Also we investigate the correlation with different income compositions and try to decompose the income impacts of renting out land into three aspects: total, direct and indirect impacts. We firstly use OLS and tobit model to estimate the correlation between land rental and household income, income compositions. Then, the PSM approach is applied to investigate the average treatment effects of renting out land on household income. A bivariate model is used to explain the impact of renting out land on off farm wage employment. Finally, a mediation analysis is exploited to decompose the impacts on household income of land rental decisions. To account for potential endogeneity, an instrumental variable is included in the analysis.

The remainder of this paper is arranged as follows: In the next section, we outline a theoretical framework and proposed research hypotheses to be examined. In section 4.3, we briefly introduce our research area, data source and descriptive statistics. Model specifications and estimation strategies are presented in section 4.4. Estimation results and main findings are summarized in section 4.5, whereas section 4.6 concludes our analysis and discuses policy implications.

4.2. Theoretical framework and research hypotheses

Following the studies of Yao (2000), Deininger and Jin (2005), and Jin and Deininger (2009), a conceptual framework about the impact of land rental on off-farm employment and household income is established. Suppose a rural household i is endowed with a certain amount of labor (L) and land area (A) resources. Household agricultural production function can be specified as: $a_i f(L_f, A_f)$, L_f is the actual quantity of labor allocated for agricultural activities of which agricultural production ability is a_i. A_f stands for the actual land area household has cultivated. What's more, $A_f = \mathrm{A} + \Delta A$, where ΔA can explain whether a household has participated in land rental market. If $\Delta A > 0$, it means a household has rented in land, while $\Delta A < 0$ indicates that a household has rented out some land plots and if a household doesn't involve into land rental market, ΔA equals to 0. A household allocates labor between farming activities on the total land area they actually cultivate (L_f) and off farm wage employment activities (L_o) with a given wage rate (w). Here, $L_f + L_o = L$. f meets the standard assumptions: $f_{l_f} > 0$, $f_A > 0$, $f_{l_f l_f} < 0$, $f_{AA} < 0$, $f_{l_f A} > 0$ and $f_{l_f l_f} f_{AA} - f_{l_f A} > 0$.

Any household will maximize their income as the equations below shows. Equation 1 shows income composition of the households who aren't engaged in land rental market from is from agricultural and off-farm wage employment activities. Equation 2 denotes household income sources when household have transferred their land.

$$\text{Max } I_0 = Max\ pa_i f(L_{f_0}, A) + wL_{w0} \quad (4.2.1)$$

$$\text{Max } I_1 = Max\ pa_i f(L_{f_1}, \mathrm{A} + \Delta A) + wL_{w1} - r(\Delta A) \quad (4.2.2)$$

where, p is the price of agricultural products. r denotes the unit rent of land leasing. When household doesn't involve in land rental market, household allocates land (A) and labor (L_{f_0} and L_{w0}) between farming activities on the land plots they own and off farm wage

employment activities to maximize their income (I_0). However, if land rental market is involved, land ($\mathrm{A} + \Delta A$) and labor (L_{f_1} and L_{w1}) will be reallocated accordingly as land areas enlarge or shrink and more available labor in a household, in turn, can result into household income changes. Hence, land rental participation can directly or indirectly influence total household income level (I_1) and its composition structure.

In our sample, there are only 61 households out of 600 samples who have rented into a total of 82 land plots which accounts for a minor proportion in the whole sample. Therefore, we only analyze the impacts of rent out land in this paper. That is, land rental and transfer specifically refers to the case of household renting out land in this paper.

In our analysis, we divide household income into four categories based on the availability of data, namely total household income, farm income, on-farm wage employment income and off farm employment income. Farm income is the cash income from own farm output, including crop cultivation, livestock rearing as well as natural resource extractions. On-farm wage employment income or agricultural wage income refers to wage employment in agricultural sector and income earned on other's farms. Non-farm wage employment income is earnings from being employed at non-farm wage employment sectors.

We further discuss the mechanism underlies the impact of renting out land on household income and its structure as follows (Zhang et al.,2018; Zhang et al.,2020).

a. Impact of renting out land on household total income and farm income

Assume agricultural product price p, productivity ability a_i and land transaction cost are constant. By applying two variables Taylor Polynomials to equation (4.2.1) and (4.2.2), we can get:

$$I_1 - I_0 = \frac{1}{2}\, pa_i[-f_{l_f l_f}\left(L_{f1}, A_f\right)\left(L_{f0} - L_{f1}\right)^2 - f_{AA}\left(L_{f1}, A_f\right)\left(A - A_f\right)^2 - 2f_{l_f A}\left(L_{f1}, A_f\right)(L_{f0} - L_{f1})(A - A_f)\,] \quad (4.2.3)$$

It is anticipated that operational land size is less after renting out land, $A > A_f$, requiring less labor, $L_{f0}^* > L_{f1}^*$ and other inputs in farming activities, then we can get $(L_{f0} - L_{f1})(A - A_f) > 0$. Then applying inequality of arithmetic and geometric means to equation (4.2.3), we can get:

$$-f_{l_f l_f}(L_{f1}, A_f) = [\sqrt{-f_{l_f l_f}(L_{f1}, A_f)}]^2 \ , \ -f_{AA}(L_{f1}, A_f) = [\sqrt{-f_{AA}(L_{f1}, A_f)}]^2$$

$$-f_{l_f l_f}(L_{f1}, A_f)(L_{f0} - L_{f1})^2 - f_{AA}(L_{f1}, A_f)(A - A_f)^2$$

$$\geq 2(L_{f0} - L_{f1})(A - A_f)\sqrt{-f_{l_f l_f}(L_{f1}, A_f)}\sqrt{-f_{AA}(L_{f1}, A_f)}$$

$$> 2(L_{f0} - L_{f1})(A - A_f) f_{l_f A}(L_{f1}, A_f)$$

From here, we can obtain that income of the households with land rental participation will be relatively high compared with those households without land rental. Renting out land has resulted in the decline in land operational area, with surplus labor and other inputs leaving farming activities, thus reducing farm income directly. However, since labor forces released from land are able to pursue better wage rate in labor market along, household total income is expected to increase.

b. Impact of renting out land on on-farm wage income and non-farm wage income

It is believed that renting out land has a positive impact on non-farm wage income due to more labor re-allocation from farming activities to off-farm employment, especially non-farm activities. Furthermore, labor force market in XSBN is still developing which pull farmers to participate. We therefore expect that the effect of renting out land is positively correlated with non-farm wage income. Nevertheless, the effect of renting out land on non-farm wage income may also be ambiguous since major of on-farm wage activities in XSBN are seasonal and part-time.

c. Mediation analysis of off-farm employment on household income

From the above analysis, we can observe that land rental can have a direct impact on household income by adjusting land size or indirectly influence household income through the interaction between land transfer and labor reallocation. Therefore, as shown in Figure 4.1, we are interested into estimating whether there is a mediation effect of off farm employment on household income.

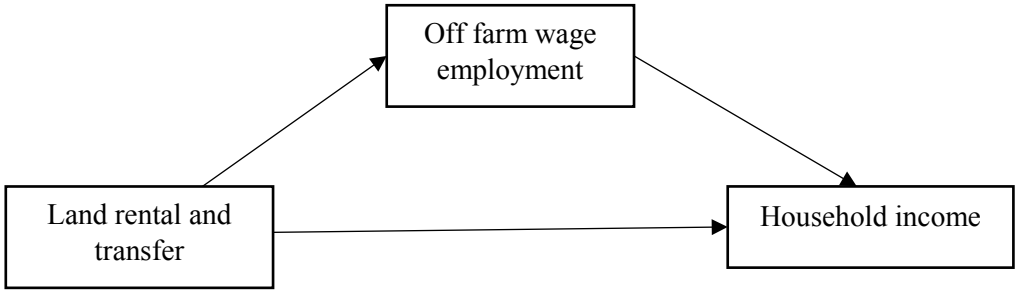

Figure 4.1 Land rental, off farm wage employment and household income

Based on above analysis, we propose the following hypotheses to be examined:

Hypothesis 1: Renting out land can raise household total income and reduce farm income.

Hypothesis 2: Renting out land is positively correlated with non-farm wage income while its impact on on-farm employment income is ambiguous.

Hypothesis 3: Households with renting out land are more likely to participate in labor market.

Hypothesis 4: Impact of land rental on household income can be divided into direct and intermediary aspects. Off farm employment, especially non-farm employment, acts as a mediation effect between land transfer and household income.

4.3. Research area, data source and descriptive analysis

4.3.1 Research area and data source

Xishuangbanna (XSBN) is a Dai Ethnic Autonomous Prefecture, located in the southernmost of Yunnan province, China. It has an area of 19,150 km^2, wherein about 95% of the area is covered by mountains and hills with altitude ranging from 475 to 2430 meters above sea level (MASL). XSBN borders Myanmar to the west and Laos in the south. An outstanding feature of XSBN is its rich biological and cultural diversity.

Since the 1950s, encouraged by the local government and triggered by high rubber prices, the land area devoted to rubber cultivation in XSBN has tripled, now reaching a total area over 424000 ha (Xu et al.,2014). The expansion of rubber cultivation has brought high profitability for smallholder rubber farmers (Fu et al., 2009). However, rubber price has decreased dramatically since 2011 which has caused income loss for rubber farmers and made rubber less profitable. In order to mitigate income loss, local farmers have reallocated land and labor to seek other income sources with an attempt to cope with the rubber price shock. In recent years, the emergence of local labor market with better wage rate has provided off farm wage opportunities for local farmers. In addition, Chinese government has launched a series of land policy reforms to guarantee farmers' land use rights. Especially the promulgation of "Rural Land Contract Law" in 2002, it gives a strict definition of land rights as property right with 30 years' duration and permits land transfer between households (Yin et al., 2013; Deininger et al. 2014). Even though land titling progress in XSBN is fell behind in XSBN (Min et al., 2017), by 2012, approximately 30% of households with at least an arable land plot has issued with farmland tenure certificate and 31% is issued with forestland tenure certificate.

Our analysis is based on a follow up survey which was conducted in 2019. In the survey, a total of 612 smallholder rubber farmers has been interviewed on the basis of two preceding surveys

performed in 2013 and 2015. The sample is believed to be representative for smallholder rubber farmers in XSBN since the sampling strategy applied a stratified random sampling approach. Households were sampled from 42 villages of 8 townships in 3 counties. A well-structured and standardized household questionnaire has been used to collect detailed socioeconomic information regarding household demographic characteristics, allocation of land and labor into each income-generating activities as well as other income sources. At the village level, a questionnaire-based interview was conducted with village head or other village committee members which has captured a wide range of information regarding demography and labor profiles, village infrastructure and institution, crop cultivation in village level as well as some general information about village head. After data cleaning, a total of 600 households were used in the analysis.

4.3.2 Descriptive analysis

Table 4.1 shows some the descriptive statistics for household income and its composition by using the cross-section data collected in 2019. Smallholder rubber farmers have allocated their land and labor into diverse income-generating activities. Among whole samples, 326 households out of 600 have rented out land, accounting for 54.33% while 274 households do not participate in the land rental market. Household income mainly derives from farming, wage employment activities plus money getting from land rental. As the table reveals, total income of households with land rental is 6900 RMB higher than those households without it. even though the difference is not significant. Household without land transfer has a higher income of agricultural activities which is significantly different from those who have rented out land with 22647 RMB difference. In terms of off farm wage employment income, households who rented out land probably have more free labor to participate in labor market. Hence, it is plausible that those households have gained up to 6300 RMB higher off farm wage employment. Income from both farming and nonfarm employment income in the household renting out land are larger, yet it is not significant.

Furthermore, we can see that renting out land can bring more 15000 RMB income for smallholder rubber farmers. Those income differences as the table 4.1 shows correspond to our hypotheses which allow us to analyze the relationship between household land transfer, and their total income, income sub-categories.

Table 4.1 Income comparison and differences between households with and without renting out land

Income categories	HHs w/o renting out land		HHs with renting out land		Diff.
	Mean	S.D	Mean	S.D	
Income	83553.10	115239.01	90455.93	81954.28	-6902.83
Farm income	52548.68	106058.96	29900.88	49154.55	22647.8***
Wage employment income	20241.35	1861.99	26542.18	2149.66	-6300.83**
Farm wage employment income	7094.02	29015.78	10660.86	35249.35	-3566.84
Non-farm employment income	25841.61	61144.83	32663.34	74815.86	-6821.73
Renting out income	0.00	0.00	15839.58	22796.74	-15839.57***
Observations	**274**		**326**		

*** p<0.01, ** p<0.05, * p<0.1; Source: own calculations; Unit: RMB

Table 4.2 demonstrates the categories of land lessee. There are a total of 737 land plots leasing out. Majority of land plots are rented to investors and some people, i.e. relatives, friends household knows before, accounting for 59% and nearly 26%.

Table 4.2 Recipients of rented-out land

Categories	Freq.	Percent
Enterprises and large-scale investors	435	59.02
Relatives, neighbor, friends and acquaintances	191	25.92
Tenants farmers don't know before	77	10.45
Occupied by government for infrastructure construction	13	1.76
Village and Sub-Village administration	14	1.90
State farms	7	0.95
Total	**737**	**100**

Source: own calculations

As table 4.3 presents, local land rental market is fairly active, a total of 326 HHs out of interviewed 600 HHs reported to have participated in land rental market, accounting for more than half of interviewed samples (54%). The average renting out area is 8.42 mu with average renting out rate being 675.16 RMB per mu.

Table 4.3 Characteristics of renting out land

	Mean	Std. Dev.
Share of households (%)	54	50
Average area (Mu)	8.42	18.89
Average price (RMB / Mu)	675.16	774.68

Source: own calculations
Notes: 15 mu = 1 hectares.

4.4. Empirical methods

In this section, we give an overview of the methodologies applied to investigate the impacts of land rental on household income and the mediation effects of off farm wage employment on household income.

4.4.1 Impacts of land rental on household income

The first issue of interest is to estimate the impacts of land rental on household income. In order to conduct an elaborate analysis on it, we not only investigate the impacts on household total income, but also have divided household income into three categories, namely farm income, farm wage employment income and non-farm wage employment income. It is assumed that household income is the function of land rental decision, household, village and regional characteristics and income distribution can be approximated by log–normal distribution (Wan and Zhou, 2005). Hence, the formulation is specified as:

$$\ln Y_i = \alpha_0 + \alpha_1 L_i + \alpha_2 X_i + \alpha_3 V_i + \alpha_4 R_i + \epsilon_i \quad (4.4.1)$$

where, Y_i represents household income from different sources, total income, farm income, farm and non-farm wage employment income. L_i is a dichotomous variable referring to the status of land rental out in a household. X_i are the vectors of explanatory variables in household level. V_i and R_i are the variables used to control the differences in the village and regional levels. $\alpha_0, \alpha_1, \alpha_2, \alpha_3, \alpha_4$ are the coefficients to be estimated. α_1 explains the extent of the correlation between land transfer and household income. It is expected to be positive when Y_i denotes household total income and non-farm wage employment income while α_1 is assumed to be negative when Y_i is farm wage employment income. α_1 may be ambiguous when estimating farm wage employment income.

Based on the characteristics of different income categories, two models have been considered. Ordinary least squares (OLS) are used to estimate household total income and farm income. Since farm and non-farm wage employment is left-censored at 0, tobit model is more appropriate.

All the independent variables are supposed to be exogenous. However, households' participation into land rental decision may be endogenous as there may be some omitted variables and unobservable factors, such as agricultural ability and government intervention (Zhang et al.,2020). This problem arises due to database limitation or researcher's subjective preference for explanatory variables (Zuo and Hong, 2022). It has made disturbance term correlate with the explanatory variables, resulting into bias estimation results. In order to address potential endogeneity problem, an instrument variable (IV) approach is executed along with OLS and tobit model. Therefore, a two stage least square (2SLS) and and tobit with instrumental variable are constructed in this section. In the first stage regression, the variable estimating the share of households who rented out land in the village is used as an instrument which we believe it directly correlates with households' decisions to rent out land but uncorrelated with household income (Zhang et al.,2018).

Using 2SLS and tobit with IV method, we further estimate the average treatment effects on the treated (ATT) (Rosenbaum and Rubin, 1983) to capture the impacts of renting out land decision on household income by using propensity score matching which can address self-selection problem. Propensity score matching (PSM) is widely used method in estimating treatment effects by matching. It has been commonly applied in economic studies, especially in estimating the impacts of implementing some programme. (Abadie & Imbens, 2006; Pufahl & Weiss,2009; Uematsu & Mishra, 2012; Melesse & Bulte, (2015); Priscilla & Chauhan, 2019) as the equation below shows:

$$ATT_{psm} = E(\Delta|L = 1) = E[Y_1 \mid L = 1] - E[Y_0 \mid L = 1] \quad (4.4.2)$$

4.4.2 Impacts of land rental on labor market participation

As analyzed above, labors can be released from land if a household rents out own land plots. These available labors are more likely to participate in labor market in pursuit of higher wage rate. In other way, renting out land is positively correlated with labor market participation. In order to estimate the correlation relationship, we specify the estimation equation as follows.

$$W_i = \beta_0 + \beta_1 L_i + \beta_2 X_i + \beta_3 V_i + \beta_4 R_i + \varepsilon_i \quad (4.4.3)$$

Where, W_i is a binary response variable denoting whether a household with at least a household member has participated in labor market. L_i, X_i, V_i, and R_i are the same explanatory variables as those in equation 4.1. Based on the binary characteristics of W_i, probit model with instrumental variable is employed to predict the effect of endogenous land rent-out variables on wage employment decisions. In the analysis, W_i is further divided into two categories as farm and non-farm wage employment income according to the availability of data.

4.4.3 Mediation model of land rental on household income

In this section, we are interested into estimating the mediation effects of renting out land on household income through wage employment. Following Baron and Kenny (1986), a variable may be considered a mediator to the extent to which it carries the influence of a focal independent variable to a given dependent variable. In order to estimate the mediation effect, the estimation equations have specified as follows:

$$\ln Y_i = \alpha_0 + \alpha_1 L_i + \alpha_2 X_i + \alpha_3 V_i + \alpha_4 R_i + \epsilon_i \quad (4.4.4)$$

$$W_i = \beta_0 + \beta_1 L_i + \beta_2 X_i + \beta_3 V_i + \beta_4 R_i + \varepsilon_i \quad (4.4.5)$$

$$\ln Y_i = k_0 + k_1 L_i + k_5 W_i + k_2 X_i + k_3 V_i + k_4 R_i + \varphi_i \quad (4.4.6)$$

Equations (4.4.4) and (4.4.5) are the same as Equations (4.4.1) and (4.4.3). we have constructed a new equation (4.4.6) including variables referring to rent out land (L_i) and wage employment (W). k_1 represents the direct effect of renting out land on household income. k_5 denotes the direct effect (DE) of wage employment on household income. β_1 explains the impacts of land rental on wage employment. The indirect effect (IE) can be estimated by the path from L_i to W_i (β_1 in model 4.5) and the path from W_i to Y_i (k_5 model 4.6), which equals to $\beta_1 * k_5$. The summation of these two effects is total effect (TE), i.e., $k_1 + \beta_1 * k_5$ and actually equals to the estimate of the α_1 in equation 4.4. Based on Baron and Kenny (1986), mediation can be said to occur when the following requirements meet: (1) the focal independent variable significantly affects the dependent variable in the absence of the mediator, (2) the focal independent variable significantly affects the mediator, (3) the mediator has a significant unique effect on the dependent variable, and (4) the effect of the independent variable on the dependent variable shrinks upon the addition of the mediator to the model. Hence, in our analysis, α_1, β_1, k_5 should be significantly estimated and the estimate of $\alpha_1 > k_1$. Zuo and Hong (2022) also suggested that if β_1 k_5 don't all pass the significant test, but only at least one coefficient of β_1 k_5 passes test. Under these circumstances,

Sobel test is needed. If the coefficients pass the Sobel test, we can still consider that mediating effects still hold. Structural equation modeling and mediation analysis in instrumental variables regressions are used to conduct analysis.

4.4.4 Specification of model variables

As suggested by previous studies (Jin, 2020; Che, 2016), household income and income composition is not only influenced by their land rental decisions, but also subjects to a number of factors. In order to thoroughly capture all the potential factors, variables included in the analysis are derived from three categories, namely household, village and regional levels.

At the household level, control variables include household demographic characteristics and household capital characteristics. XSBN is comprised of 13 ethnic groups with different culture and traditions, thereby different livelihood strategies have been practiced. We have included three ethnicity groups to investigate whether ethnicity has significant impact on household income and income composition. Household head characteristics like gender can play a role since she/he is vital in the decision of a household member to work outside the farm (Abdulai, & Delgado, 1999; Beyene, 2008). Average age of household members is a proxy for the skill and experience. We expect that household income goes up with the household average age and then declines when reaching to some extent, like aging. Average education attainment reflects a household's managerial ability. It is anticipated that better educated household members are more willingly to participate in labor market with higher payment and, thus households with better educated members may have a higher off farm income and a lower farm income with less labor involved into farming activities. Dependent ratio tells the proportion of dependent members and the availability of labor. The higher dependent ratio, the less household income, especially nonfarm wage income. Furthermore, Rubber harvesting area can determine rubber profitability as well as labor allocation and thus has an impact on household income and income composition. and together with income from other farm and non-farm sources are likely to influence labor

allocation decisions. Land certificate is an important means to secure farmers' land property rights which can encourage farmers rent out land and reallocate more labor forces into off farm employment. We have included two variables: total farming material cost in log form and share of farming material cost to reflect investment level of farming activities. Share of farming material cost refers to the total farming material cost relative to total farm income. The higher of it may negatively correlate with household total income and off farm wage employment but positively with farm income. We assume that the truck and motor bike offer conveniences for farming and off-farm activities for farmers. Whether a household has been attacked by shocks can really influence their resources allocation into different income-generating activities and as a result, income sources are different. The households with shock attacks are assumed to be more likely to stick with farming activities.

At the village level, transport cost serves as a proxy for the distance to the township from the village where is the center of urban or peri-urban. The lower the transport cost, the higher household total income, especially higher nonfarm income. High quality two-lane paved road makes labor market more accessible. Enterprise is the proxy for available job market opportunities which is expected to be positively correlated with non-farm employment income.

Furthermore, our samples are collected from three different counties: Menghai, Jinghong and Mengla. In order to control the regional differences, three dummy county variables are also included.

Table 4.4 summarizes the differences of variables between households with and without land rental. The description of variables is presented in Appendix. Generally, more Dai ethnic households rent out their land. Average age and education of households with land rental are slightly higher than those without land rental whose dependency ratio and rubber cultivation area are higher nevertheless. It is surprising to find that share of farming material cost in the land lessor households is 30% higher than households without land rental participation. The proper

explanation is agricultural productivity ability is much lower in those households, thus they have a relatively lower farm income which lead them to leasing out land plots. The proportion of land lessor household suffered from shock is lower. Also, for them, the minimum transport cost to the center of township is 1 RMB less. Share of renting out indicating the share of household renting out land in a village is used as an instrumental variable. The control variables in all estimations keep the same.

Table 4.4 Summary of variables included in the analysis

Variables	Unit	Whole samples		HHs w/o land rental		HHs with land rental	
		Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
Household characteristics							
Ethnicity							
Han Ethnicity	(0 1)	0.05	0.21	0.05	0.21	0.05	0.21
Dai Ethnicity	(0 1)	0.58	0.49	0.45	0.50	0.69	0.46
Other ethnic minorities	(0 1)	0.37	0.48	0.50	0.50	0.26	0.44
Household female head	(0 1)	0.08	0.27	0.07	0.26	0.08	0.27
Household mean age	Years	37.59	8.52	36.80	8.33	38.25	8.63
Household mean education	Years	6.57	6.30	6.51	6.42	6.63	6.21
Dependency ratio	%	43.74	44.86	46.88	53.29	41.11	36.17
Rubber harvesting area	Mu	24.21	39.47	27.99	51.66	21.04	24.65
Land certificate	(0 1)	0.97	0.18	0.98	0.13	0.96	0.20
Total farming material cost (log)	log	7.50	2.01	7.48	2.27	7.52	1.75
Share of farming material cost	%	68.55	344.30	52.11	170.76	82.37	439.96
No. of truck	No.	0.02	0.13	0.02	0.12	0.02	0.14
No. of motor	No.	1.47	1.20	1.35	1.10	1.57	1.27
Shock	(0 1)	0.31	0.46	0.34	0.47	0.29	0.45
Village characteristics							
Transport cost	Yuan	8.22	7.05	8.96	7.56	7.60	6.54
High quality two-lane paved road	(0 1)	0.38	0.49	0.37	0.48	0.39	0.49
Enterprise	(0 1)	0.39	0.49	0.36	0.48	0.41	0.49
Regional characteristics							
Menghai	(0 1)	0.14	0.34	0.22	0.41	0.07	0.26
Jinghong	(0 1)	0.46	0.50	0.34	0.47	0.56	0.50
Mengla	(0 1)	0.41	0.49	0.45	0.50	0.37	0.49
Instrument variable							
Share of Rent out	%	52.62	30.40	32.71	25.11	69.35	23.63

Source: own calculations

4.5. Estimation results

In this section, we present the estimation results of the three modes illustrated in section 4.4. First, the impacts of land rental on total household income and income sub-categories are shown in detail in section 4.5.1. Different models, OLS with IV and tobit with IV, have investigated the factors correlated with income, including renting outland as a focal factor as well as other factors. Second, IV-probit is employed to estimate the correlation between land rent out and off farm wage employment in section 4.5.2. Last, in section 4.5.3, we demonstrate the mediation analysis results which has proved there is a mediation impacts of land rental on household income through wage employment participation.

4.5.1 The impacts of land rental on household income

Table 4.5 shows the results from 2SLS regressions estimating the effect of renting out land on total income and farming income. The fifth and sixth columns in the table shows the results from the first step establishing the relationship between instrument and renting out decisions. Variables like average age and whether land certificate has been issued to at least a land plot in a household, are positively with land rental participation while rubber harvesting area can hinder farmers to rent out land. It also shows that a significant correlation between renting out decision and chose instrument variable, which is a prerequisite for the adequacy of instruments (Ahmed & Waibel, 2019). Columns 1 to 4 show the results from the second step of the least squares estimation. The impact of household leasing land out on household total income remains positive and statistically significant. While the effect of it on farm income is significantly negative. Specifically, total household income will increase by 64% in a household has rented out their land. This is also the estimates of land rental on household income without the inclusion of mediation variables. Contrarily, farm income will decline by 87%. Therefore, our first hypothesis has been proved, that is, renting out land can increase household total income and reduce farm income. In addition to the focal dependent variable of renting out land, we have controlled other variables. We find that total income differs among ethnicities. Compared with Han ethnic group, total income of Dai ethnicity is fewer. Rubber harvesting area plays a statistically positive role in household total income and farm income as rubber

cultivation still an important farm income source for smallholder rubber farmers in XSBN. An increase in farming material cost by 10% can lead to an increase in household income and farm income by 0.7% and 4.3 %. However, the higher of the share of farming material cost leads to the decline farm income. Motors offer conveniences for farmers with a statistically significant contribution to household income and farm income. Farmers in Jinghong where local government locates, are more likely to have lower farm income.

Table 4.5 Results of 2SLS regressions to estimate the effect of land rental on total income and farm income

	(1)		(2)	(3)		(4)	(5)		(6)
	Total income (2nd)			Farm Income (2nd)			Rent out (1st)		
Variables	Coef.		S.E.	Coef.		S.E.	Coef.		S.E.
1 if HHs has rented out land	0.642	***	0.186	-0.876	**	0.372			
Dai Ethnicity	-0.420	**	0.173	-0.082		0.532	0.040		0.082
Other ethnic minorities	-0.170		0.195	0.421		0.541	0.065		0.085
Household female head	0.084		0.172	-0.389		0.434	-0.010		0.062
Household mean age	-0.014		0.010	-0.009		0.014	0.003	**	0.002
Household mean education	0.001		0.007	-0.022		0.014	0.004		0.003
Dependency ratio	-0.001		0.001	0.003		0.002	-0.0004		0.0004
Rubber harvesting area	0.003	***	0.001	0.009	**	0.004	-0.001	***	0.0004
Land certificate	0.533		0.555	0.037		0.678	0.089	***	0.100
Total farming material cost (log)	0.074	**	0.035	0.429	***	0.077	0.010		0.009
Share of farming material cost	-0.021		0.020	-0.122	***	0.042	0.004		0.005
No. of truck	0.302		0.280	0.715		0.514	0.131		0.132
No. of motor	0.166	***	0.038	0.133	**	0.065	0.020		0.014
Shock	-0.187	*	0.097	-0.185		0.199	-0.009		0.036
Transport Cost	0.012		0.008	0.010		0.016	0.0003		0.003
High quality two-lane paved road	0.003		0.098	0.220		0.218	0.008		0.035
Enterprise	-0.175	*	0.091	-0.351		0.218	0.003		0.036
Menghai	-0.067		0.171	-0.482		0.372	-0.015		0.055
Jinghong	-0.111		0.097	-0.486	**	0.209	-0.024		0.039
Mengla					(omitted)				
Instrument variables									
Share of renting out land							1.01	***	0.067
Constant	10.095	***	0.676	6.660	***	1.268	-0.328		0.183
Robust score chi2(1)							3.07	*	
Robust regression F(1,579)							3.05	*	
F(19, 580)							37.50	***	

Weak identification test				
Robust F(1,580)			265.9	***
Minimum eigenvalue statistic			214.39	
Shea's partial R2			0.2699	
Under identification test				
Kleibergen-Paap rk LM statistic			135.72	***
Observations	**600**	**600**		**600**

*** p<0.01, ** p<0.05, * p<0.1; Source: own calculations

Table 4.6 shows the results from tobit regressions investigating the impact of land lessor households' land rental decisions on farm (column 1 and 2) and non-farm wage employment income (column 3 and 4). The results show that renting out land is positively correlated with income from non-farm wage employment at 1% level. A positive but insignificant correlation between land rental and farm wage employment income is found. The findings here can support our second hypothesis. In addition, dependent ratio is negatively correlated with farm and non-farm wage employment income, since the more dependent people in a household, the less availability of labors in a household. Land certificate is significantly and positively correlated with non-farm wage income in a household. Min et al., (2017) suggested that the availability of a land certificate was a significant factor in facilitating participation in the land market in XSBN. The more land plots are rented out, the more labor is released and thereby, non-farm wage income will increase as a result of land and labor reallocation. Households resides in Menghai more likely to have higher farm income while households located in Jinghong and Menghai has a higher possibility to earn higher non-farm compared with those lives in Mengla.

Furthermore, endogeneity test shows that there exits an endogeneity problem at 5% significance level based upon robust score chi^2 and robust regression F statistic in table 4.6. The instrumental variable used in the analysis has passed weak and under identification tests as the indicators show in the table 4.6, indicating that "Share of renting out in a village" as instrument variable is efficient.

Table 4. 6 IV-Tobit regressions estimating the effects of land rental on farm and non-farm wage employment income

Variables	(1) On-farm employment income		(2)	(3) Nonfarm employment income		(4)
	Coef.		S.E.	Coef.		S.E.
1 if HHs has rented out land	**5.924**		**4.278**	**4.626**	**	**2.240**
Dai Ethnicity	-0.756		4.967	-2.921		2.561
Other ethnic minorities	-5.067		5.311	-0.829		2.636
Household female head	4.519		3.562	-1.030		2.039
Household mean age	-0.150		0.138	-0.070		0.070
Household mean education	0.164		0.166	0.075		0.088
Dependency ratio	-0.033	**	0.028	-0.055	***	0.013
Rubber harvesting area	0.025		0.029	-0.003		0.014
Land certificate	2.278		6.151	8.388	**	3.614
Total farming material cost (log)	-0.336		0.544	0.100		0.288
Share of farming material cost	0.193		0.245	-0.008		0.148
No. of trucks	-0.716		8.263	4.734		4.140
No. of motors	1.584	*	0.836	0.492		0.460
Shock	0.024		2.278	-0.542		1.201
Transport Cost	0.113		0.163	-0.163	*	0.084
High quality two-lane paved road	-0.728		2.239	0.321		1.148
Enterprise	-2.914		2.292	1.264		1.184
Menghai	6.780	*	3.558	2.266		1.828
Jinghong	5.596	**	2.538	2.629	**	1.254
Mengla		(omitted)			(omitted)	
Constant	-18.343		11.522	-8.178		6.069
lnsig_1	2.799	***	0.094	2.409	***	0.056
lnsig_2	-0.932	***	0.029	-0.932	***	0.029
LR chi2(38) =	306.87			335.96		
Prob > chi2	0.00			0.00		
Observations		**600**			**600**	

*** p<0.01, ** p<0.05, * p<0.1; Source: own calculations

Table 4.7 shows average treatment effects on the treated (ATT) of renting out land on household income and off-farm employment. The ATT is estimated by using propensity score matching approach. The treatment effects are significant showing that the estimated total household income of households who has rented out land (ATT) is significantly higher by approximately 50%. On the contrary, the treatment effect of estimated farm income of land lessor households is significantly lower by 50-65%. These can further prove we can accept the first hypothesis. The ATT of farm and off farm wage employment incomes for households who rented out land is around 60% but it is not significant. When we apply different matching numbers, the effects are slightly different in total quantity.

Table 4.7 Average treatment effects of land rental on household income (ATT) using PSM

Income categories (log)	Number of matching	Coef.		R.S.E
Income	1	0.59	***	0.14
	2	0.44	***	0.11
	3	0.58	***	0.11
Farm income	1	-0.57	***	0.21
	2	-0.65	***	0.19
	3	-0.49	***	0.18
On-farm employment income	1	0.50		0.47
	2	0.62		0.41
	3	0.62		0.39
Non-farm employment income	1	1.09		0.67
	2	0.64		0.62
	3	0.84		0.63

*** p<0.01, ** p<0.05, * p<0.1; Source: own calculations

4.5.2 The impacts of land rental on wage employment participation

Table 4.8 presents the estimation results of the impact of land rental on wage employment (column 1 and 2) and non-farm wage employment (column 3 and 4) participation by using probit model with an instrumental variable. Wage employment refers to the activities being employed by others, including both on- and nonfarm employments. The results of two estimations are fairly constant. Land rental is significantly correlated with wage employment participation at 5% significance level and non-farm wage employment at 10% level, implying that labor forces released from land after renting out land are more likely to join labor market to pursue wage income. Regarding other control variables, households with

higher dependency ratio and transport cost to the center of township are less likely to participate in labor market. Land certificate and living in Jinghong are influential factors which are significantly correlated with labor market participation. In addition, average household age and No. of motors increase the possibility to be involved in labor market. The analysis in this section correspond to our third hypothesis which we cannot reject based on our estimation results.

Table 4.8 Results of IV-probit regressions estimating the effect of land rental on wage employment participation

Variables	(1) Wage employment		(2)	(3) Nonfarm wage employment		(4)
	Coef.		S.E.	Coef.		S.E.
1 if HHs has rented out land	**0.359**	*	**0.222**	**0.446**	**	**0.227**
Dai Ethnicity	-0.208		0.270	-0.312		0.268
Other ethnic minorities	-0.127		0.279	-0.100		0.277
Household female head	0.070		0.204	-0.101		0.208
Household mean age	-0.009		0.007	-0.007		0.007
Household mean education	0.016	*	0.009	0.006		0.009
Dependency ratio	-0.005	***	0.001	-0.005	***	0.001
Rubber harvesting area	0.000		0.001	-0.000		0.001
Land certificate	0.683	**	0.333	0.785	**	0.357
Total farming material cost (log)	0.015		0.028	0.010		0.029
Share of farming material cost	-0.002		0.020	0.004		0.020
No. of trucks	0.738		0.505	0.640		0.467
No. of motors	0.092	**	0.046	0.053		0.047
Shock	-0.087		0.120	-0.055		0.122
Transport Cost	-0.014	*	0.008	-0.017	*	0.008
High quality two-lane paved road	0.004		0.115	0.045		0.117
Enterprise	0.085		0.120	0.135		0.121
Menghai	0.317	*	0.182	0.241		0.186
Jinghong	0.327	***	0.126	0.254	**	0.127
Mengla	-		-	-		-
Constant	-0.627		0.596	-0.861		0.611
Wald chi2(19)	57.05			49.3		
Prob > chi2	0.00			0.00		
Observations	600			600		

*** p<0.01, ** p<0.05, * p<0.1; Source: own calculations

4.5.3 Mediation results analysis land rental' impact path on household income

Table 4.9 shows the estimation results of factors affecting household income with mediation variable, that is, whether there is at least a household member involved in labor market. In this section, we still use the same instrumental variable to correct for the potential endogeneity problem. After doing a mediation

analysis, we can see that focal variable referring to land rental out is significantly correlated with household income and mediator variable of wage employment participation is also significantly correlated. The only difference is the impact from focal variable decreases by 20% as compared with the impacts in Table 4.9, indicating the impact of renting out land on household income has shrunk after taking mediator into consideration. This satisfies one of the requirements of mediation analysis outlined in theoretical section. It is noticed that there is a slight change in the significance of some variables-average household age, total farming material cost, transport cost. A plausible explanation is that there may exist a multicollinearity problem after controlling for mediator (Zhang et al.,2020). However, we have used VIF to test potential multicollinearity, and found no obvious multicollinearity problem. The test results are put in the appendix. We therefore mainly report the estimation results of other control variables without mediation variables as section 4.5.1 shows.

Table 4.9 Estimation results of mediation analysis

Variables	(1) Income(log)		(2)
	Coef.		S.E.
1 if HHs has rented out land	**0.435**	***	**0.089**
1 if HHs participated in labor market	**0.946**	***	**0.086**
Dai Ethnicity	-0.342		0.208
Other ethnic minorities	-0.143		0.216
Household female head	0.056		0.157
Household mean age	-0.011	**	0.005
Household mean education	-0.004		0.007
Dependency ratio	0.001		0.001
Rubber harvesting area	0.003	***	0.001
Land certificate	0.272		0.249
Total farming material cost (log)	0.067	***	0.022
Share of farming material cost	-0.019		0.013
No. of truck	0.086		0.336
No. of motor	0.136	***	0.035
Shock	-0.160	*	0.092
Transport Cost	0.017	***	0.006
High quality two-lane paved road	-0.001		0.089
Enterprise	-0.208	**	0.093
Menghai	-0.201		0.136
Jinghong	-0.222	**	0.097

Mengla			
Constant	9.918	***	0.442
Observations	600		

*** p<0.01, ** p<0.05, * p<0.1; Source: own calculations

Table 4.10 shows the decomposition of the effects of renting out land on household income. The decomposition impact is comprised of total effect (TE), direct effect (DE), and indirect effect (IE). The total effect of renting out land on household total income is 0.642, indicating that household income increased by 64% after renting out their land. The direct effect is significantly positive, implying that renting out land can directly improve household income by 37% through land reallocation. And indirect effect is the mediation path which shows land rental can improve household income by 27% mainly through labor reallocation into labor market even though it is not significant. The mediator has explained 42.17% of the total effect. Even though four requirements of mediation analysis are met in our analysis, we still did a Sobel test, and the results keeps constant.

Table 4.10 Decomposition of effects of land rental on household income (IV-median analysis)

	Income (log)		
Decomposition	Coef.		S.E.
Total effect	0.642	***	0.188
Direct effect	0.371	***	0.162
Indirect effect	0.271		0.336

*** p<0.01, ** p<0.05, * p<0.1; Source: own calculations

4.6. Conclusions

Land rental markets play an important role in understanding rural economic development in China. This paper has extended the literature by investigating the role of renting out land for household income and household income composition. We also investigate off farm employment income, and correlation between land transfer and off farm wage employment participation and finally decompose the impacts of renting out land on household income. The study has used cross section survey data of smallholder rubber farmers collected in 2019 in XSBN. In our analysis we use an ordinary least squares and tobit model with

instrumental variable along with the PSM method. A probit model with instrumental variable is employed to investigate the correlation between land rental and labor market participation. Lastly, we used mediation analysis to explore the underlying impact mechanism of renting out land on household income. Off farm employment decision acts as a mediation variable, while the effects of renting out land are further divided into three aspects, namely total effect (TE), direct effect (DE) and indirect effect (IE).

The main findings can be concluded from our analysis as follows. First, renting out land can significantly increase household total income and non-farm wage income but is negatively correlated with farm income. The average treatment on the treated shows that the total income in households with renting out lands significantly is higher by approximately 50% while farm income is less approximately than 50% - 65% based on the different matching numbers. Second, Probit regression shows that land lessor household's land rental decision is significantly correlated with wage employment participation at 5% significance level and non-farm wage employment at 10% level, implying that labor forces released from land after renting out land are more likely to join labor market to pursue higher wage rate. Last, our mediation analysis has proved that the total land rental impact on household income is 64%. Direct effect accounts for 37% and indirect effect is 27%, implying that a mediation path exists through labor market participation.

We can draw some policy implications based upon the analysis results. First, land titling and land tenure certificates should be continued to be issue in XSBN to facilitate rural transformation. Second, the advancement of the land rental market is also necessary as it helps to reduce transaction cost and promote land transfers to improve productivity in agriculture. Third, renting out land has released labor thus offering the possibility to join labor market, and hereby increase household income. Therefore, it is also necessary to promote the development of labor market in XSBN. Especially considering the Covid-19 pandemic, and in view of the ongoing Zero Covid-19 policy in China, rebuilding and advancing local labor market is an important issue.

References

Abadie, A., & Imbens, G. W. (2006). Large sample properties of matching estimators for average treatment effects. *econometrica*, 74(1), 235-267.

Ahmed, B. N., & Waibel, H. (2019). The role of homestead fish ponds for household nutrition security in Bangladesh. *Food Security*, *11*(4), 835-854.

Beyene, A. D. (2008). Determinants of off-farm participation decision of farm households in Ethiopia. *Agrekon*, *47*(1), 140-161.

Behrman, J. R., & Wolfe, B. L. (1984). Labor force participation and earnings determinants for women in the special conditions of developing countries. *Journal of Development Economics*, 15(1-3), 259-288.

Baron, R. M., & Kenny, D. A. (1986). The moderator–mediator variable distinction in social psychological research: Conceptual, strategic, and statistical considerations. *Journal of personality and social psychology*, 51(6), 1173.

Chang, H., Ai, P., & Li, Y. (2018). Land tenure policy and off-farm employment in rural China. *IZA Journal of Development and Migration*, 8(1), 1-28.

Che, Y. (2016). Off-farm employments and land rental behavior: evidence from rural China. *China Agricultural Economic Review*, 8(1), 37-54.

Cheng, W., Xu, Y., Zhou, N., He, Z., & Zhang, L. (2019). How did land titling affect China's rural land rental market? Size, composition and efficiency. *Land Use Policy*, 82, 609-619.

Deininger, K., & Feder, G. (2001). Land institutions and land markets. *Handbook of agricultural economics*, 1, 287-331.

Deininger, K. (2003a). Land markets in developing and transition economies: Impact of liberalization and implications for future reform. *American Journal of Agricultural Economics*, 85(5), 1217-1222.

Deininger, K. W. (2003b). *Land policies for growth and poverty reduction*. World Bank Publications.

Deininger, K., & Jin, S. (2005). The potential of land rental markets in the process of economic development: Evidence from China. *Journal of Development Economics*, 78(1), 241-270.

Deininger, K., Jin, S., Xia, F., & Huang, J. (2014). Moving off the farm: land institutions to facilitate structural transformation and agricultural productivity growth in China. W*orld Development*, 59, 505-520.

Editing Committee of China Agriculture Yearbook. (2010–2016). *China agriculture yearbooks 2010–2016*. Beijing, China: China Agriculture Press.

Feng, S. (2006). *Land rental market and off-farm employment: rural households in Jiangxi Province, PR China*. Wageningen University and Research.

Feng, S., & Heerink, N. (2008). Are farm households' land renting and migration decisions inter-related in rural China? *NJAS-Wageningen Journal of Life Sciences*, 55(4), 345-362.

Feng, S., Heerink, N., Ruben, R., & Qu, F. (2010). Land rental market, off-farm employment and agricultural production in Southeast China: A plot-level case study. *China Economic Review*, 21(4), 598-606.

Fu, Y., Brookfield, H., Guo, H., Chen, J., Chen, A., & Cui, J. (2009). Smallholder rubber plantation expansion and its impact on local livelihoods, land use and agrobiodiversity, a case study from Daka, Xishuangbanna, southwestern China. *International Journal of Sustainable Development & World Ecology*, 16(1), 22-29.

Hong, W., Luo, B., & Hu, X. (2020). Land titling, land reallocation experience, and investment incentives: evidence from rural China. *Land Use Policy*, 90, 104271

Jin, S., & Deininger, K. (2009). Land rental markets in the process of rural structural transformation: Productivity and equity impacts from China. *Journal of Comparative Economics*, 37(4), 629-646.

Jin, S., Huang, J., & Waibel, H. (2020). Location and economic resilience in rubber farming communities in southwest China. *China Agricultural Economic Review*.

Kung, J. K. S. (2002). Off-farm labor markets and the emergence of land rental markets in rural China. *Journal of Comparative Economics*, 30(2), 395-414

Melesse, M. B., & Bulte, E. (2015). Does land registration and certification boost farm productivity? Evidence from Ethiopia. *Agricultural Economics*, 46(6), 757-768.

Min, S., Waibel, H., & Huang, J. (2017). Smallholder participation in the land rental market in a mountainous region of Southern China: Impact of population aging, land tenure security and ethnicity. *Land Use Policy*, 68, 625-637.

Peng, K., Yang, C., & Chen, Y. (2020). Land transfer in rural China: incentives, influencing factors and income effects. *Applied Economics*, 52(50), 5477-5490.

Pufahl, A., & Weiss, C. R. (2009). Evaluating the effects of farm programmes: results from propensity score matching. *European Review of Agricultural Economics*, 36(1), 79-101.

Priscilla, L., & Chauhan, A. K. (2019). Economic impact of cooperative membership on dairy farmers in Manipur: a propensity score matching approach. *Agricultural Economics Research Review*, 32(347-2019-3221), 117-123.

Rosenbaum, P. R., & Rubin, D. B. (1983). The central role of the propensity score in observational studies for causal effects. *Biometrika*, 70(1), 41-55.

Su, W., Eriksson, T., & Zhang, L. (2018). Off-farm employment, land renting and concentration of farmland in the process of urbanization: Chinese evidence. *China Agricultural Economic Review*, 10(2), 338-350.

Uematsu, H., & Mishra, A. K. (2012). Organic farmers or conventional farmers: Where's the money? *Ecological Economics*, 55–62.

Wan, G., & Zhou, Z. (2005). Income inequality in rural China: Regression-based decomposition using household data. *Review of development economics*, 9(1), 107-120.

Xu, Y., Huang, X., Bao, H. X., Ju, X., Zhong, T., Chen, Z., & Zhou, Y. (2018). Rural land rights reform and agro-environmental sustainability: Empirical evidence from China. *Land use policy*, 74, 73-87.

Xu, J., Grumbine, R. E., & Beckschäfer, P. (2014). Landscape transformation through the use of ecological and socioeconomic indicators in Xishuangbanna, Southwest China, Mekong Region. *Ecological Indicators*, 36, 749-756.

Yao, Y. (2000). The development of the land lease market in rural China. *Land Economics*, 252-266.

Yan, X., & Huo, X. (2016). Drivers of household entry and intensity in land rental market in rural China: Evidence from North Henan Province. *China Agricultural Economic Review.*

Ye, J. (2015). Land Transfer and the Pursuit of Agricultural Modernization in China. *Journal of agrarian change,* 15(3), 314-337.

Yin, R., Yao, S., & Huo, X. (2013). China's forest tenure reform and institutional change in the new century: What has been implemented and what remains to be pursued? *Land Use Policy*, 30(1), 825-833

Zuo, X., & Hong, Z. (2022). The Impact of Digital Technology on Land Rent-Out Behavior: Information Sharing or Exclusion? *Agriculture*, 12(7), 1046.

Zhang, L., Feng, S., Heerink, N., Qu, F., & Kuyvenhoven, A. (2018). How do land rental markets affect household income? Evidence from rural Jiangsu, PR China. *Land Use Policy*, 74, 151-165.

Zhang, J., Mishra, A. K., Zhu, P., & Li, X. (2020). Land rental market and agricultural labor productivity in rural China: A mediation analysis. *World Development*, 135, 105089.

Zhang, J., Mishra, A. K., & Zhu, P. (2021). Land rental markets and labor productivity: Evidence from rural China. *Canadian Journal of Agricultural Economics*, 69(1), 93-115.

Appendix

Table 4A.1 The descriptions of variables included in the analysis

Variables	Descriptions
Household characteristics	
Ethnicity	
Han Ethnicity	Han ethnic group(1=yes, 0 otherwise)
Dai Ethnicity	Dai ethnic group(1=yes, 0 otherwise)
Other ethnic minorities	Other ethnic groups, other than Dai and Han(1=yes, 0 otherwise)
Household female head	If HH head is female (1=yes, 0 otherwise)
Household mean age	Average age of HH members
Household mean education	Average highest education attainment
Dependency ratio	The No. of dependents relative to No. of laborers in a HH
Rubber harvesting area	Rubber harvesting area
Land certificate	If land certificate is issued in a HH (1=yes, 0 otherwise)
Total farming material cost (log)	Total material input in farming; in log form
Share of farming material cost	Share of farming material cost relative total farming income
No. of truck	Number of trucks a household owns
No. of motor	Number of motors a household owns
Shock	If a HH has suffered from any shock (1=yes, 0 otherwise)
Village characteristics	
Transport cost	Minimum cost of a one-way trip to the center of township
High quality two-lane paved road	If has high quality two-lane road (1=yes, 0 otherwise)
Enterprise	If there is an enterprise in the village (1=yes, 0 otherwise)
Regional characteristics	
Menghai	Menghai county (1=yes, 0 otherwise)
Jinghong	Jinghong county (1=yes, 0 otherwise)
Mengla	Menghai county (1=yes, 0 otherwise)
Instrument variable	
Share of Rent out	Share of HHs renting out land in a village

Source: own compilation

Table 4A.2 Multicollinearity test

Variable	VIF	1/VIF
Other ethnic minorities	6.51	0.15
Dai Ethnicity	6.31	0.16
Jinghong	1.39	0.72
Menghai	1.30	0.77
Enterprise	1.22	0.82
Transport cost	1.21	0.83
if HHs has rented out land	1.17	0.85
Total farming material cost	1.16	0.86
Land certificate	1.14	0.88
Rubber harvesting area	1.14	0.88
Share of farming material cost	1.14	0.88
High quality two-lane paved road	1.11	0.90
Household mean education	1.11	0.90
if HHs participated in labor market	1.11	0.90
Household mean age	1.11	0.90
No. of trucks	1.11	0.90
Dependency ratio	1.07	0.93
Shock	1.07	0.93
No. of motors	1.07	0.93
Household female head	1.05	0.95
Mean VIF	**1.68**	

Source: own calculations