

Studying Socio-Economic Problems in the Mekong Delta, Vietnam: An Agent-based Modelling Approach



THE UNIVERSITY OF
NEWCASTLE
AUSTRALIA

Khanh Hung Nguyen

School of Electrical Engineering and Computing
The University of Newcastle

This dissertation is submitted for the degree of
Doctor of Philosophy

May 2020

*To my parents, Nguyen Quan and Lan Phuong,
my sister, Khanh Huyen,
my wife, Ngoc Bich, and my son, Hung Son*

Statement of Originality

I hereby certify that the work embodied in the thesis is my own work, conducted under normal supervision.

The thesis contains no material which has been accepted, or is being examined, for the award of any other degree or diploma in any university or other tertiary institution and, to the best of my knowledge and belief, contains no material previously published or written by another person, except where due reference has been made. I give consent to the final version of my thesis being made available worldwide when deposited in the University's Digital Repository, subject to the provisions of the Copyright Act 1968.

Khanh Hung Nguyen

Acknowledgement of Authorship

I hereby certify that the work embodied in this thesis contains published papers/scholarly work of which I am a joint author. I have included as part of the thesis a written declaration endorsed in writing by my supervisor, attesting to my contributions to the joint publications/scholarly work.

Khanh Hung Nguyen

By signing below I confirm that Khanh Hung Nguyen made major contributions in conducting the literature review, designing and developing the models and writing all papers that are listed in Section 1.6.

Dr Raymond Chiong

Acknowledgements

Foremost, I would like to express my sincere appreciation to my supervisors, Dr Raymond Chiong and Professor Richard Middleton, for their continuous support of my PhD research, for their patience, motivation, enthusiasm and immense knowledge. My sincere thank also goes to my collaborator, Dr Manuel Chica, for his helpful advice during my PhD study. I could not imagine having better advisors for my PhD study. Their guidance has helped me in all aspects of my research, as well as in my personal life, which eventually helps me to become a better person.

I am indebted to the University of Newcastle for all the opportunities that have been available to me as a research higher-degree student. My PhD project was funded by the Australian Research Council (ARC Grant ID: IC140100032). I, therefore, appreciate the support from the ARC Training Centre for Food and Beverage Supply Chain Optimisation. I thank my fellow labmates in the ARC Training Centre, the Mathematics Building and the ICT Building for stimulating discussions, for the sleepless nights we were working together before deadlines, and for all the fun we have had in the last four years.

I would especially like to thank my parents, Nguyen Quan and Lan Phuong, and my lovely sister, Khanh Huyen, for all of the sacrifices that they have made on my behalf. I owe a lot to them since they encouraged and helped me at every stage of my life. I am forever indebted to my parents for giving me the opportunities and experiences to explore new directions in life and seek my own destiny. This journey would not have been possible if not for them.

Finally, I would like to express my appreciation to my beloved wife, Ngoc Bich. Words cannot express how grateful I am to her. She has supported me in every possible way to see

the completion of this work. The time we have lived together and raised my son, Hung Son, in Newcastle has been one of the best times of my life. We have been striving through ups and downs in every corner of life as a family, learning to become better parents, husband and wife. I dedicate this milestone to them.

Abstract

The Mekong Delta (MKD), located in the far south of Vietnam, is known as the ‘Rice Bowl of Vietnam’. The region accounts for half of the country’s total rice production and 95% of its rice exports. Despite its increasing standard of living, the MKD has lagged behind the national average in terms of many socio-economic development indicators, such as employment, education, health care, and housing welfare. In this research, we address two pressing problems influencing the socio-economic progress of the region: (i) the failure of implementing the agricultural contract-farming scheme in the MKD rice supply chain, and (ii) the high out-migration rate from the MKD to the South East (SE) region.

We use agent-based modelling (ABM), which is a computational approach that focuses on a population of autonomous and interacting agents. ABM has the unique power of modelling individual decision making while also incorporating heterogeneity, social interaction/feedback and the dynamic impacts of different external factors. We present two agent-based models to tackle the above-mentioned socio-economic problems in the MKD region. Simulation results from the two agent-based models are then validated, providing further scenario-based insights into the related problems.

For the first problem, we investigate obstacles to the expansion of contract rice farming in the MKD region. We develop an agent-based contract-farming model and focus on two critical components of the contractual relationship: financial incentives and trust. The agent-based model is then used to predict emergent system-wide behaviour and compare different counterfactual scenarios of different policies and initiatives on maintaining contract rice farming. The results of this model showed that a fully equipped contractor who opportunistically exploited only a relatively small proportion of the contracted farmers in most instances could

outperform spot-market-based contractors in terms of achieved average profit. In addition, a committed contractor who offered lower purchasing prices than the typical rate could obtain better earnings per ton of rice and a higher profit per crop. However, in both of those cases, the contractors could not enlarge their contract-farming scheme, as either the farmers' trust towards them gradually decreased or their offers could not compete with those of a competitor or the spot market. Another important observation was that the contract-farming scheme is not a cost-effective method for buyers with limited rice-processing capacity, which is a common situation among the contractors in the MKD region. The model also identified the ranges of contracted purchasing prices for two rice types, in which both parties – the contractor and farmer – might find it beneficial to remain committed to contract rice farming.

For the second problem, the aim is to understand the dynamics of migrants' decision-making processes in the MKD region and explain why the MKD is the main migration-sending region in the country, with the highest out-migration rate and the highest deficit of net migration. We incorporate the Theory of Planned Behaviour into the agent-based model to break down migration intention into three related components: behavioural attitude, social network and perceived behaviour control. Different economic, social and environmental circumstances are considered to model the way an individual makes migration decisions. Outputs of the model are automatically calibrated via real province-level data using a genetic algorithm. This automated calibration yields some significant results, with most observed net- and out-migration data captured within the 95% confidence interval. Parameter exploration and sensitivity analysis are carried out to understand the impact of critical migration determinants. We further explore the migration behaviour of people in certain demographic groups and delineate the migration flows across cities and provinces from the MKD to the SE region.

Contents

List of Figures	xvii
List of Tables	xix
1 Introduction	1
1.1 Background	1
1.2 Problem Statement	4
1.3 Research Objectives	7
1.4 Research Methodology	10
1.4.1 Agent-based Modelling	10
1.4.2 Desk Research and Expert Interview	13
1.5 Thesis Outline	15
1.6 Research Contributions and Publications	17
I Contract Rice Farming	23
2 Contract Rice Farming in the Mekong Delta	25
2.1 Agricultural Supply Chain and Contract Farming	25
2.1.1 Agricultural Supply Chain	25
2.1.2 Contract Farming	30
2.2 Rice Supply Chain and Spot Market in the Mekong Delta	38
2.2.1 Traditional Rice Supply Chain	38

2.2.2	Spot Market	42
2.3	Contract Rice Farming in the Mekong Delta	43
2.3.1	‘Linking Together the Four Houses’ Model	44
2.3.2	‘Large-scale Paddy Field’ Model	46
2.3.3	Problems of Contract Rice Farming	49
3	Agent-based Modelling of Contract Rice Farming in the Mekong Delta	51
3.1	Agent-based Modelling of Agricultural Supply Chain and Contract Farming	51
3.1.1	Agricultural Supply Chain	51
3.1.2	Contract Farming	55
3.2	Agent-based Model of Contract Farming	57
3.2.1	The Process of Contract Farming	57
3.2.2	Decision Making Rules	59
3.3	Case Study of Contract Rice Farming in the Mekong Delta	66
3.3.1	Farmer Agent	66
3.3.2	Contractor Agent	68
3.4	Experimental Set-up	70
3.5	Experimental Results and Discussion	75
3.5.1	Evolution of Contract Farming Performance	75
3.5.2	Viability of the Contract Farming Scheme	78
II	Inter-Provincial Migration	87
4	Dynamics of Inter-provincial Migration Flows	89
4.1	Migration in Vietnam and the Mekong Delta	89
4.1.1	Overview of Internal Migration in Vietnam and the Mekong Delta .	89
4.1.2	Differentials in Regional Migration	94

4.1.3	Dynamics of Inter-provincial Migration	98
4.2	Determinants of Migration	100
5	Theoretical Models and Modelling Frameworks	109
5.1	Agent-based Modelling of Migration	109
5.2	Theory of Planned Behaviour	112
5.3	Purely Empirical Rules	119
6	Agent-based Modelling of Inter-provincial Migration in the Mekong Delta	123
6.1	Agent-based Model of Inter-provincial Migration	123
6.1.1	Assessment of migration intention	125
6.1.2	Development of final migration behaviour	129
6.2	Case Study of Inter-provincial Migration in the Mekong Delta	130
6.3	Experimental Set-up	134
6.3.1	Initialisation	134
6.3.2	Genetic Algorithm of Calibration	136
6.4	Experimental Results	139
6.4.1	Model Calibration Results	139
6.4.2	Parameter Exploration	143
6.4.3	Sensitivity Analysis	149
6.4.4	Further Analysis of the Results	153
7	Conclusion	159
7.1	Concluding Remarks for Part I (Contract Rice Farming)	160
7.2	Concluding Remarks for Part II (Inter-Provincial Migration)	164
	Bibliography	169

List of Figures

2.1	The Agricultural Supply Chain (adapted from Tsolakis et al. 2014)	27
2.2	A traditional rice supply chain in the MKD region	41
2.3	The contract rice-farming model in the MKD region	47
3.1	Contract rice farming in the MKD region	57
3.2	Trust increases when agents have trustworthy behaviour	60
3.3	Simulated geographic region of the contract rice-farming model	71
3.4	Monthly spot-market prices of dry ordinary paddy from 2009 to 2017	73
3.5	Time-series evolution of contract farming performance with both rice varieties	76
3.6	Comparison between fully equipped contractors and spot-market-based buyers	79
3.7	Comparison between non-equipped contractors and spot-market-based buyers	82
3.8	Scenarios for contractors related to the availability of processing capacity .	84
3.9	Scenarios for four contractors with different commitment behaviours	86
4.1	A regional map of Vietnam. Source: GSO Vietnam 2018a	91
4.2	Differential of migration patterns among regions in Vietnam in the 13-year period between 2005 and 2017	95
4.3	Number of regional migrants in five-year period from 2004 to 2009	96
4.4	Number of regional migrants in the five-year period from 2009 to 2014 . . .	97
4.5	Differentials of migration among the provinces in Vietnam in the 13 years period from 2005 to 2017	99

5.1	Presentation of the TPB in the migration decision-making process (adapted from Fishbein and Ajzen 2011, Willekens 2017)	113
6.1	Individual cognition of the migration decision-making process	124
6.2	Locations and geographical boundaries of cities and provinces in the MKD and SE region	131
6.3	Q-Q Plots of the in-migration, out-migration, and net migration flow rates of several provinces in the MKD region	141
6.4	Comparison of simulated results and actual data of the average net-, out-, and in-migration rates of provinces in the MKD region from 2005 to 2017 .	143
6.5	Boxplots showing the values of α^1 , α^2 and α^3 from the best GA calibration solutions	144
6.6	Boxplots showing the values of β^1 , β^2 , β^3 and β^4 from the best GA calibration solutions and the weighted values of relevant parameters	145
6.7	Boxplots showing the values of γ , δ^1 , δ^2 and δ^3 from the best GA calibration solutions	147
6.8	Boxplots showing the values of θ^2 , θ^3 , θ^4 and θ^5 from the best GA calibration solutions and the weighted values of relevant parameters	148
6.9	Heatmap indicating the sensitivity analysis on three parameters α^1 , α^2 , α^3 .	149
6.10	Boxplots showing the values of different groups of parameters obtained from the worst GA calibration solutions	152
6.11	Percentage of total number of migrants from the MKD region by income quintiles	153
6.12	Comparison of in-migration flows to the SE region in the 13 years period from 2005 to 2017	155
6.13	Provincial-level in-migration flows from the MKD to the SE region	156
6.14	Provincial-level out-migration flows from the MKD to the SE region	157

List of Tables

3.1	Parameters of farmer agents	67
3.2	Parameters of contractor agents	69
3.3	Experimental settings of scenario-based parameter values	74
4.1	The average of migration rates and number of migrants across the cities and provinces in the MKD and the SE regions, from 2005 to 2017	100
4.2	Accumulation of registered FDI projects and total registered capital effective as of 31/12/2017 by region and top five cities and provinces	102
6.1	Socio-economic development level, environmental impacts and the contributing factors	133
6.2	Set of 15 calibration parameters in the agent-based migration model in the context of the MKD region	137
6.3	Parameter values for the GA calibration method	139
6.4	Calibrated parameters using the GA	140
6.5	Shapiro-Wilk's test of migration flow rates of the 13 cities and provinces in the MKD region	142
6.6	Statistical summary of the group of parameters obtained from all worst GA calibration solutions	153