December 9, 2019

Search Committee College of Agriculture and Life Sciences Texas A&M University 600 John Kimbrough Blvd #510 College Station, TX 77843

Dear Search Committee:

I am writing to apply for the position of Assistant Professor, advertised in the Job Openings for Economists. I am currently a doctoral candidate in the Department of Economics at the University of Notre Dame, where I study under the direction of Dr. Joseph Kaboski and expect to receive my Ph.D. in May 2020.

My research interests lie broadly in the field of development economics, with a primary focus on agriculture and the effect of improved land rights on economic outcomes. My job market paper studies the impact of the land-titling program on migration of rural households in Vietnam. I find that having land titles encourages more migration both at the extensive and intensive margins and the effects are heterogeneous across wealth distribution, types of migration, age and gender. In a second paper, which has been accepted for publication at the Journal of Development Studies, I investigate the effect of land rights on the adoption of high-yield rice varieties by farmers in Vietnam. A third paper studies the role of international trade on generating structural change patterns in recently developed and developing countries.

While at Notre Dame, I had the opportunity to serve as the sole instructor of an independently designed Statistics for Economics course for two semesters. I greatly enjoyed teaching the course and look forward to expanding my teaching portfolio. In addition to teaching core courses, I would welcome the opportunity to teach development economics, agrigcultural economics, econometrics, and international trade. I have received the Striving for Excellence in Teaching Certificate and Advanced Teaching Scholar Certificate from the Kaneb Center for Teaching and Learning at Notre Dame.

I believe I am a good fit for the assistant professor position at your institution. Included with this document are my C.V. and other requested materials. I will gladly provide any other supporting materials upon request. I will also be available to interview at the ASSA meeting in San Diego. Thank you for your consideration.

Sincerely, Linh Nguyen

Department of Economics University of Notre Dame 3046 Jenkins Nanovic Hall Notre Dame, IN 46556

Tel: 919-768-2199 E-mail: <u>lnguye10@nd.edu</u> Web: <u>https://sites.google.com/view/linhnguyen90</u>

Updated: November, 2019

## Linh Nguyen

Contact Information	Department of Economics University of Notre Dame 3046 Jenkins Nanovic Halls Notre Dame, IN 46556	Phone: (919) 768-2199 E-mail: lnguye10@nd.edu Web: https://sites.google	ı e.com/view/linhnguyen90							
Education	University of Notre Dame, N Ph.D., Economics Committee: Joseph Kaboski (a Kevin Donovan, and Nilesh F	lotre Dame, Indiana chair), Lakshmi Iyer, ernando	2014-2020 (expected)							
	Duke University, Durham, No	rth Carolina								
	M.A., Economics		2012-2014							
	National Economics University, Hanoi, Vietnam									
	B.A., Finance and Banking		2008-2012							
Research Interests	Development Economics, Interna	ational Trade								
Job Market Paper	"Land Rights and Migration in V	Vietnam"								
Publications	"Land Rights and Technology Adnal of Development Studies,	doption: Improved Rice Variet 2019, <i>forthcoming</i> .	ies in Vietnam", <b>Jour-</b>							
In Progress	"(De)Industrialization: Structura "Institutional Long-Lasting Effec	al Change in an Open Econom ets on Agricultural Outcomes"	ıy"							
Presentations	<ul> <li>2019: Annual Midwest Graduat and Urban Studies, University of tory, Demography, and Developm</li> <li>2020: (scheduled) Midwest Ecor</li> </ul>	te Student Summit on Applie of Illinois at Urbana-Champaig ment) Research Day, Universit nomics Association Conference	d Economics, Regional, gn; H2D2 (Health, His- y of Michigan. e, Evanston, IL							
Teaching Experience	<ul> <li>Instructor, University of Notre ECON 30330: Statistics for E</li> <li>Fall 2017: class size 39, n</li> <li>Spring 2018: class size 42</li> </ul>	Dame Conomics nedian evaluation score 3.7/5 2, median evaluation score 4.4	Fall 2017-Spring 2018							
	<b>Teaching Assistant</b> , University ECON 10011: Principle of Ma ECON 10020: Principle of Ma	v of Notre Dame icroeconomics acroeconomics	Fall 2014 Spring 2015							
	Academic Tutor, University of Academic Services for Student	<sup>E</sup> Notre Dame t Athletes, Econometrics (ECC	ON 30331) Fall 2018							

Research Experience	Research Assistant, University of Notre Dame Professors Ethan Lieber and Lakshmi Iyer Professors Abigail Wozniak and Christopher Cre	2016-2017 2015-2016
	<b>Research Assistant</b> , Duke University Professor Timur Kuran	2012-2014
Teaching Certificates	Kaneb Center for Teaching and Learning, Universi Striving for Excellence in Teaching Certificate	ty of Notre Dame 2018
	Advanced Teaching Scholar Certificate	2019
Honors and Awards	Graduate Student Presentation Travel Grant Department of Economics, University of Notre	2019 Dame
	Graduate Assistantship College of Arts and Letters, University of Notre	2014-2020 2 Dame
	Graduate Assistantship Department of Economics, Duke University	2012-2014
	President's Distinction Academic Award National Economics University, Vietnam	2012
	Amcham Scholarship for Vietnam's top students in American Chamber of Commerce in Vietnam	n Economics and Business 2011
TECHNICAL SKILLS	Stata, MATLAB, R, ArcGIS, $L^{ATEX}$	
LANGUAGES	Vietnamese (native), English (fluent), French (begi	nner)
Other Affilication	Kellogg Institute Doctoral Student Affiliate University of Notre Dame	2018-current
Reference	Joseph Kaboski (Chair) University of Notre Dame Department of Economics Phone: (574) 631-9906 E-mail: jkaboski@nd.edu	Lakshmi Iyer University of Notre Dame Department of Economics Phone: (574) 631-8954 E-mail: liyer@nd.edu
	Kevin Donovan Yale University School of Management Phone: (203) 432-4333 E-mail: kevin.donovan@yale.edu	<b>A. Nilesh Fernando</b> University of Notre Dame Department of Economics Phone: (574) 631-1432 E-mail: nilesh.fernando@nd.edu

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## **UNIVERSITY OF NOTRE DAME**

lnguye10@nd.edu

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## **NOTRE DAME, INDIANA 46556**

#### Date Issued: 05-NOV-2019 Page: 1

Nguyen, Mai Ha Linh Student ID: XXXXX1264

Birth Date: 12-18-XXXX

Issued To: Linh Nguyen

- Degree Awarded: Master of Arts Date Conferred: August 04, 2019 College: Social Science Final Exam: Passed master's comprehensive exam June 2015 Candidacy Date: Admitted to master's degree candidacy 7/30/2019 Degree Sought: Philosophiae Doctor
  - College: Social Science

Oral Date: Passed oral candidacy exam 8/17/2018 Candidacy Date: Admitted to doctoral degree candidacy 1/29/2019

Course Level:	Graduate
Program:	PhD - Economics
College:	Social Science
Major:	Economics

Program: MA - Economics College: Social Science Major: Economics

					UND	SEMESTE	R TOTALS		0	VERALL T	OTALS	
CRSE ID	COURSE TITLE	CRS HRS	GRD	QPTS	ATTEMP HRS	EARNED HRS	GPA HRS	GPA	ATTEMP HRS	EARNED HRS	GPA HRS	GPA
UNIVERSITY OF Fall Semester Social Scie	NOTRE DAME CREDIT: 2014 nce											
ECON 60101	Microeconomic Theory I	4.500	A-	16.502								
ECON 60201	Macroeconomic Theory I	4.500	B+	14.999								
ECON 60302	Econometrics I	4.500	A	18.000								
-		Total		49.500	13.500	13.500	13.500	3.667	13.500	13.500	13.500	3.667
Spring Semest Social Scie	er 2015 nce											
ECON 60102	Microeconomic Theory II	4.500	в	13.500								
ECON 60202	Macroeconomic Theory II	4.500	A-	16.502								
ECON 60303	Econometrics II	4.500	A-	16.502								
-		Total		46.503	13.500	13.500	13.500	3.445	27.000	27.000	27.000	3.556
Fall Semester Social Scie	2015 nce											
ECON 70351	Monetary Policy	3.000	А	12.000								
ECON 70552	Int'l Macroeconomics	3.000	А	12.000								
ECON 73002	Research Seminar - Macro	3.000	A	12.000								
			C	ONTINUED ON	I PAGE 2							

# **UNIVERSITY OF NOTRE DAME**

## NOTRE DAME, INDIANA 46556

Nguyen, Mai Ha Linh

Student ID: XXXXX1264

Birth Date: 12-18-XXXX

					UND	SEMESTE	R TOTALS		0	VERALL T	OTALS	
CRSE ID	COURSE TITLE	CRS	GRD	QPTS	ATTEMP	EARNED	GPA	GPA	ATTEMP	EARNED	GPA	GPA
		HRS			HRS	HRS	HRS		HRS	HRS	HRS	
Universit	y of Notre Dame Information contin	ued:										
-		Total		36.000	9.000	9.000	9.000	4.000	36.000	36.000	36.000	3.667
Spring Se	mester 2016											
Social	Science											
ECON 7056	2 Economic Development II	3.000	Α	12.000								
ECON 7070	1 Public Economics I	3.000	B+	9.999								
ECON 7300	2 Research Seminar: Macro	3.000	A	12.000								
-		Total		33.999	9.000	9.000	9.000	3.778	45.000	45.000	45.000	3.689
Fall Seme	ster 2016											
Social	Science											
ECON 7056	1 Economic Development I	3.000	A	12.000								
ECON 7056	6 International Economics I	3.000	A-	11.001								
ECON 7300	2 Research Seminar - Macro	3.000	Α	12.000								
-		Total		35.001	9.000	9.000	9.000	3.889	54.000	54.000	54.000	3.722
Spring Se	mester 2017											
Social	Science											
ECON 7056	0 Economic Development Topics	3.000	Α	12.000								
ECON 7300	2 Research Seminar: Macro	3.000	Α	12.000								
ECON 7739	0 Research and Dissertation	3.000	S	0.000								
-		Total		24.000	9.000	9.000	6.000	4.000	63.000	63.000	60.000	3.750
Fall Seme	ster 2017											
Social	Science											
ECON 7300	2 Research Seminar - Macro	3.000	A	12.000								
ECON 7739	0 Research and Dissertation	6.000	S	0.000								
-		Total		12.000	9.000	9.000	3.000	4.000	72.000	72.000	63.000	3.762
Spring Se	mester 2018											
Social	Science		_									
ECON 7300	2 Research Seminar: Macro	3.000	A	12.000								
ECON 7795	1 Research and Dissertation	6.000	ន	0.000								
-		Total		12.000	9.000	9.000	3.000	4.000	81.000	81.000	66.000	3.773
Fall Seme	ster 2018											

Social Science

CONTINUED ON PAGE 3

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## NOTRE DAME, INDIANA 46556

Nguyen, Mai Ha Linh

Student ID: XXXXX1264

Birth Date: 12-18-XXXX

Date Issued: 05-NOV-2019 Page: 3

							UND	SEMESTE	R TOTALS		0	VERALL T	OTALS	
CRSE ID	COURSE TI	ITLE		CRS	GRD	QPTS	ATTEMP	EARNED	GPA	GPA	ATTEMP	EARNED	GPA	GPA
				HRS			HRS	HRS	HRS		HRS	HRS	HRS	
University of	Notre Dam	ne Information	continue	d:										
ECON 70801	Workshop	Seminar - Macr	0	3.000	Δ	12,000								
ECON 73002	Research	Seminar - Macr	0	3.000	A	12.000								
ECON 77390	Research	and Dissertati	on	3.000	S	0.000								
-				Total		24.000	9.000	9.000	6.000	4.000	90.000	90.000	72.000	3.792
Spring Semest	er 2019													
Social Scie	ence													
ECON 70562	Economic	Development II		3.000	A	12.000								
ECON 73002	Research	Seminar: Macro	•	3.000	А	12.000								
ECON 77390	Research	and Dissertati	on	3.000	s	0.000								
-				Total		24.000	9.000	9.000	6.000	4.000	99.000	99.000	78.000	3.808
Fall Semester	2019													
IN PROGRESS V	IORK													
ECON 73001 M	Research	Seminar -Micro		3.0	00 IN	PROGRESS								
ECON 77390 M	Research	and Dissertati	on	6.0	00 IN	PROGRESS								
	In Progres	ss Credits	9.0	00										
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NOTRE DAME	Ehrs:	99.000 Q	Pts:	2	97.003	3								
	GPA-Hrs:	78.000	GPA:		3.808	3								
TDANCEED	Fbwg	0 000 0	Dta		0 000	SC								
IRANSFER	CDA-Hrg.		CDA.		0.000									
	GPA-HIS:	0.000	GPA:		0.000									
OVERALL	Ehrs:	99.000 Q	Pts:	2	97.003	3								
	GPA-Hrs:	78.000	GPA:		3.808	3								
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#### CAMPUS CODES

All courses taught at an off campus location will have a campus code listed before the course title.

- The most frequently used codes are:
- Angers, France AF
- DC Washington, DC
- Fremantle, Australia FA ۱Δ
- Innsbruck, Austria
- IR Dublin, Ireland
- London, England (Fall/Spring) IA
- London, England (Law-JD) LE
- London, England (Summer EG) LG
- London, England (Summer AL) IS
- PA Perth. Australia
- PM Puebla, Mexico
- RE Rome, Italy
- RI Rome, Italy (Architecture)
- SC Santiago, Chile
- SP Toledo, Spain
  - For a complete list of codes, please see the following website: http://registrar.nd.edu/pdf/campuscodes.pdf

#### **GRADING SYSTEM - SEMESTER CALENDAR**

Previous grading systems as well as complete explanations are available at the following website:

http://registrar.nd.edu/students/gradefinal.php August 1988 - Present

enrolled.

Letter	Point	
Grade	Value	Legend
A	4	
A-	3.667	
B+	3.333	
В	3	
B-	2.667	
C+	2.333	
С	2	Lowest passing grade for graduate students.
C-	1.667	
D	1	Lowest passing grade for undergraduate students.
F	0	Failure
F*	0	No final grade reported for an individual student (Registrar assigned).
Х	0	Given with the approval of the student's dean in extenuating circumstances beyond the control of the student. It reverts to "F" if not changed within 30 days after the beginning of the next semester in which the student is

- Ω Incomplete (reserved for advanced students in advanced studies courses only). It is a temporary and unacceptable grade indicating a failure to complete work in a course. The course work must be completed and the "I" changed according to the appropriate Academic Code.
- Unsatisfactory work (courses without semester credit hours, as well as research courses, departmental seminars or colloquia or directed studies; workshops: field education and skill courses).

#### Grades which are not Included in the Computation of the Average

- S Satisfactory work (courses without semester credit hours, as well as research courses, departmental seminars or colloquia or directed studies; workshops; field education and skill courses).
- V Auditor (Graduate students only).

U

- \٨/ Discontinued with permission. To secure a "W" the student must have the authorization of the dean.
- Р Pass in a course taken on a pass-fail basis.
- NR Not reported. Final grade(s) not reported by the instructor due to extenuating circumstances.

For current and historical grade point averages by class, as well as additional information regarding prior grading policies and current distribution ranges, see: http://registrar.nd.edu/students/gradefinal.php

#### THE LAW SCHOOL GRADING SYSTEM

The current grading system for the law school is as follows: A (4.000), A-(3.667), B+ (3.333), B (3.000), B- (2.667), C+ (2.333), C (2.000), C- (1.667), D (1.000), F or U (0.000).

Effective academic year 2011-2012, the law school implemented a grade normalization policy, with mandatory mean ranges (for any course with 10 or more students) and mandatory distribution ranges (for any course with 25 or more students). For Legal Writing (I & II) only, the mean requirement will apply but the distribution requirement will not apply. The mean ranges are as follows: for all first-year courses (except for the first-year elective, which is treated as an upper-level course), the mean is 3.25 to 3.30; for large upperlevel courses (25 or more students), the mean is 3.25 to 3.35; for small upper-level courses (10-24 students), the mean is 3.15 to 3.45.

For current and historical grade point averages by class, as well as additional information regarding prior grading policies and current distribution ranges, see: http://registrar.nd.edu/students/gradefinal.php





CHUCK HURLEY, UNIVERSITY REGISTRAR

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#### COURSE NUMBERING SYSTEM

#### Previous course numbering systems (prior to Summer 2005) are available at the following website: http://registrar.nd.edu/faculty/course numbering.php

Beginning in Summer 2005, all courses offered are five numeric digits long (e.g. ENGL 43715).

The first digit of the course number indicates the level of the course.

ENGL 0 X - XXX	=	Pre-College course
ENGL 1 X - XXX	=	Freshman Level course
ENGL 2 X - XXX	=	Sophomore Level course
ENGL 3 X - XXX	=	Junior Level course
ENGL 4 X - XXX	=	Senior Level course
ENGL 5 X - XXX	=	5th Year Senior / Advanced Undergraduate Course
ENGL 6 X - XXX	=	1st Year Graduate Level Course
ENGL 7 X - XXX	=	2nd Year Graduate Level Course (MBA / LAW)
ENGL 8 X - XXX	=	3rd Year Graduate Level Course (MBA / LAW)
ENGL 9 X - XXX	=	Upper Level Graduate Level Course

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November 2, 2019

#### Dear Recruiting Committee Chair:

This letter is to recommend Linh Nguyen for a position at your institution. Linh and I met while I was a faculty member at Notre Dame. She took my development economics class, and I frequently discussed the early stages of her work that resulted in both her job market paper and another, already published, paper. She asked me to remain on her dissertation committee when I moved to Yale, and I happily obliged.

Linh works in development economics, with particular focus on the link between institutional arrangements and technology adoption. One of her papers focuses on the link between land tenure arrangements and high-yield seed adoption ("Land Rights and Technology Adoption: Improved Rice Varieties in Vietnam"), and is already published at the *Journal of Development Studies*. This is a nice start to her career, and as I will highlight below, is indicative of a well-defined research agenda that will serve her well as she continues to publish. In addition to her research, she is a fantastic teacher. I highly recommend her to schools that value high quality teaching along with research. Her ability to elucidate economic results derived from a variety of techniques would also make her a great fit for the private sector and international organizations.

Linh's job market paper ("Land Rights and Migration in Vietnam") deals with another link between land institutions and technology adoption, specifically, the lack of ruralurban migration. The motivating fact is one subjected to much debate in the literature – if wages are so much higher in urban areas, why don't farmers in rural areas move to these jobs? The answer has important implications for policy. Is it that the labor market itself is distorted in some way (low job finding rates, discrimination, uninformed about urban wage premium)? Or, is the lack of migration the result of some other underlying market failure? Linh takes on the latter, and shows that missing land tenure decreases the incentives to migrate off-farm.

She begins with a model that formalizes the tradeoffs between economies in which farmers hold formal land titles (that allow trade, rentals, etc.) and one in which they do not. Without a title, migrating off-farm comes at the risk your land will be expropriated while vacant. This lowers the return to migration, thus lowering rural-urban migration. On the other hand, missing land titles also limits farm productivity, since farmers are unlikely to make costly, productivity-enhancing investments if land is likely to be expropriated. This provides a countervailing force, as the low agricultural wage makes the high urban wage even more attractive.

This theoretical ambiguity motivates her empirical work in the next part of the paper. Using her institutional knowledge of Vietnam, she studies the 1993 land reform that took place there. In the late 1980s, Vietnam was decollectivizing farms, but land transactions remained illegal until 1993. Only then did it become legal to sell, rent, or inherit land. What is most interesting – and useful for identification – is that there was substantial temporal and spatial variation in the role out of the program. To see why this is the case, a bit of detail is in order. First, the titling program required households to apply to the Bureau of Land Administration (BLA) for a title. Second, there was massive demand for titles (nearly 11 million distributed by 2000). However, limited capacity in

#### **KEVIN DONOVAN** Assistant Professor of Economics

PO Box 208200 New Haven CT 06520-8200 T 203 432-4333 kevin.donovan@yale.edu som.yale.edu/donovan

*courier* 165 Whitney Avenue New Haven CT 06511



the BLA coupled with this demand caused substantial delays for some areas and households. Linh exploits this variation for identification.

Linh combines this idea with detailed panel data from Vietnam. The first is the Vietnam Household Living Standards Survey, which started in 1992. The second is the Vietnam Access to Resources Household Survey, which started in 2002. Armed with the data, she leverages the spatial and temporal variation induced by the particulars of the program for causal identification.

Linh finds that getting access to a land title increases the likelihood of rural-urban migration by 17 percent; implying land titles play an important role in generating off-farm migration. From there, she turns to understanding the "why" part of the question. Here, she finds interesting heterogeneity – households in the middle two quartiles are most affected. This is consistent with an important role for credit constraints. If a household is extremely poor, then giving it the ability to sell land is insufficient to cover the cost of migration. They remain unaffected by titling. Rich households, on the other hand, can already self-finance migration. Thus, they too are unaffected by the ability to now fund with land sales. This leaves only those in the middle of the wealth distribution to be pushed into migration. They are rich enough that allowing them to benefit from land transactions pushes them over the migration threshold, but poor enough that they would not be able to finance the move otherwise.

Overall, I suspect this paper is a good indication of what Linh's research will look like going forward. It combines economic theory and empirical work, leveraging her institutional knowledge of Vietnam to study important questions in economic development about rural livelihoods.

As further evidence of this, her second paper studies this same land titling program and its relationship with the adoption of high-yield rice varieties. This paper takes on the details of an aspect highlighted in her JMP: that a formal land title potentially increases the incentives to invest in productivity-enhancing technology. I am less familiar with this paper, so I will leave it to Joe, Lakshmi, and Nilesh to discuss it in more detail. However, **this paper is already published in the** *Journal of Development Studies*. It is no small feat for a graduate student to navigate the R&R and publication process on her own, and her ability to do so projects favorably on her future ability to publish.

Linh is also an fantastic teacher, one of the best through the Notre Dame program. She twice taught Statistics for Economics, an extremely demanding class that is most students' first introduction to statistics. Her median score in the first class was 3.7 of 5, jumping to 4.4 in the second (teaching scores range from 1-5, where 3 is "Good", 4 is "Very Good" and 5 is "Excellent"). It is hard to overemphasize how difficult it is to get high teaching evaluations at a school like Notre Dame, where both the administration and students demand teaching excellence. The student comments in her evaluations similarly reinforce the fact that she excelled in the classroom. Finally, Linh did all the little things that suggest she takes this part of the job seriously – she included a midterm evaluation to get real-time feedback from students, and utilized the Kaneb Center to increase her teaching quality through their programs. She will be a successful teacher anywhere she ends up.



At Notre Dame, I served on committees for macro and development students who placed at the Central Bank of Chile (Jianyu Lu), the Federal Reserve Board (Eva van Leemput), and Sam Houston State (Sara Esfahani). Linh is similar to Sara in terms of research quality, though I suspect Linh will ultimately have a more productive publishing career given her well-defined research agenda and comfort with the publishing process. However, Linh is likely a better teacher than all of them and I suspect this will be her long-term comparative advantage. Any college or university that values a combination of research and teaching – and especially any that values an expert in Southeast Asian economic policy – should be sure to consider her.

On a personal level, Linh is friendly, hardworking, and professional. She will make an excellent colleague. Please feel free to contact me with any additional questions at kevin.donovan@yale.edu or +1 203-432-4333.

Sincerely,

Kevin Donovan Assistant Professor of Economics Yale School of Management



DEPARTMENT OF ECONOMICS 3081 Jenkins Nanovic Halls, Notre Dame, IN 46556 USA tel 574-631-1432 email nilesh.fernando@nd.edu web nileshfernando.com/

## October 31<sup>st</sup>, 2019

Dear Colleague,

I am writing in support of Linh Nguyen's application to your department. Linh will be completing her PhD in Economics from the University of Notre Dame in 2020. She previously completed a Master's degree in Economics from Duke University and her undergraduate education in Vietnam. As such, Linh has terrific training in both economic theory and empirical work that is evident in her work. She is industrious and has already published one of her papers in the *Journal of Development Studies*. In addition, her solid background in core economics courses and prior teaching experience make her especially well-suited to teaching undergraduates.

I've known Linh for the past two years both through her participation in the development economics lunch, which I organize, repeated interactions for advising because of shared interests, and through a graduate course in development economics that I taught. At the outset, I will say that Linh was an excellent student in this class. She asked terrific questions, often drawing from her own background in Vietnam and worked hard to revise a proposal – the main deliverable of the class – that eventually became her job market paper.

Linh's research agenda focuses on the process of structural change in development economics, and, in particular, the role played by land market institutions. Her papers compliment this agenda by tackling various aspects of structural change at both the micro and macro levels using both empirical work and theory. Her completed papers showcase the breadth of her training in both theory and empirical work. In addition, she draws upon her background from Vietnam to both generate interesting questions and bring a contextual understanding that enriches our understanding of her findings. Her job market paper focuses on the exit of labor from agriculture through migration, her second (published) paper looks at the adoption of high-yielding varieties of seed and her third paper takes a more macro approach, using a trade model to understand broad patterns of structural change. I will focus on the first two papers as I have advised her on them and they are especially close to my own interests.

Her job market paper, "Land Rights and Migration: Heterogeneous Effects for Rural Households in Vietnam", is motivated by the influential research by Gollin, Lagakos, and Waugh (2013) which show there are large consumption and wage gaps across rural and urban areas in the developing world. While debate rages on about what might produce these gaps in a macro and methodological standpoint, we know comparatively less about the micro mechanisms that might underlie these gaps. Understanding the role land markets play in producing these gaps – as Linh does -- is especially important, both because the macro literature (Restuccia and co-authors) are suggestive of their importance and because land is often the fundamental asset to much of the world's rural poor.

Linh's job market looks at the role of land markets in Vietnam in inhibiting rural to urban migration. She leverages a land titling scheme and uses spatial and temporal variation to estimate its effects on migration using panel data. The intuition is clear, if land is inherited and rarely exchanges hands (either through sale or rental) this can result in allocative efficiencies in the land market, of course, but also in the labor market: in essence, unproductive farmers really ought to shift into other occupations while productive ones should increase their landholdings. This is a serious problem as it implies that interventions in agriculture that raise the returns to farming may further exacerbate labor market distortions if underlying failures in the market for land are not addressed.

Linh proposes a formal model that outlines the tradeoffs one faces in seeking migration for work and schooling and how this might vary by age and income. The model guides her empirical work and delivers a set of testable propositions that ring true to one's intuition: the young face much higher returns to migration, the relatively wealth-poor are the ones mostly likely to migrate in search of work (rich farmers have no need to migrate!) while the relatively wealthy are those be induced to educate their children.

Linh finds that the reform – controlling for region specific trends that might hinder identification – increases the probability that households migrate by nearly a fifth relative to the baseline rate. This is, of course, a large effect, and she finds that women are induced to migrate for education among wealthier families, while men migrate for work among families who own less land. Her findings are especially important in that they tell us about – and gives us a useful theoretical lens – the heterogeneous effects of land titling and the many reasons households choose to migrate in the developing world. It also outlines the competing manner by which titling schemes may influence migration.

Linh's second paper is forthcoming in the *Journal of Development Studies*. In this paper, she uses that same land reform in Vietnam as in her job market, but this time to understand how land institutions may facilitate technology adoption. She finds that improved tenure security results in the adoption of improved varieties of rice. Conceptually, she finds evidence to suggest that this is a driven through tenure security – similar to the work by Goldstein and Udry – where farmers who now do not run the risk of expropriation are now willing to invest in their land.

Linh is an especially dedicated teacher and has previously taught two sections of 'Statistics for Economists'. Notre Dame is an especially demanding place to teach – students expect a lot of face time and direction and develop high expectations for instruction as the quality of teaching is comparable to that at a liberal arts college – and her median scores which started at 3.7 and then jumped to 4.4 (out of 5) are exceptional. Moreover, they suggest an upward trajectory which is not a coincidence: Linh took the time to go to the Kaneb Center – the on-campus institute for teaching – and learn how to improve her method of instruction.

I hope that this letter has persuaded you that Linh is a talented economist doing creative work on structural change, who is well versed in both empirical techniques and theory. She is also very humble, amiable, geared towards improvement, and will make an excellent colleague. As such, I recommend her without hesitation.

Sincerely,

Navon fore - -

A. Nilesh Fernando Assistant Professor of Economics University of Notre Dame



## LAKSHMI IYER Associate Professor

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Department of Economics 3054 Jenkins Nanovic Halls Notre Dame, IN 46556-7000.

November 3, 2019

To Whom It May Concern:

I am pleased to write a letter for Linh NGUYEN, who is applying for a position at your institution. I have known Linh since I moved to Notre Dame in 2016. She worked for me as a research assistant, I am a member of her PhD dissertation committee and have had several discussions with her about her research. I should note that while Notre Dame's graduate program is quite young and relatively small, we have been successful in placing all our PhD students and the quality of our graduate students is consistently improving.

Linh is a capable researcher, with research interests focused on development economics and international trade. She is well trained, and uses a wide range of techniques in her work, including macroeconomic modeling, applied econometrics and theoretical modeling. Unusually for a PhD student, Linh already has a solo-authored journal publication under her belt, in the *Journal of Development Studies*. She is an enthusiastic and effective teacher, and an involved and engaged member of the economics community at Notre Dame. Linh will be a particularly good fit for departments that place emphasis on both research and teaching. Her range of methodological skills will also serve her well in research-oriented positions in policy institutions or the private sector.

Linh's job market paper examines the impact of better property rights on rural-to-urban migration. This is motivated by the observation that rural-urban wage differentials in developing countries are often extremely large and unusually persistent. Linh therefore hypothesizes that lack of secure property rights in land may inhibit migration either because people fear losing the land if they are not physically present to guard or use it, or because they lack sufficient collateral in order to finance migration costs. She writes down a simple theoretical framework to model these constraints, which may manifest differently for older and younger people. Her model generates two interesting testable predictions, beyond the obvious one that relaxing these constraints will increase migration. The first is that improved land rights will increase migration more for middle-income households rather than for the poorest or the richest. The second is that migration will increase migration more for younger people at all wealth levels.

Linh conducts a careful empirical analysis to test these predictions, using data from three waves of the Vietnam Access to Resources Household Survey (VARHS). The primary advantage of using these data is that she can exploit the household panel nature of the data to examine migration for households before and after they receive a Land Use Certificate (LUC) for any of their agricultural plots. She also includes commune\*year fixed effects in her regressions, which effectively controls for any changes in local labor markets or other regional variables. Linh finds that having a LUC increases the probability of a household having a migrant member by 4 percentage points, which represents a 17% increase over the mean. She finds support for her theoretically motivated predictions: the impact of LUC is greatest for households in the middle ranges of landholding or income, and also higher for younger people. She also uncovers an interesting additional fact: women tend to migrate more for educational reasons, while men migrate more for work reasons. This implies that studies of migration (especially for women) may underestimate the full long-run economic benefits.

In addition to the job market paper, Linh also has an already published paper that examines the impact of the LUC on whether the household chooses to use high-yielding varieties of seeds. Secure land rights could be important in this regard, if households need a way to finance the up-front experimentation and learning costs of using this new technology. Linh finds a positive and significant effect of land rights on such technology adoption, both in the VARHS and in the nationwide Vietnam Living Standards Survey. The paper is carefully done, with significant attention paid to the measurement of key variables (e.g. Linh manually examined the 60 different rice varieties reported by households prior to creating her key variable of using improved seeds) and robustness checks. Linh is also to be commended for navigating the entire journal submission and revision process on her own. The paper is now <u>published</u> at the *Journal of Development Studies*. As you know, having a solo-authored paper published prior to PhD completion is extremely rare in economics.

Finally, Linh also has ongoing work on the role of international trade in generating patterns of deindustrialization in the developing world. Here she uses models from the macro and trade literature, and data from Mexico and Italy to calibrate the model. As you can see, this highlights the range of skills and methodologies that Linh is able to deploy effectively in her research. This also means that she is on track to successfully finish her PhD in 2020.

Linh has proved herself to be an effective teacher. She was the principal instructor in an undergraduate Statistics class for two semesters at Notre Dame and has also served as TA for classes in microeconomics and macroeconomics; some of her RA work for me was actually TA work, since she helped me greatly in creating data analysis assignments for undergraduates in my political economy class. I should note that the statistics class is not particularly easy to teach, since students tend to consider the material dry and abstract. Linh put in considerable effort into making the class accessible by using real-world examples, conducting a mid-semester evaluation so as to respond to students' concerns quickly, and working with the on-campus Kaneb Center to learn strategies to improve her teaching. Her teaching evaluations improved quite considerably as a result, reaching a score of 4.4 on a 5-point scale where 4 represents "very good" and 5 represents "excellent." I should note that this is very commendable, given that the department and the students at Notre Dame place an unusually high emphasis on teaching quality. Linh's English is good, and she is able to connect and communicate well with students. Linh would be a good choice to teach

undergraduate and graduate courses in development economics, microeconomics, international trade, statistics or applied econometrics.

Finally, I will mention that Linh is a good departmental citizen. She is a regular attendee at seminars and departmental events, she has a humble and cheerful presence, and works hard to learn more about economics. I believe Linh will be an asset to any department that hires her, and I am pleased to give her a high recommendation. Please feel free to contact me at <u>liver@nd.edu</u> if you need any further information.

Sincerely,

Lakshin Iye

Lakshmi Iyer

Joseph P. Kaboski David F. and Erin M. Seng Foundation Professor of Economics Department of Economics Notre Dame, IN 46556-5644 E-Mail jkaboski@nd.edu



October 31, 2019

To Whom It May Concern:

I am happy to recommend Linh Nguyen for a position with your institution. I have known Linh for several years, and have interacted with her both in the classroom and with her research. As a second year student, Linh took my course on growth and development. Although she wrote her second year paper with Kevin Donovan, I have been her primary advisor for her dissertation research overall, and she has been a research assistant for me.

Linh is a development economist, whose main area of research is on agriculture in poor countries. She is a skilled researcher and a very dedicated, capable, and experienced teacher. She has a breadth of knowledge in many fields: both the macroeconomics and microeconomics of development, growth, trade, econometrics and statistics, Asian economies, and more. Research wise, **she has already published a paper in the** *Journal of Development Studies*, which is a nice head start on her career. She has a mix of empirical skills and quantitative modeling skills and a clear and focused research agenda, which will help her to continue publishing solid, insightful papers in similar journals. I strongly recommend her to a wide range of institutions but especially to universities and liberal arts colleges that value teaching.

Linh's research is motivated by the agricultural productivity gap common to developing countries: a large share of the workforce is engaged in agriculture despite the fact that agricultural productivity is so much lower in the agricultural sector, even in nominal terms. One might think that this is easily explained by the need for food in poor countries ("the food problem"), but it is surprising that the food problem wouldn't manifest itself in high prices for food, increasing the nominal output per worker in agriculture. I will discuss her research papers in the order they were written because it shows her breadth of skills and the development of her research agenda, but the last paper is her job market paper.

The first chapter of her dissertation focused on the macroeconomic question of movement out of agriculture and into industry, a primary policy goal for most developing countries. An influential 2016 paper by Dani Rodrik argued that recent developers had failed to industrialize to the same extent as later developers, and had actually experienced "premature deindustrialization". Linh conjectured that the size and emergence of China as a global industrial giant had played a large role in this. She therefore wrote down a multicountry, multi-sector trade model, where both agriculture and industry were tradable goods. The three countries involved a small, poor country (call it Mexico), a large, poor country (call it China), and an advanced economy (call in the United States). She used the model. Linh wrote the model, calibrated it, and simulated it in order to quantitatively assess the conjectured channel both positively and normatively. She found that indeed China's development lowered the industrial share of Mexico, but that Mexico nonetheless benefited from openness, and both were potentially sizable. I emphasize this paper to show the breadth of Linh's research interests and expertise. This paper focused on the trade and macro side of development, and was empirically motivated but model centered.

Linh's latter two chapters focused on more on the ground ways of addressing the agricultural productivity gap in developing countries. The methods are those of empirical microeconomics with simple models that help to interpret her results.

Many authors, including Hernando de Soto, have emphasized the importance of property rights as an institution for development in agriculture. With these thoughts in mind, Linh turned toward Vietnam, where she has personal expertise. Vietnam's agricultural sector is particularly interesting because it was collectivized under the Communist regime, but then land rights were effectively re-introduced through a titling program that was started in 1993 and rolled out in the subsequent years. The staggered roll out of the program gave variation in space and time in the prevalence of land titles, which is plausibly exogenous after controlling for a wide set of controls.

Linh has rich panel data from two surveys that were designed precisely to be able to think about heterogenous histories and causal identification. The first dataset is the Vietnam Household Living Standards Survey (VHLSS), which is World Bank funded, and started conveniently in 1992. That was a large representative cross-section that asked retrospective questions enabling some panel analysis. The second survey, the Vietnam Access to Resources Household Survey (VARHS), is a true panel survey that started in 2002. It covers a wide range of areas from the far north to the south. Both surveys have rich data on agriculture and related development topics. Supplementing these surveys, Linh develops simple models in her final two essays to interpret and motivate additional tests to identify not only the impacts of land titling but the channels.

In Linh's second essay, which is already published in the *Journal of Development Studies*, she examines how the land titling impacted the adoption of high yield varieties of seeds. Vietnam is one of the world's leading producers and exporters of rice, and in a global market increased productivity means increased income for farmers. Linh surmised that adoption of hybrid seeds was costly and yet had long term payoffs, so one could think of it as an investment. She distinguishes between two potential channels by which land rights could positively impact the adoption of high yield seeds: a credit channel (as titled land could be collateralized) and a land tenure channel (by which the security of land leads to greater investment). Linh notes that the use of high yield seeds as an investment is a unique choice since the learning aspects of high yield varieties give it an investment aspect without increasing the potential right to land itself (as in the case of land improvements, trees, etc.). She finds a positive impact of land rights on adoption, and using plot level data she identifies evidence for both channels. The credit channel, by freeing up resources to buy seeds, would not necessarily lead to adoption on the titled plots, whereas the tenure would. However, she also finds that credit increases as a result of the titles.

This is a nice paper, and what impresses me most is that Linh was quite diligent and quick to get it published. Often young scholars, even my own junior colleagues, are slow to get things out the door. The fact that Linh has already gone through the submission and revision process – overwhelming on her own, I should add – bodes well for her doing what is necessary to get publications needed for tenure. I think this is quite impressive.

Linh's job market paper looks at the impact of land titling on migration. Rural-urban migration is closely connected to the movement from agriculture to industry (and services). In principle land titles, could lower migration by increasing the returns to agriculture through agricultural investments like the high yield varieties Linh examined in her published paper. However, land titling may also lead to higher migration, however, for other reasons. In cases where ownership is uncertain, people often need to actively farm and occupy the land in order to maintain ownership, which can lead to "guard labor". Moreover, the collateral to credit channel that Linh examined in her earlier paper, may enable people to finance the costs of migrating. Linh's research was inspired by recent influential work, de Janvry, Emerich, Gonzalez-Navarro, and Sadoulet (*AER*, 2015), who showed that in Mexico, land titling led to increased out migration, but since they used aggregate data, they could say less about who outmigrated and why. Linh realized that she could make further progress here.

Linh's job market paper focuses on Vietnam and gives some answers to these questions, at the same time giving insight into why different studies find different impacts of land titling on migration. She finds significant positive impacts on households sending migrants but that these impacts vary considerably depending on the wealth of the household. The largest impacts are on the middle class, who can benefit from the titling enough. There members migrate for work. Wealthy households' members migrate for education. Using a simple model, she shows how the natural assumption that education entails higher migration costs (both direct and indirect) leads to wealth thresholds that can naturally reconcile this with the credit channel. The differences in wealth levels and landholding distributions in different countries and contexts may well give insight into the very different results found in the literature.

But Linh has a still richer set of findings. She shows that it is the young who are more likely to migrate, and, while both men and women migrate, they migrate for different reasons. Men migrate more for work, while women migrate for education. The emphasis on education migration (especially for females) is entirely novel to her study, and it highlights an additional channel of how land titles may affect long term income. Moreover, he strong gender component suggests that the distributional impacts of land titling may be more nuanced than previously thought. I anticipate that this job market paper will publish as easily as her improved seeds paper, which will give Linh a strong head start as an assistant professor.

Together Linh's essays show a keen understanding of important details in the local situation studied, yet address important issues for developing countries in general, and are

yielding practical insights. Over the years, Linh has come up with a list of other ideas related to agriculture. These include using the division of Vietnam as a natural experiment to assess the long term impacts of collectivization and examining at how land titling impacts the allocation of resources (labor, intermediates) across plots of land in a community. A strong research program on these issues lies ahead of her.

While I believe Linh will be a productive researcher, I am truly convinced that her relative strength is in teaching. At Notre Dame, she taught two course of Statistics for Economics. This is a very difficult course to teach for multiple reasons. First, Notre Dame evaluations are extremely unforgiving. My own experience is that I quickly moved from the right tail of the distribution at Ohio State to the left tail of the distribution at Notre Dame. Notre Dame takes teaching very seriously, and only hires the best teachers as faculty. Students are consequently quite demanding and accustomed to outstanding teachers. Moreover, Notre Dame is quite insular, so students are not used to having foreign teachers with accents. Second, statistics is quite difficult to get students excited about. Those that are interested in the course and have an affinity for it have often already come in with AP credit to test out and go directly into Econometrics.

Linh's experience shows a tremendous performance and upward trajectory. Her first time teaching it, she earned an average of 3.8, which lies between "good" (3) and "very good" (4). Her second time teaching, however, she earned an average evaluation of 4.4, which is approaching "excellent" (5). Not only is that a high evaluation, but the improvement shows her commitment and care to the class. I know that Linh was one of the few people to introduce a midterm evaluation, so she could improve the course in real time. Students praised her for her clarity and commitment. While Notre Dame students are smarter and harder working than students at most universities, it is interesting that students even in the class mentioned that she catered toward those who were struggling.

I am convinced that Linh, having taught one of the more difficult classes – econometrics is probably the most difficult – to one of the most demanding groups of students, will excel in teaching anything, anywhere.

Finally, Linh is polite, personable, and honorable and would make a wonderful colleague at your institution. She has been a great departmental citizen, organizing our development lunch the previous two years, for example. Her English is good. I strongly recommend her.

Please contact me at jkaboski@nd.edu, if you have any questions.

Sincerely,

forth P. Jahn

Joe Kaboski David F. and Erin M. Seng Foundation Professor of Economics

## Land Rights and Migration in Vietnam

Linh Nguyen\*

November 2019

#### Abstract

Large rural-urban wage gaps that exist in developing countries are suggestive of distortions that hinder labor mobility. In principle, better land rights can encourage migration through multiple channels, including: improving tenure security; relaxing financial constraints through collateral; and increasing land transferability. Using panel data from Vietnamese rural households and the rollout of a land titling program, I find that having land titles increases migration both at the extensive and intensive margins. The effects are heterogeneous across wealth distribution, types of migration, age and gender. Obtaining land titles significantly increases employment migration by small landholders but only affects the education migration decisions of large landholders. This evidence is consistent with the importance of a credit channel, in which using land as collateral helps households borrow money to fund migration costs. The impact of land titles is stronger among young migrants, and while men increasingly migrate for work, women tend to migrate more for education as the result of getting land titles.

JEL classification: O15, Q15, R23

<sup>\*</sup>Department of Economics, University of Notre Dame, 3046 Jenkins Nanovic Halls, Notre Dame, IN 46556. Email: lnguye10@nd.edu. I would like to thank Taryn Dinkelman, Nilesh Fernando, Lakshmi Iyer, and Joseph Kaboski for their immensely valuable advice as well as participants in the development seminar at the University of Notre Dame for their helpful comments. All errors are my own.

### 1 Introduction

The gap between higher productivity in non-agriculture than in agriculture is pervasive, but it is especially large in poorer countries.<sup>1</sup> Despite this gap, a sizable share of the labor force in developing countries is concentrated in agriculture, making their aggregate productivity even lower compared to the developed.<sup>2</sup> Thus, shifting labor out of agriculture into a more productive sector is a major economic goal for many developing countries. Migration to urban areas can increase earnings for the migrant, reduce income risk that is associated with agricultural shocks, and potentially improve the welfare of the rural household.<sup>3</sup> However, if the choice of migration is a function of the wage gap and the cost of migration, the existence of a rural-urban wage gap in developing countries can reflect frictions that hinder labor mobility.<sup>4</sup> The lack of well-defined property rights over land can be a source of such friction.

Theoretically, well-defined land rights can affect migration through multiple channels, including: improving tenure security, relaxing credit constraints by increased use of land collateral, and facilitating land transactions.<sup>5</sup> First, land insecurity opens up the possibility of expropriation. To avoid this risk, households have to assign labor to actively occupying and using the land. Improving tenure security releases this type of labor and thus, encourages migration. However, a higher level of security also means more agricultural investment and this can lead to higher demand for on-farm labor, which decreases the off-farm labor supply.<sup>6</sup> These two competing forces imply an indeterminate effect of the tenure security channel. Second, people without liquid resources to pay the (initial) cost of migration can borrow money using their land as collateral to fund the costs of migration, including direct and indirect costs. Third, when land transactions are prohibited, households to keep at least some profit from the land and hence reduce the cost of migration.

This paper examines the relationship between land titles and migration in Vietnam using a historical policy experiment. After the introduction of the 1993 land law, the government issued land titles to households, legalizing their rights to *transfer*, *exchange*, *lease*, *inherit*, *and mortgage* their land. It proved to be "one of the largest rural titling programs in the

<sup>&</sup>lt;sup>1</sup>See Gollin et al. (2013)

<sup>&</sup>lt;sup>2</sup>See Caselli (2005) and Restuccia et al. (2008)

<sup>&</sup>lt;sup>3</sup>See de Brauw and Mueller (2012), de Brauw et al. (2017), and Hicks et al. (2017).

<sup>&</sup>lt;sup>4</sup>For example, Munshi and Rosenzweig (2016) documented a 25% rural-urban wage gap in India after accounting for differences in living costs.

<sup>&</sup>lt;sup>5</sup>As presented in Besley and Ghatak (2010).

<sup>&</sup>lt;sup>6</sup>Do and Iyer (2008) finds that people in provinces with a higher level of LUC registration invest more in long-term crops; Nguyen (2019) finds that farmers with land titles are more likely to plant high-yield rice varieties.

developing world" (Do and Iyer, 2008). The details of the program created variation in the timing and levels of land use certification. I present a simple model to formalize the arguments behind the channels through which better land rights (i.e., having land titles) can affect migration decisions. The model predicts a potential ambiguous effect of land titling on migration and anticipates that the effects on migrating for work and migrating for education vary by wealth level.

Using household-level panel data on migration and land ownership from the Vietnam Access to Resources Household Survey (VARHS), I study the effect of having land titles on the decision to migrate at the household level and examine how the effects differ across groups. Using a difference-in-difference setup, I find that having land titles increase the probability that a household has a migrant member by 5.2%. Accounting for household size, on average, having land titles increases 0.086 migrants per household, which amounts to an increase of about 26% over the mean. My results are robust to multiple data specifications.

I also find that land title holdings matter the most for the migration decisions of households in the middle of the wealth distribution (measured by land holdings and income). Using a simple theory, I illustrate how this is consistent with a credit channel story where sufficiently rich households are not bound by credit constraints, while households that are at the bottom of the distribution still cannot afford to migrate even with some relaxation from having land titles. The middle-wealth households are those who are around the credit threshold and get the right amount of push from improved land rights. I find that the effect of land rights on migration is not only heterogeneous in household wealth distribution but also in the types of migration. For employment migration, having land titles matters only for small landholders and not for large landholders. The opposite occurs for education migration: the effect is only significant for the richest households. Given that the cost of moving for work can be substantially less than the cost of attaining education in an urban area, this is more evidence in support of the presence of the credit channel.

I also find that the increase among young migrants is larger than older migrants as a result of getting land titles. The effects are similar for both men and women, but the two groups are induced to migrate for different reasons. Males are positively induced to migrate for work, while women are significantly and positively induced to migrate for education. This finding shows an aspect that has not been studied in the literature: the ability to invest in higher education through migration because of improved land rights. Given that in Vietnam, universities are only available in big cities and not in rural areas, this channel can be important.

My paper contributes to a literature that studies the frictions and barriers that restrict

rural-urban migration in developing countries.<sup>7</sup> However, empirical studies of the effect of land rights on migration have yielded mixed results. Valsecchi (2014) and de Janvry et al. (2015) show evidence of a general positive effect of land titling programs on migration in Mexico. Chernina et al. (2014) find a dramatic increase in internal migration in Russia in the early 1900s at the provincial level due to the Stolypin land titling reform. Mullan et al. (2011) find a significant and positive effect of tenure security on migration only for households with forest land in China, while for agricultural households, the effect is negative. In the study of migration in Ethiopia, de Brauw and Mueller (2012) find that households with higher perceived transferability have less migration. This paper provides evidence about a wealth heterogeneity effect of land rights on migration of financial constraints is only meaningful for those who are close to the threshold, it predicts the effects depend on the level and distribution of wealth of the population in each study. In contrast to most of these papers which focus only on general migration or employment migration, my paper also looks at migration for education.

My paper is also in line with the extensive literature on the impact of well-defined property rights on broader economic outcomes. Besley (1995), Banerjee et al. (2002), Deininger and Jin (2006), Do and Iyer (2008), Goldstein and Udry (2008), Fenske (2011), Nguyen (2019) and many other papers have looked at the effect of land rights on agricultural investment. de Janvry et al. (2015) is most closely related to this paper. They also argue that delinking the land rights from land use by issuing land titles increases migration. My study finds a similar result, but it also adds insight into the channels through which land rights affect migration by observing patterns of wealth heterogeneity. In addition, my study provides a new potential effect of getting a land title, migration for education, which means investing in human capital by obtaining higher education in an urban area. The welfare gain of migration may be underestimated in other studies since the return on higher education is not calculated as part of it or is not well observed in the short run.

The rest of the paper is organized as follows. Section 2 provides some background information about Vietnam's land titling program. Sections 3 and 4 introduce a theoretical framework and the data set used in the study. Sections 5 and 6 discuss the empirical analysis and regression results. Section 7 concludes.

<sup>&</sup>lt;sup>7</sup>Gollin and Rogerson (2010) emphasize the importance of transportation; Bryan et al. (2014) and Angelucci (2015) look at credit constraints, while Fernando (2018) finds that inheriting agricultural land reduces the likelihood of migration; and Munshi and Rosenzweig (2016) argue that rural insurance networks can deter urban migration.

### 2 Background of the land titling program in Vietnam

This section gives some background about the introduction of the land titling program in Vietnam and how the issuance of land titles creates variation across households.

After the Vietnam War ended in 1975, farmers were organized to work on collective farms and paid based on the number of attended work days. Due to the system's inefficiency which led to output shortages, in 1981 the Communist Party initiated a new arrangement that only required farmers to deliver a certain level of output to the cooperative and allowed them to keep or market any surplus above the quota. In 1988, following Resolution 10, land was allocated to households, usually based on household size. Individuals took control of cultivation decisions and production output. Land tenure was 10-15 years for annual crops and one or two planting cycles for forestry and perennial crops. Although households had use rights, land market transactions such as trading or renting remained illegal until 1993. The 1993 Land Law gave households the right to transfer, exchange, lease, inherit, and mortgage through the issuance of land use certificates (LUCs). LUCs have a duration of 20 years for annual land, 50 years for perennial and forestry land. They can generally be renewed when the terms expire if land holders comply with the designated use of the land given by its LUC. The ownership of all land is still reserved by the state, but having land titles facilitate land transactions and give households a high level of tenure security. Households also receive compensation in case of expropriation. By 2000, nearly 11 million land titles had been issued to rural households, making this "one of the largest rural titling programs in the developing world" (Do and Iyer (2008)).

The details of the program created variation in the timing and levels of land use certification. To acquire land use certificates for their plots, individuals first submitted an application for the LUC. After that, the District Bureau of Land Administration did the groundwork, examining each commune to see if the application information provided was correct and whether there had been any conflicts over the land. According to Do and Iyer (2008), the process of issuing LUCs was time consuming because of the limited human capacity and financial constraints of the Bureau of Land Administration at the district level. Because of the tedious work, not all households obtained LUCs for their plots at the same time; the rollout was instead staggered. Additional variation in LUC status between households has a number of causes. First, some of the households do not have eligible documents to prove their claim to the land. In many cases, when joining collective farms before 1988, households contributed their own land to the farms and took it back after 1988, when the collective farms collapsed. Without written agreements for both events, they continued to use and cultivate this land (without conflict), but could not provide enough evidence to get an LUC.<sup>8</sup> Second, some households have cultivated unclaimed land without conflict despite not having an LUC. Third, in many communes, a form of collective farm still exists to coordinate and promote agricultural activities among farmers. These collective farms also own a fair amount of land that is distributed and rotated among households so that each household has the opportunity to cultivate higher-quality land. These rotating collective farm plots do not have LUCs. Last but not least, some plots do not receive certification because of unresolved land conflicts. Local governments are sometimes also reluctant or very slow to resolve these conflicts.

In many of the cases mentioned above, the variation in LUC holdings appears to be exogenous due to the transition process and historical events, but it can also be confounded by selection. There might be concern that highly educated, wealthier, more politically connected households will get land titles before the rest of the population. Given this study look at the years 2006-2010, a period long after the introduction of the 1993 land law, these selection biases should already be diminished. Even though there is a process of applying for the land titles, the timing of households getting LUCs can be thought of as random. Having said that, in the empirical analysis, I minimize potential endogeneity by using household fixed effects and region-time fixed effects to control for some innate differences in households as well as potential characteristics in certain regions over time. I also use a placebo test as a robustness check.

### 3 Theoretical framework

Theoretically, well-defined land rights can affect migration through improving tenure security, relaxing credit constraints through increased use of land collateral, and facilitating land transactions. First, land insecurity opens upthe possibility of expropriation. To avoid this risk, households have to assign labor to actively occupying and using the land. Improving tenure security releases this type of labor and thus, encourages migration. However, a higher level of security also means more agricultural investment, and this can lead to higher agricultural return, which attracts labor to stay on the farm. These two competing forces imply an indeterminate effect of the tenure security channel. Second, with land titles, people without liquid resources to pay the (initial) cost of migration can borrow money using their land as collateral to fund their trips. Third, when land transactions are prohibited, households cannot sell or rent out their land when they are away. Transferability allows households to

<sup>&</sup>lt;sup>8</sup>The recent 2013 land law allows individuals to apply for LUCs in this type of situation.

keep, at least, some profit from the land and hence reduce the cost of migration.

To fix ideas and formalize the arguments for these channels, I propose a simple model of two agents: old and young. The model will form testable hypotheses about the effects of land rights on the migration decisions of different groups of households. It can also help distinguish the results for two types of migration: employment migration and education migration.

Each individual is endowed with ability z, drawn from the distribution of the CDF  $\Phi(z)$ . Two types of agents, *old (o)* and *young (y)*, have the same distribution of ability but differ in their life cycle. *Old* people live for only one period while *young* people live for two periods. Each person has three choices of jobs: working on a farm in the village, working in non-farm jobs in urban areas (migrate), and going to school in urban areas (migrate). The income for working is  $w_i z$ , where *i* can be *a* (agriculture) or *n* (non-agriculture), assuming  $w_n > w_a$ . Costs for migrating for work and migrating for school are respectively  $f_w$  and  $f_s$ . When migrating to work outside the village, a person can still earn some profit from their land *T* by renting out the land:  $\alpha T$ . The parameter  $\alpha \in [0, 1]$  determines how much one receives from utilizing her land while away. In the extreme case where land transactions are not allowed,  $\alpha = 0$ . Note that  $\{w_a z > \alpha T$  for all z, which means return on agricultural land is always higher when you work on the farm yourself. While not staying on their rural land, migrants face the expropriation risk of probability g.

*Problem of 'old' people* – An *old* person chooses the option that maximizes her income among three options subject to financial constraints:

}

$$\max\{\underbrace{w_a z}_{\text{work on farms}}; \underbrace{w_n z + (1-g)\alpha T_i - f_w}_{\text{migrate for work}}; \underbrace{(1-g)\alpha T_i - f_s}_{\text{migrate for education}} \\ \text{s.t. } A_i + \frac{\rho T_i}{1+r} \ge f_w \text{ if choosing the second option} \\ \text{ or } A_i + \frac{\rho T_i}{1+r} \ge f_s \text{ if choosing the third option.} \end{cases}$$

where  $A_i$  is its liquid asset,  $T_i$  is the amount of landholdings,  $\rho$  is the collateral multiplier that depends on the land rights status, and r is the interest rate. With a legal certificate of land use rights, a piece of land used as collateral would have a higher value from the perspective of banks since its seizure cost is lower. Thus, better land rights means a higher value of  $\rho$  and borrowing capacity for the household.

Since  $w_a z > \alpha T_i$ , it does not make sense for an *old* person to go to school outside the village, because she always earns more working on her farm  $(-f_s + (1-g)\alpha T_i < w_a z)$ . Old

people choose to work outside if the return is higher than working on the farm and they can afford the cost of moving:

$$w_n z + (1 - g)\alpha T_i - f_w \ge w_a z \tag{1}$$

$$A_i + \frac{\rho T_i}{1+r} \ge f_w \tag{2}$$

Solving for the cut-off z in equation (1) yields  $\underline{z}_o = \frac{f_w - (1-g)\alpha T_i}{w_n - w_a}$ . Old people with ability  $z \ge \underline{z}_o$  and satisfaction of the financial constraint (2) will choose to work outside.

Problem of 'young' people – A young person chooses the option that maximizes her income among three options:

$$\max\{\underbrace{(1+\beta)w_a z}_{\text{work on farms}};\underbrace{(1+\beta)[w_n z + (1-g)\alpha T_i] - f_w}_{\text{migrate for work}};\underbrace{[\gamma\beta w_n z + (1+\beta)(1-g)\alpha T_i] - f_s}_{\text{migrate for education}}\}$$
  
s.t.  $A_i + \frac{\rho T_i}{1+r} \ge f_w$  if choosing the second option  
or  $A_i + \frac{\rho T_i}{1+r} \ge f_s$  if choosing the third option.

where  $\gamma$  represents the education multiplier, i.e., how much one's wage increases after attaining higher education.  $\beta$  is the discount factor of earnings in the second period. Note that  $\gamma\beta > 1 + \beta$  for an individual to ever choose to go to school. When satisfying the financial constraint (2), *young* people decide to migrate for work outside of the village if their return is better than both of the other options. Solving for the cut-off ability,  $\underline{z}_y$  and  $\overline{z}_s$  are the lower bound and upper bound in order for *young* people to migrate for work.

$$z \ge \underline{z}_y = \frac{f_w - (1+\beta)(1-g)\alpha T_i}{(1+\beta)[w_n - w_a]} \tag{3}$$

$$z \le \bar{z}_s = \frac{f_s - f_w}{[\gamma\beta - (1+\beta)]w_n} \tag{4}$$

For this group of work migrants to be a non-empty group,  $\underline{z}_y \leq \overline{z}_s$ . This is true if

$$f_s \ge \frac{\gamma\beta w_n - (1+\beta)w_a}{(1+\beta)(w_n - w_a)} \times f_w + \frac{(1-g)\alpha T_i[\gamma\beta - (1+\beta)]w_n}{w_n - w_a}$$
(5)

The multiplying term of  $f_w$  is greater than one, implying that the cost of migrating for school is higher than the cost of migrating for employment. It is realistic given that besides



Figure 1: Migration decisions of 'young' and 'old' people based on their abilities

living costs, students also have to pay for tuition and other educational expenses such as books.

Young people choose to go to school outside of their villages if:

z

$$z \ge \bar{z}_y = \frac{f_s - (1 - g)\alpha T_i}{\gamma\beta w_n - (1 + \beta)w_a} \tag{6}$$

$$\geq \bar{z}_s$$
 (7)

$$A_i + \frac{\rho T_i}{1+r} \ge f_s \tag{8}$$

The ability cut-off for people who want to go to school is  $\max\{\bar{z}_y, \bar{z}_s\}$ . The condition for  $\bar{z}_s > \bar{z}_y$  is again the inequality in (5). Thus, if (5) is satisfied, the choice of agent is based on their ability as in Figure 1. The migration cut-off value for old people  $(\underline{z}_o)$  is higher than that of young people  $(\underline{z}_y)$ , because of the term  $1 + \beta$ . It is not surprising since young people have a longer time to work if they choose to migrate; thus they are more likely to offset the initial fixed cost.

Implications of improved land rights – Better land rights increase tenure security (probability of expropriation g decreases), relax credit constraints through collateralizing land ( $\rho$  increases), and facilitate land transactions, which means one can rent out or exchange her land even if she is away ( $\alpha$  increases). These effects imply a decrease in the cut-off values  $\underline{z}_y$  and  $\underline{z}_o$  and a relaxation of the financial constraints in equations (2) and (8) that would positively influence migration. However, improved land rights can also potentially increase agricultural return,  $w_a^9$ , which may dis-incentivize people from migrating. Thus the direction of land titling's impact on migration is ambiguous theoretically but can be

<sup>&</sup>lt;sup>9</sup>Do and Iyer (2008) find that people in provinces with higher levels of LUC registration invest more in long-term crops; Nguyen (2019) finds that farmers with land titles are more likely to plant high-yield rice varieties.

tested empirically using data.

Implication 1: Land titling's impact on migration is ambiguous in sign because of three positive forces (lower probability of expropriation, higher value of collateral, and ability to rent out land) and one negative force (higher agricultural return).

For people with sufficient ability to make migration more profitable than staying on the farm, the initial fixed costs of moving can hinder their migration decision:  $A_i + \frac{\rho T_i}{1+r} < f_k$ , where  $k \in \{w, s\}$  and  $f_s > f_w$ . With land titles used as collateral (an increase in  $\rho$ ), the credit constraints are relaxed for these people. However, this relaxation is only meaningful for those whose financial abilities are very close to the thresholds. In other words, people who are rich enough so that the constraint is not binding will not see any effect of getting land titles. There could also be potential migrants with assets well below the initial costs of migration who will not be able to afford it even after obtaining land titles.

Implication 2 (Wealth heterogeneity): Improved land rights will have larger impacts for those who are close to the financial threshold. Since  $f_s > f_w$ , migration for education will be most affected in the top wealth group while migration for work might be most affected in the lower wealth group.

At each level of wealth, young people are more likely to migrate than old people, assuming the same distribution of ability. With the obtainment of land titles, the financial constraints are relaxed for both old and young people. If everything else stays the same, young migrants will increase more than old migrants. If improved land rights lower the migration cut-off values (and thus, increases migration), then the cut-off for young people  $\underline{z}_y$  will be lower more than the cut-off for old people  $\underline{z}_o$ .

Implication 3: If improved land rights have positive effects on migration, then the effect will be larger for young individuals than old ones at each level of wealth.

These hypotheses can be tested using the data from rural households in Vietnam, as presented in the next section.

### 4 Data

The data come from the Vietnam Access to Resources Household Survey (VARHS), conducted every other year since 2006. Even though the VARHS data is not nationally representative, the sample of VARHS households resembles, to a large extent, the samples in the representative Vietnam Household Living Standard Survey (the Vietnamese version of the LSMS), which is a nationwide survey. The VARHS data is particularly suitable for this study of rural households in that it It covers 12 provinces across the country,<sup>10</sup>, focusing mostly on the rural areas. Using information from the household rosters in the surveys of 2006, 2008, and 2010, I build a panel data set of households with migration information.

The definition of migration in this study is similar to what has been defined as seasonal migration in other studies.<sup>11</sup> It is as follows: a "migrant member" is a household member who was absent for at least one month in the last 12 months; a migrant household is a household that has at least one migrant member. The explanatory variable of interest is a measure of land rights ownership. Households were asked to report all their plots of land, including residential and agricultural lands, and whether each plot has a land use certificate (LUC) or as it is often called in Vietnam, the "red book". I look at whether a household has any LUCs and the share of the household's plots that are certificated among all the plots that they own.

Table 1 presents the summary statistics for the balanced panel data of 1,910 households from the VARHS 2006-2010. Most of the household head characteristics do not change very much over time (except for age); household size seems to slightly decrease in 2010. Households accumulate more durable assets and savings over time. However, total land holdings as well as the average number of plots households own appear to decline over time. The independent variables of interest "have any LUC" (whether households have any LUC over their land) were 85% in 2006, 80% in 2008, and 85% in 2010. We do not see a linear increase over time because some of the households are inconsistent in their LUC reports. There are plots that were claimed to have LUCs in 2006 (2008) but later reported to not have LUCs in 2008 (2010). If I exclude these "inconsistent households" then the dummy variable of having an LUC would be 82% in 2006, 84% in 2008, and 92% in 2010 (Table A1). In my main empirical analysis, I will include all households to utilize the largest sample possible, but the results hold when omitting the "inconsistent households".

Table 2 reports more details of the migration patterns of Vietnamese rural households. About a quarter of households in the sample have some members that migrate; of these, 60% are men. The average age for migrants of both genders decreases over time as over the years a higher fraction of them are sent out for education rather than work. The people who migrate for work are predominantly male, while female members often migrate for education. Migrants' overall level of education is much higher than the education level of the rest, with 42% of migrants finishing high school in 2006 compared to only 11% of non-migrant individuals. The gap narrows in 2010 (55% and 27% respectively). Although

<sup>&</sup>lt;sup>10</sup>They are Dak Lak, Dak Nong, Dien Bien, Ha Tay, Khanh Hoa, Lai Chau, Lam Dong, Lao Cai, Long An, Nghe An, Phu Tho, and Quang Nam.

<sup>&</sup>lt;sup>11</sup>See de Brauw and Harigaya (2007), for example.

my survey data do not distinguish whether it is rural-urban or rural-rural migration, about 75% of rural migration in Vietnam is rural-urban migration, according to United Nation Development Programme (UNDP) statistics.

### 5 Empirical analysis

I estimate the impact of land rights on migration for household i in commune c at time t,  $y_{ict}$ , using the following regression equation:

$$y_{it} = \alpha + \beta LUC_{it} + u_i + \gamma_{ct} + \epsilon_{ict} \tag{9}$$

where  $y_{ict}$  is a measure of migration, which can be a dummy variable of whether the household has any migrants or the number of household members that migrate;  $LUC_{it}$  is the status of formal land title holdings, which can be a dummy variable of whether a household has LUCs or the fraction of area of the household that has LUCs. The regression also includes household fixed effects  $u_i$  and commune-year fixed effects  $\gamma_{ct}$  which control for any household-specific characteristics and commune-specific trends. The commune level is a relevant geographic unit: it is the smallest administrative unit, containing one or more villages with an average of 1,600 households per commune.

In order to identify the causal effect, the main assumption is that  $\epsilon_{ict}$  is not correlated with  $LUC_{it}$ . Recall that the rollout of the program created variation in LUC that is plausibly exogenous. Furthermore, panel data allows me to control for household fixed effects  $u_i$  and commune-time fixed effects  $\gamma_{ct}$  that partially mitigate the issue of selection. Household fixed effects can account for household-specific characteristics such as household size, productivity, head's age, gender and education, or political connection. The commune-time fixed effects  $\gamma_{ct}$  can account for any input price shocks, the season's weather and any natural disasters such as flood, drought, or unusual cold weather specific to the region that may induce flows of migration. In addition,  $\gamma_{ct}$  can also control for variation in the local land title registration process between communes over time. The large number of controls makes it unlikely that my results are driven by omitted variables. The variables that I do not control for have to be very particular, namely time-varying household-specific variables that vary within the commune.

The identification strategy relies on the assumption that households that get an LUC during the time period surveyed (treated) and the ones that have never got any LUC (control) should behave the same if they both do not get the land titles. To support this assumption, I have done a placebo test that assigns households that received LUC in 2010 to receive LUCs in 2008.

I will then test the hypotheses discussed in the theoretical framework section to distinguish the effect of land rights on different types of migration as well as different groups of people. Based on the amount of landholdings and income of households in 2006, I divide households into different groups in the wealth/income distribution. Specifically, I will break them down into two groups of small landholders and large landholders (below and above the median) and into quartiles. I then run the same regression as in equation (9) for each group.

Regression results are presented below.

## 6 Empirical results

In this section, I first look at the effect of land rights on migration both at the extensive and intensive margins. I will then examine the wealth heterogeneity in the effects across different types of migration. Lastly, I present regression results for different age and gender groups.

#### 6.1 The effects of land rights on migration

I first estimate equation (9) using the VARHS panel data to establish the relationship between land titles obtainment and household's decision to migrate. I find a positive link between having land titles and migration. The first three columns of Table 3 shows the relationship between multiple measures of land title possession and whether a household has any migration during the year. The coefficient  $\beta$  is positive and statistically significant at 5% level in column (1): having an LUC increases the chance that the household sends out at least one migrant by 5.2%. Given that in 2006, 24% of households had a migrant member, this increase is equivalent to about 22% of the mean, which is certainly non-trivial. The magnitude is similar to what has been found by de Janvry et al. (2015). The estimated coefficient is smaller and not significant, albeit positive in column (2), where land rights were measured by the fraction of plots that got LUCs among all the plots owned by a household. How much of the land was registered with an LUC does not matter as much as whether households have any land that is registered. In column (3), conditional on having the LUC, we see that whether the household has fully registered their land (meaning no fear of expropriation of any plots) also does not matter while having any land titled remains positive and significant.

Columns (4)-(6) of Table 3 report the results of similar regressions, except that here

the outcome variable is the number of migrant members in a household. The coefficients are also positive and significant, even when household size is controlled. In column (4), having an LUC increases the number of migrants per household by 0.086 migrants, which amounts to 26% of the average number of migrants per household in 2006. Again, having all plots fully registered does not have a significant effect conditional on having an LUC. Bigger households are also more likely to have a migrant member.

When migrants are separated by gender, Table 4 shows that the effects are significant for both men and women, and not necessarily dominated by any gender. If any, the increase seems larger for women.

Having better land rights affects both the extensive (migrant household) and intensive (number of migrants per household) margins of migration. The results hold for multiple specifications of the sample: the unbalanced panel, the balanced panel in which the 'inconsistent' households are omitted; or the same balanced panel but where the values of the LUC variable for these 'inconsistent' households are changed to zeros. The estimated coefficients in all these cases are displayed in three panels of Table A2; they display the same signs and are similar in magnitude.

The identification strategy relies on the assumption that households that get an LUC during the time period surveyed (treated) and the ones that have never received any LUC (control) should behave the same if they both do not get the land titles. To support this assumption, I have done a *placebo test* that assigns households that get LUCs in 2010 to hypothetically get the LUC in 2008. Since there are only 3 waves of survey, the group of people who get LUCs for the first time in 2010 is the only group that can be used for the placebo test, since when reassigning them to treatment year 2008, there is still information pre- and post- treatment. Table A3 confirms that there is no effect for the placebo treatment.

### 6.2 Wealth heterogeneity and financial constraints

The model predicts that there is heterogeneity in the effect of having land titles on migration for households with different amounts of land holdings in 2006. Table 5 shows the estimated coefficients for the group of small landholders (below median) and large landholders (above median). Here I also look at the dummy for migrant households and number of migrant members. We see that the effects for people with more landholdings appear to be larger in magnitude for the number of migrants in each household while similar in the extensive margin, although the difference between these two coefficients is not statistically significant.

The second and third rows break down further into the quartiles of the wealth distri-

bution. In both the extensive and intensive margins of migration, households in the third quartile are those whose decisions are most affected as the coefficients for this group are statistically significant and the largest in magnitude among all groups. In this group, having any LUC increases the chance of having a migrant by 16% and the number of migrants by 0.26 per household, much larger than the estimates in the general results. Overall, the middle group observes larger change than the top and the bottom of the distribution. Even though they are not statistically different from each other, the pattern is consistent with the model predictions.<sup>12</sup>

This is consistent with what is predicted by the credit constraints: the effect should be strongest for those who are close to the threshold of the financial constraints. In the case of rural households in Vietnam, it appears that the impact is largest for the middle group (especially the third quartile) because the financial constraints might not be binding for the richest households while it is not enough for the ones with lower wealth level to afford the cost of migration even with the relaxation of credit.<sup>13</sup>

In similar fashion to what we have done with different groups based on the amount of landholdings, we can separate households by their levels of income. The correlation between income and landholdings in the data are 0.12. Table A4 shows the coefficients for each quartile of income groups. The second quartile sees the largest and most precise estimates. Overall, we also see that the middle-income group appears to be most affected.

My theoretical framework also predicts that the financial threshold for people who migrate for work might be different than that of those who are moving away for education because the cost of moving can vary in each situation. If this is the case, we should see that wealth-heterogeneous effects of better land rights on migration are different for each type of migration. I break down the effects of having land titles on migration for different groups of landholdings into two types of migration: migration for employment and migration for education. Table 6 displays the estimated effects of whether a household has any LUC on migration, separated by the purposes of migration. In columns (1) and (2) of panel A, the outcome variable is a dummy of whether the household has any member that migrates for work. For small landholders, the effect is larger in magnitude and also statistically significant at 10%. It is not surprising that better land rights relax financial constraints for small landholders who want to work in an urban area while they do not have a significant effect for large ones.<sup>14</sup> In columns (3) and (4), similarly, the dependent variable is a dummy of

 $<sup>^{12}</sup>$ The third quartile coefficient is statistically different from the first quartile at 15% level.

<sup>&</sup>lt;sup>13</sup>Bazzi (2017) also finds that income shocks have different effects on migration for different wealth groups.

<sup>&</sup>lt;sup>14</sup>Bazzi (2017) also finds that income shocks have a bigger impact on international migration (assumably for work) in Indonesian villages with more small landholders.
whether the household has any member who migrates for education. Even though both estimated coefficients are not significant, it is very close to zero for the small landholders, while positive for large ones.

Panel B shows the same regression, except the dependent variable is the number of migrant members, which tells us more about the intensive margin of migration. The coefficients for work migration are both non-significant but they are still larger in magnitude for small landholders. In terms of migrants who move away for schooling, the coefficient is positive and significant for large landholders, while still very close to zero for the small landholders. The coefficients of columns (3) and (4) in Panel B are statistically different at the 10% level. Indeed, if I break down the wealth distribution further into quartiles, the only group that sees a significant effect is the fourth quartile (Table A5). The effect estimates for this group group show up to be significant on the number of education migrants, while positive and much larger than other groups in both extensive and intensive margins.

As we have seen so far, there are heterogeneous effects of land title possession on migration for different groups of wealth and different types of migration. I have shown that overall, the upper middle group sees the biggest change in migration due to getting land titles. However, the effect on employment migration is stronger among smaller landholders, and the effect on education migration is stronger among larger landholders. These patterns are consistent with the credit channel argument, in which households are financially constrained in funding the cost of migration and being able to use land titles as collateral to borrow money would help them relax these constraints; the people who are closest to the threshold benefit the most. The findings suggest that the cost of migration for employment is smaller than the cost of migration for schooling. Migrants seeking work only need to pay a fixed initial cost to travel to and settle down in the cities, and will receive a higher wage compared to working at home. Education migrants need tuition and living expenses throughout their stay and do not expect to earn money during the period.<sup>15</sup>

If having land titles indeed allows households to relax financial constraints through using land titles as collateral, then we should see them borrow money more. The VARHS also collected information about loans that households make and the main purpose for the loans. Even though respondents did not specify whether they borrow to migrate, they reported education loans. In Table 7, I look at the effect of having LUCs on taking out educational loans, conditional on their previous borrowing for the same purpose and whether they take out any loan at all. In columns (1) and (2), the results show that having an LUC increases

<sup>&</sup>lt;sup>15</sup>Students can certainly work while studying but (1) high school workers are not popular in Vietnam and (2) college students can have part-time jobs but they usually cannot cover a significant part of tuition and living expenses.

at least 3% the likelihood of taking out educational loans (coefficients are positive and significant). As presented above, the richest families are the ones who are closest to the threshold. Thus having land titles is expected to have the largest effect on this group. Indeed, columns (3) and (4) show that having an LUC increases the probability of taking out education loans more for large landholders where the coefficients are larger and more precise.<sup>16</sup>

The differential effects shown above offer us a way to reconcile the mixed findings in the literature. First, the effects can depend on the threshold of the financial constraints, which involve level of wealth and cost of migration. If not many people are close to the binding threshold, we might not see a positive effect of land rights on migration. The relative level of wealth of the population we are looking at is important whether we see an effect or not.<sup>17</sup> Second, most of the papers in the literature only focus on people who migrate for work or look for jobs, while neglecting another type of migrant who goes to urban areas to attain education; other studies cannot distinguish the two. Migration for higher schooling is particularly relevant for the case of Vietnam since universities are only available in big cities.<sup>18</sup> If we only look at employment migration or general migration, the impact could be different.

This finding also highlights another aspect of the effects of improving land rights on economic outcomes: migrating to obtain education. The return on accumulating human capital is longer term, which might not be immediately observed. Studies will underestimate the welfare effect of migration if they only look at employment migration or do not observe over a longer period of time.

#### 6.3 Effects of land titles on different age groups

Another implication of the model is that young people will migrate more than old people as a result of getting titles. In this section, we will break down the migrants into different age groups. Table 8 (with "have any LUC" as the RHS variable) reports the regressions

<sup>&</sup>lt;sup>16</sup>The model also implies that people whose abilities are above the cut-off will migrate, and the highest ability group will migrate for education. One may argue that credit constraint is not the problem here, but the families that have largest land holdings are also the smartest people and thus, when getting land titles, they will be the group that migrates most for schooling. One piece of evidence that may convince us that this is not totally the case is that the average level of education migration among small landholders was not statistically different than that of large landholders in 2006. If only the richest households meet the cut-off for ability, then we should see they migrate for education more than the small landholders.

<sup>&</sup>lt;sup>17</sup>Bazzi (2017) finds that "positive agricultural income shocks increase labor emigration flows, particularly in villages with relatively more small landholders. However, in the most developed rural areas, persistent income shocks reduce emigration."

 $<sup>^{18}</sup>$ In the survey data, 78% of education migrants have a high school diploma and 84% of them are between 17 and 24 years old. We can assume that most of the people migrating for education are going to college or higher.

results of four age groups: below 15 years old, 16 to 35 years old, 36 to 60 years old, and above 60 years old. The dependent variable here is whether a household has a migrant in this age category (row 1) or the number of migrants in this age category (row 2). Among these groups, the estimated effect on the group between 16 and 35 years old is the largest in magnitude: 2.8% for the migrant household dummy and 5.5% for the number of migrants per household; the later is also statistically significant at 10 percent. The second most affected group is between 36-60 years old: the coefficients are positive and statistically significant.

Rows 3 and 4 of the table separate the migrants into work migration and education migration. Again, the value is highest for the younger group 16-35 years old. It is even negative and significant for education migration in the 36-60 age group.

# 6.4 Other results: The effects on different types of migration by gender

In Table 9, I break down the effects by migration for work and education in each gender. If focusing on the work migrants, we see that the positive effect is strongly driven by male (2.6% and 3.4% for the extensive and intensive margins) while the coefficients for female are very close to zero. Even though the coefficients for men's migration are not significant, there is a large difference in magnitude. However, in terms of education migration, the effects are positive and significant only for female migrants. Having an LUC increases a household's probability of sending a girl to study in a different city by 3.6%. Since most increase of female migration is from women going for school, we observe a bigger effect for younger women.<sup>19</sup> Meanwhile, the effect for male migrants for school is close to zero, even negative albeit not significant. The differences between men and women in terms of their purpose for migration in relation to the household getting LUCs may reflect differences in the return to work and the return to schooling for each gender. It is possible that women do not get paid for urban jobs as well as men do; thus they are more likely to pursue a higher education. Some other papers in the literature usually focus on people who migrate to look for jobs and find effects for male migration and not for women. The case of Vietnam shows that the effect can be important to women as they migrate for attaining more schooling and potentially earn higher wages in the future.

 $<sup>^{19}</sup>$ When I break down the age group effects further by male and female migrants, I find that the effect on the groups aged 16-35 is highly driven by female migrants (See Table A6).

### 7 Conclusion

Rural-urban migration is considered one way for people to shift out of agriculture to a more modern sector with higher wages. Understanding what hinders rural households in making the decision to migrate is therefore an important topic in development economics. Lack of well-defined rights over land can discourage migration by imposing a higher cost on moving. Improved land rights impact migration through increasing the level of tenure security, relaxing credit constraints through use of land collateral, and facilitating land transactions. In this paper, using panel data from Vietnam Access to Resources Households Surveys 2006-2010 in a difference-in-difference setup, I show that there is a positive link between having land titles and migration. The effects are heterogeneous for households in different wealth groups and across different types of migration. Specifically, having land titles significantly increases employment migration of the smaller landholders but only affects education migration decisions of the largest landholders. The evidence is consistent with the arguments for the credit channel, in which households that are affected the most are those who are close to financial constraint thresholds. This finding can potentially reconcile, at least partially, the mixed findings in the literature about the effects of land rights on migration. Whether we observe a positive or a negative effect, it would depend on the distribution and the level of wealth of the population of interest.

I also show that the increase in migration of young people is higher than that of older people. There are positive effects for both men's and women's migration but men tend to migrate more for work while women move away more for higher education. While most studies of this topic look at employment migration and thus usually focus on and find more effects for male migrants, this paper shows that women can also benefit from having better land rights through attaining education via migration. Studies that look at the welfare effect of migration may underestimate the impact if they do not take into consideration people who migrate for schooling. We should also be careful when making those calculations because the return on schooling might be long term and not immediately observed.

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*			
	2006	2008	2010
HH size	4.59	4.57	4.35
Head of HH's age	50.24	51.7	53.02
Head's gender	0.81	0.79	0.79
Head's marital status	0.83	0.82	0.82
Head's literacy	0.89	0.87	0.88
HH's durable asset (mil VND)	26.22	28.74	34.14
HH's savings (mil VND)	14.29	13.06	19.13
Total land holdings $(m^2)$	8,875	$7,\!815$	7,700
Average number of plots	5.18	5.08	4.87
Have any LUC	0.85	0.80	0.85
Share of LUC plots <sup>*</sup>	0.87	0.85	0.91
Migrant household	0.24	0.32	0.26
No. of migrant members	0.33	0.49	0.35
No. of migrant members $^{**}$	1.37	1.46	1.34
% migrate for work	55%	58%	43%
% migrate for education	35%	31%	45%
Number of households	1910	1910	1910

Table 1: Descriptive statistics - Benchmark

 $\ast$  conditional on having LUC  $\ast\ast$  conditional on being a migrant household

Table 2: VARHS Panel Data 2006-2008					
	2006	2008	2010		
Households that have migration	0.24	0.32	0.26		
Migrant is male	0.59	0.60	0.63		
Average age for male migrant	29.3	27.0	24.6		
Average age for female migrant	26.8	26.0	24.8		
Male migration for work	0.63	0.55	0.49		
Female migration for work	0.46	0.44	0.25		
Male migration for education	0.29	0.36	0.46		
Female migration for education	0.40	0.43	0.60		
Migrants that finished high school	0.42	0.44	0.55		
General population that finished high school	0.11	0.09	0.27		

Table 2: VARHS Panel Data 2006-2008

	ous of main		in millingradion	*			
	migi	migration dummy			number of migrants		
	(1)	(2)	(3)	(4)	(5)	(6)	
Have LUC	$0.052^{**}$		$0.057^{**}$	$0.086^{**}$		$0.106^{**}$	
	(0.026)		(0.028)	(0.038)		42)	
Share of plots w/ LUC		0.026			0.017		
		(0.026)			(0.031)		
All plots w/ LUC			-0.010			-0.040	
- ,			(0.022)			(0.029)	
HH size			× ,	$0.137^{***}$	0.138***	0.137***	
				(0.015)	(0.015)	(0.015)	
Mean of dependent variable in 2006		0.24			0.33		
Household FE	YES	YES	YES	YES	YES	YES	
Commune-Year FE	YES	YES	YES	YES	YES	YES	
No. of obs	5,720	5,720	5,720	5,720	5,720	5,720	
No. of HHs	1,910	1,910	1,910	$1,\!910$	$1,\!910$	$1,\!910$	
R-squared	0.631	0.631	0.631	0.667	0.666	0.667	

Table 3: Effects of having LUC on migration

Note: "Migration dummy" is outcome variable whether the household has any migrant; "number of migrants" is the number of household members that migrate. Standard errors are clustered at household level. Standard errors in parentheses. \*\*\* p<0.01, \*\* p<0.05, \* p<0.1

	Table 4. Land titles and ingration divided by gender						
	dummy	migration	number o	f migrants			
	(1)	(2)	(3)	(4)			
	male	female	male	female			
Have any LUC	0.030	$0.056^{*}$	$0.040^{**}$	$0.051^{**}$			
	(0.023)	(0.029)	(0.019)	(0.023)			
No. of obs	5,720	5,720	5,720	5,720			
No. of HHs	1,910	1,910	1,910	1,910			
R-squared	0.616	0.621	0.626	0.638			
Household FE	YES	YES	YES	YES			
Commune - Year FE	YES	YES	YES	YES			

Table 4: Land titles and migration divided by gender

"Migration dummy" is outcome variable whether the household has any migrant; "number of migrants" is the number of household members that migrate. Regressions include household FE and commune-year FE. Standard errors clustered at HH level, \*\*\* p<0.01, \*\* p<0.05, \* p<0.1

	dummy	migration	number of	f migrants
	(1)	(2)	(3)	(4)
	$\operatorname{small} \operatorname{LH}$	large LH	small $LH$	large LH
Have any LUC	0.051	0.056	$0.096^{*}$	0.149**
	(0.033)	(0.041)	(0.050)	(0.069)
		dummy r	nigration	
	1st quartile	2nd quartile	3rd quartile	4th quartile
Have any LUC	0.024	0.071	$0.161^{**}$	0.039
	(0.038)	(0.066)	(0.074)	(0.058)
		number of	f migrants	
	1st quartile	2nd quartile	3rd quartile	4th quartile
Have any LUC	0.020	0.147	$0.260^{*}$	0.133
	(0.062)	(0.095)	(0.134)	(0.094)

Table 5: Wealth heterogeneity: effects of land rights on migration for different groups of wealth

"Migration dummy" is outcome variable whether the household has any migrant; "number of migrants" is the number of household members that migrate. Small (large) landholders are those whose amount of landholdings is below (above) the median in 2006. Regressions include household FE and commune-year FE. Standard errors clustered at HH level, \*\*\* p<0.01, \*\* p<0.05, \* p<0.1

	work m	igration	edu migration		
	(1)	(2)	(3)	(4)	
	small $LH$	large LH	small $LH$	large LH	
Panel A: dummy migration LHS					
Have any LUC	$0.0513^{*}$	0.011	-0.002	0.034	
	(0.030)	(0.035)	(0.019)	(0.031)	
Mean of LHS variable	0.	14	0.0	09	
Panel B: number of migrants LHS					
Have any LUC	0.058	0.031	0.009	$0.076^{*}$	
	(0.040)	(0.046)	(0.023)	(0.042)	
Mean of LHS variable	0.18		0.	12	
No. of observations	2,572	2,646	2,572	$2,\!646$	
No. of households	858	884	858	884	

Table 6: Wealth heterogeneity: effects of land rights on work migration and education migration

Outcome variable in row 1 is whether the household has any migrant; outcome variable in row 2 is the number of household members that migrate. The dependent variable is whether the household has any LUC. Small (large) landholders are those whose amount of landholdings is below (above) the median in 2006. Regressions include household FE and commune-year FE. Standard errors clustered at HH level, \*\*\* p<0.01, \*\* p<0.05, \* p<0.1

Table 7: Land titles and education loans						
Take any edu loans	(1)	(2)	(3)	(4)		
	All	All	small $LH$	large LH		
Have any LUC	$0.038^{***}$	$0.030^{***}$	$0.025^{*}$	$0.044^{***}$		
	(0.005)	(0.005)	(0.010)	(0.016)		
Take edu loans in t-1	0.282***	0.263***	0.298***	0.265***		
	(0.028)	(0.026)	(0.052)	(0.042)		
Take any loan		$0.116^{***}$				
		(0.007)				
Observations	$5,\!874$	$5,\!874$	1,704	1,860		
R-squared	0.071	0.132	0.070	0.064		

Regressions include household FE. Small (large) landholders are those whose amount of landholdings is below (above) the median in 2006. Standard errors are clustered at household level. Standard errors in parentheses. \*\*\* p<0.01, \*\* p<0.05, \* p<0.1

	0		1 0 0	-
	(1)	(2)	(3)	(4)
Indep. var: have any LUC	$<\!\!15$	16-35	36-60	$>\!60$
dummy migration	0.002	0.028	$0.022^{*}$	0.006
	(0.006)	(0.022)	(0.012)	(0.006)
number of migrants	0.008	$0.055^{*}$	$0.026^{*}$	0.004
	(0.008)	(0.032)	(0.014)	(0.008)
work migrants	-0.003	0.027	0.015	-0.001
	(0.004)	(0.027)	(0.012)	(0.001)
edu migrants	0.007	0.031	-0.003*	0.000
	(0.005)	(0.021)	(0.002)	(0.000)
	. ,	. ,	. ,	. ,
Observations	5,720	5,720	5,720	5,720

Table 8: Land titles and migration divided by age groups

Regressions include household FE and commune-year FE and control for the number of household members in the corresponding age group. Standard errors are clustered at household level. Standard errors in parentheses. \*\*\* p<0.01, \*\* p<0.05, \* p<0.1

	Work m	Work migration		on migration
	(1)	(2)	(3)	(4)
Indep. var: have LUC	male	female	male	female
dummy migration	0.026	0.006	-0.011	0.036***
	(0.019)	(0.014)	(0.013)	(0.012)
migrant members	0.034	0.003	-0.006	$0.041^{***}$
	(0.023)	(0.016)	(0.015)	(0.015)
Observations	5,720	5,720	5,720	5,720

Table 9: Land titles and migration divided by reasons for migration and gender

P	0000100			
	2006	2008	2010	inconsistent HH 2006
HH size	4.48	4.47	4.27	4.9
Head of HH's age	50.90	52.40	53.89	48.25
Head's gender	0.81	0.79	0.80	0.81
Head's marital status	0.83	0.82	0.82	0.84
Head's literacy	0.91	0.88	0.90	0.85
HH's durable asset (mil VND)	23.5	24.05	38.04	34.14
HH's savings (mil VND)	14.37	13.76	19.93	14.05
Total land holdings $(m^2)$	$7,\!997$	7,758	$7,\!697$	11,490
Average number of plots	5.04	4.94	4.75	5.58
Have any LUC	0.82	0.84	0.92	0.95
Share of LUC plots <sup>*</sup>	0.88	0.90	0.94	0.84
Migrant household	0.25	0.33	0.26	0.22
No. of migrant members	0.35	0.49	0.35	0.28
No. of migrant members <sup>**</sup>	1.40	1.50	1.36	1.31
% migrate for work	56%	50%	37%	
% migrate for education	33%	39%	51%	
Number of households	1,430	1,430	1,430	480

Table A1: Descriptive statistics - omit "inconsistent HH"

 $\ast$  conditional on having LUC  $\ast\ast$  conditional on being a migrant household

"inconsistent" households are the ones who claim they have LUC for a particular plot in 2006 (2008) but later report the plot does not have LUC in 2008 (2010).

	migration dummy		number of migrants			
	(1)	(2)	(3)	(4)	(5)	(6)
Panel A: unbalanced par	rel					
Have LUC	$0.041^{**}$		$0.050^{**}$	$0.059^{*}$		$0.080^{**}$
	(0.020)		(0.022)	(0.030)		(0.034)
Share of plots w/ LUC		0.012		0.017		
		(0.021)		(0.031)		
All plots w/ LUC			-0.018			-0.040
			(0.019)			(0.029)
No. of obs	$7,\!850$	$7,\!850$	7,850	$7,\!850$	$7,\!850$	7,850
No. of HHs	3,004	$3,\!004$	3,004	3,004	3,004	$3,\!004$
R-squared	0.641	0.640	0.641	0.685	0.685	0.686
-						
Panel B: balanced panel	- drop 'in	consisten	t' household	ls		
Have LUC	$0.070^{*}$		$0.078^{*}$	0.080		0.113*
	(0.038)		(0.041)	(0.056)		(0.059)
Share of plots w/ LUC		0.029	( )	0.049		
1 /		(0.040)		(0.059)		
All plots w/ LUC			-0.016	· · · ·		-0.062
1 /			(0.029)			(0.042)
			( )			
No. of obs	4,290	4,290	4,290	4,290	4,290	4,290
No. of HHs	1,430	1,430	1,430	1,430	1,430	1,430
R-squared	0.647	0.646	0.647	0.685	0.685	0.685
Panel C: balanced panel	- consider	· 'inconsia	stent' house	holds do not	have $L$	UC
Have LUC	0.054**		0.053**	$0.093^{***}$		0.095***
	(0.023)		(0.024)	(0.035)		(0.036)
Share of plots w/ LUC		0.026	( )	0.057		
1 /		(0.026)		(0.040)		
All plots w/ LUC			0.004	· · · ·		-0.011
1 /			(0.020)			(0.031)
			<pre> - /</pre>			<pre> - /</pre>
No. of obs	5,720	5,720	5,720	5,720	5,720	5,720
No. of HHs	1,910	1,910	1,910	1,910	1,910	1,910
R-squared	0.631	0.631	0.631	0.667	0.666	0.667
1	0.00-	0.00-	0.00-		5.000	

Table A2: Effects of having LUC on migration - Robust check (other specifications)

Note: "Migration dummy" is outcome variable whether the household has any migrant; "number of migrants" is the number of household members that migrate. Regressions include household FE and communeyear FE. Standard errors are clustered at household level. Standard errors in parentheses. \*\*\* p<0.01, \*\* p<0.05, \* p<0.1

	(1)	(2)			
	dummy migration	number of migrants			
Have any LUC	-0.0096	0.0192			
	(0.0555)	(0.0875)			
Number of observations	208	208			
R-squared	0.547	0.497			
Household FE	YES	YES			

Table A3: Placebo test for households that get LUC in 2010

Standard errors are clustered at household level. Standard errors in parentheses. \*\*\* p<0.01, \*\* p<0.05, \* p<0.1

	(1)	(2)	(3)	(4)
Indep. var: have any LUC	1st quartile	2nd quartile	3rd quartile	4th quartile
dummy migration	-0.015	$0.097^{*}$	0.024	0.024
	(0.062)	(0.055)	(0.059)	(0.078)
number of migrants	0.072	0.124	0.086	0.091
	(0.094)	(0.091)	(0.091)	(0.119)
Household FE	YES	YES	YES	YES
Commune - Year FE	YES	YES	YES	YES

Table A4: Income heterogeneity: Effects of land rights on migration for different groups of income

	Independent variable: Have any LUC			
	(1)	(2)	(3)	(4)
	1st quartile	2nd quartile	3rd quartile	4th quartile
LHS: dummy migration	0.031	-0.038	0.029	0.054
	(0.024)	(0.038)	(0.056)	(0.043)
LHS: number of migrants	0.0363	-0.0276	0.0613	$0.119^{*}$
	(0.0279)	(0.0472)	(0.0728)	(0.0659)
No. of observations	$1,\!142$	$1,\!142$	1,140	$1,\!140$
No. of households	381	381	380	380

Table A5: Wealth heterogeneity: Effects of land rights on education migration

	(1)	(2)	(3)	(4)
Indep. var: have any LUC	$<\!\!15$	16-35	36-60	>60
male dummy migration	$0.011^{**}$	0.007	0.014	0.003
	(0.005)	(0.019)	(0.011)	(0.004)
female dummy migration	-0.006	$0.030^{*}$	0.011	0.001
	(0.004)	(0.017)	(0.008)	(0.006)
Observations	5,720	5,720	5,720	5,720

Table A6: Land titles and migration divided by gender and age groups





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## Land Rights and Technology Adoption: Improved Rice Varieties in Vietnam

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# Land Rights and Technology Adoption: Improved Rice Varieties in Vietnam

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ABSTRACT Adopting improved seed varieties is a type of agricultural investment that has substantially ensured food security in developing countries and helped farmers transition out of poverty. This paper examines the impact of land rights on the adoption of high-yield rice varieties by farmers in Vietnam. Using panel data from representative surveys of Vietnamese households, I find that having land-use certificates has a positive influence on households' adoption of improved rice varieties. Additionally, I explore the channels through which land rights affect improved seeds adoption. Within households, having a land title matters at the plot level, which suggests the significance of the tenure security channel. I also find evidences of the credit channel, in which holding land titles encourages a household to take loans for rice production.

#### 1. Introduction

Having secure property rights over land is often considered important for economic development, especially for promoting investment in more efficient agricultural technology. Theoretically, welldefined property rights can provide farmers with incentives for agricultural investment (see Besley, 1995). The lack of tenure security may discourage cultivators from making investments that will generate profit in the future since they will not be able to collect on its return if their land is taken away. In contrast, land ownership could greatly reduce the fear of eviction, potentially help farmers access credit more easily using land as collateral, and/or enhance factor mobility via transfer rights. The empirical findings of the link between land rights and agricultural investment, however, appear to be inconclusive: the direction is sometimes ambiguous and the magnitudes are often small<sup>1</sup>. The literature also suggests that the relationship depends on the type of investment (Fenske, 2011). Most of the papers that study this relationship focus on soil-improving and conservation technologies, such as terracing, mulching, tree planting, irrigation, and manure fertilisers. In this paper, our technology of interest is improved crop varieties, a productivity-enhancing technology that has been shown to substantially ensure food security in developing countries and help farmers transition out of poverty<sup>2</sup>. Prior literature has focused much more on long-term decisions, often posed as a 'fixed cost', while there is little attention on short-term investments like improved seeds. It is therefore essential to study the link between land rights and improved seed adoption and the channels of this effect.

This study examines the impact of land certification on farmers' adoption of improved rice varieties in Vietnam. Vietnam presents a good case to examine this relationship for two reasons. First, Vietnam underwent a formal land-titling process which produced variation in land rights among

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farmers. The land law of 1993 legalised households' rights to *transfer, exchange, lease, inherit, and mortgage* their land-use rights by issuing land titles to households, inducing one of the largest rural titling programmes in the developing world (Do & Iyer, 2008). Second, Vietnam has been and remains dominated by a single staple crop, rice, which allows for easier measurement of the adoption of improved varieties. Since the 1980s, many improved rice seeds, including both hybrid and improved ordinary varieties, have been developed and introduced to farmers in Vietnam. Rice yields and rice production have continually increased over the years, making the country one of the world's largest rice-producing and rice-exporting countries. The results of this paper, nevertheless, have important implications for other Asia and African countries, especially those in Sub-Saharan Africa, where the level of the adoption of modern varieties is still quite low.<sup>3</sup>

I build a theoretical framework that presents a two-period model that shows the links between land rights and improved seeds adoption. An increase in land rights leads to a higher level of improved seed adoption through improving tenure security and relaxing credit constraints. For empirical analysis, I use data drawn from the Vietnam Household Living Standards Survey (VHLSS) and the Vietnam Access to Resources Household Survey (VARHS), both of which have wide geographic coverage across Vietnam and are fairly representative of the population of households. These data allow me to form quasi-panel and panel data across many years (1998-2004 from VHLSS and 2006–2012 from VARHS) to perform my analysis. Land titles in Vietnam are in the form of land use certificates or LUCs. I find that having an LUC has a positive impact on households' adoption of improved rice varieties during the 1998-2004 period. At the household level, having an LUC increases the probability of planting any high-yield rice varieties by 3.5%. I also find suggestive evidence of this positive link in 2006–2008 though they are not as clear. At the plot level, having an LUC on a particular plot also affects the probability of planting improved rice seeds after controlling for the plot's characteristics and its quality relative to other plots owned by the household. This finding suggests the significance of the tenure security channel. I also find evidences of the credit channel, in which holding land titles encourages a household to take loans for rice production.

This paper contributes to an existing literature on the relationship between land rights and agricultural investment. One of the biggest issues in this literature is potential endogeneity from reverse causality: investments may be made in order to increase tenure security rather than as a result of better tenure security (see Besley, 1995; Deininger & Jin, 2006). Most of the papers in this area focus on land-improving technologies such as soil and water conservation (see Abdulai, Owusu, & Goetz, 2011; Brasselle, Gaspart, & Platteau, 2002; Deininger & Ali, 2008; Deininger & Jin, 2006). Relative to these papers, the novel aspect of my paper is its focus on a specific type of technology – improved varieties adoption, which should not suffer from reverse causality. While investment in land-improving technologies may strengthen one's right to land, the fact that someone chooses to plant improved seeds instead of regular seeds does not appear to enhance tenure security or whether a household is granted land titles. Nevertheless, as illustrated in my theoretical model, improved seeds have an investment aspect to them because of the requisite learning curve in their adoption.<sup>4</sup> Their educational effort made to acquire cultivation skills will bring benefit in the next period instead of the current one. Moreover, while most of these papers have only cross-sectional data, one advantage of my study is the availability of panel data that allows me to track households' investment decisions over time while controlling for household fixed effects. The endogeneity problem is thus minimised so causality can be more clearly identified.

My paper is not the first to look at the adoption of improved varieties and land tenure. The theoretical and empiric findings, however, are mixed in this specific topic, as surveyed by Feder, Just, and Zilberman (1985), Chirwa (2005) and Zeng et al. (2018). The closest paper would be the last, where they analyse the role of land contracting on the adoption of improved maize varieties in Ethiopia. Zeng et al. (2018), like most studies in this literature, studies African countries where a formal land-titling system does not exist so owners have limited rights and their rights vary from one to another. In contrast, my paper looks specifically at a land-titling programme that gives households a legal document for their well-defined rights. Moreover, Zeng et al. (2018) conclude

that the lack of land ownership does not discourage improved crop varieties, while I show a positive link between legal land rights (demonstrated by the possession of land-use rights certificates) and cultivation of improved rice varieties. I am also able to investigate multiple channels of improving land rights, rather than just look at it as an increase in the level of tenure security.

The rest of the paper is organised as follows. Section 2 provides some background information about Vietnam's rice production and its land reform. Sections 3 and 4 introduce a theoretical framework and the sets of data used in the study. Sections 5 and 6 discuss the empirical analysis and results. Section 7 concludes.

#### 2. Background: land reform and rice production in Vietnam

This section first gives a brief history of Vietnam's land consolidation and later land-titling reform, which I will exploit as policy variation, and then provides some background about rice production in Vietnam.

Farm collectivisation started in 1957 in the north of Vietnam. It was implemented in the south in 1975 after the Vietnam War ended. During this period, farmers worked on collective farms and were paid based on the number of hours worked. Facing a shortfall in output, farmers pushed back against the collectivisation system. In response, in 1981, Directive 100 of the Communist Party initiated a system that required farmers to deliver a set quota of grain to the cooperative but allowed them to keep or market any surplus above the quota. In 1988, Resolution 10 came into effect, granting individuals land-use rights. Land was allocated to households following a relatively fair process, usually based on household size. The tenure of land was about 10-15 years for annual crops and one or two planting cycles for forestry and perennial crops. Individuals took control of cultivation decisions and production output. Still, land market transactions such as trading or leasing remained illegal until the adoption of the 1993 Land Law. This law gave households the right to *transfer*, exchange, lease, inherit, and mortgage through the issuance of land-use certificates (LUCs). LUCs have a duration of 20 years for annual land, 50 years for perennial and forestry land, and can generally be renewed when the terms expire. After the 1993 land law was introduced, individuals first submitted an application for the certificate; after that, the District Bureau of Land Administration did the groundwork, measuring the area, examining each commune to see if the application information provided was correct and whether there had been any conflicts over the land. By 2000, nearly 11 million land titles had been issued to rural households, making this one of the largest rural titling programs in the developing world (Do & Iyer, 2008).

The details of the programme created variation in the timing and level of land-use certification. Over the years, beginning with the introduction of the 1993 land law, households applied to acquire land-use certificates for their plots. According to Do and Iver (2008), the process of issuing LUCs was time consuming because of the limited human capacity and financial constraints of the Bureau of Land Administration at the district level. Because of the tedious work, not all households obtained LUCs for their plots at the same time; the rollout was instead staggered. Additional variation in LUC status between households has a number of causes. First, some of the households do not have eligible documents to prove their claim to the land. In many cases, when joining collective farms before 1988, households contributed their own land to the farms and took it back after 1988, when the collective farms collapsed. Without written agreements for both events, they continued to use and cultivate this land (without conflict), but could not provide enough evidence to get an LUC.<sup>5</sup> Second, some households have cultivated unclaimed land without conflict despite not having an LUC. Third, in many communes, a form of collective farm still exists to coordinate and promote agricultural activities among farmers. These collective farms also own a fair amount of land that is distributed and rotated among households so that each household has the opportunity to cultivate higher-quality land. These rotating collective farm plots do not have LUCs. Last, but not least, another reason some plots do not receive certification is because of unresolved land conflicts. Local governments are sometimes also reluctant or very slow to resolve these conflicts.

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In many of the cases mentioned above, the variation in LUC holdings appears to be exogenous due to the transition process and historical events, but it can also be confounded by selection. In the empirical analysis, I will show that we can minimise this by using household fixed effects and time fixed effects to control for some innate differences in households as well as the level of LUC issuance over time. I also add an interaction term of region-time fixed effects to account for potential variations in regions over time.

Vietnam is the world's fifth-largest rice-producing country and one of the leading rice exporters in the world. Following the economic transformation and farm de-collectivisation in the second half of the 1980s, rice production has continuously increased, from 25 million tons in 1987 to almost 40 million tons in 2010. Rice remains the staple food in Vietnam with an average annual per capita consumption of around 140 kg, but rice exports have also grown substantially, from 2 million tons in 1995 to almost 6.9 million tons in 2010.

According to Hossain, Ut, and Janaiah (2003), the high growth rate in rice production can be attributed largely to the availability of higher-yielding rice varieties with resistance to major insects and diseases. The yield of spring season rice, for example, improved to 5.2 tons/hectare in 2010 from 2.3 tons/hectare in 1980. The use of input-responsive modern varieties and sufficient fertiliser, and an increase in the proportion of rice area under irrigation account for the high-yields in recent years. Besides developing modern inbred rice varieties (open-pollinated varieties), the Vietnam Agricultural Research Institute also initiated hybrid rice research in 1979 and set up the National Hybrid Rice Research Program in 1992. The government also permits private sector seed companies to import high-yield seeds from other countries, mostly China, as well as develop their own seeds. According to a report by Mordor Intelligence, local centres and institutes in Vietnam have bred 260 inbred rice varieties and 70 hybrid rice varieties. Each improved open-pollinated variety and hybrid seed has its own characteristics that are customised and appropriate for certain conditions. I jointly refer to both improved inbred and hybrid varieties as improved seeds or high-yield varieties (HYV) as opposed to the ordinary local varieties that usually give lower yield.

#### 3. Theoretical framework

The theoretical arguments for a positive relationship between land rights and high-yield varieties adoption considered here are similar to the arguments in Besley (1995). The first view is that tenure security encourages agricultural investment because people are not afraid of expropriation and 'the fruits of their investment being seized by others' (Besley, 1995, p. 906). Since there might be delayed profit of the new seeds adoption, that is, farmers may not enjoy the result of the investment right in the first season, the possibility of being evicted may reduce their overall expected return, thus decrease their willingness to adopt. The second potential channel is through the credit market: better well-defined rights make the land more valuable from banks' perspective, thus relax the credit constraint.<sup>6</sup> To fix ideas and formalise the arguments behind these channels, I develop the model below.

I present a simple two-period model, in which households maximise the profits in their agricultural production. Both return and cost are functions of  $\mu_i$ , household characteristics (such as productivity, size, level of risk aversion) and  $\gamma_{ct}$ , time-variant commune characteristics (season's weather, regional price shocks, and so forth). Denote the adoption decision of the household  $A_t \in [0, 1]$ , a continuous variable. Each period, the household chooses how much improved seed to plant among all the cultivated area. The return on production  $f = f(A_t, \mu_i, \gamma_{ct})$  is a concave function of adoption choice, while the cost is a function of the adoption decision both in the current period and the previous period. The idea is that with a higher level of adoption in the previous period, farmers accumulate knowledge and experience of improved seed cultivation, that leads to a decrease in the cost of planting improved seed next period. Since we only have 2 periods, the cost of period 1 is  $c_1 = c_1(A_1, \mu_i, \gamma_{c1})$ , where  $\frac{\partial c_1}{\partial A_1} > 0$  and that of period 2 is  $c_2 = c_2(A_1, A_2, \mu_i, \gamma_{c2})$ , where  $\frac{\partial c_2}{\partial A_1} < 0$ . In the model below, returns and costs will be written only in terms of adoption decisions because they are the only varying arguments. In the second period, there is a probability of being expropriated,

 $\tau \in [0, 1]$ , which depends on the property rights of that current period,  $R_2$ , that in turns depends on the property rights of the previous period,  $R_1$ . Thus, we can write  $\tau$  as a function of  $R_1$ :  $\tau = \tau(R_1)$ , and the more rights you have, the smaller chance of expropriation, hence  $\frac{\partial \tau}{\partial R_1} < 0$ .

With a legal certificate of land-use rights, a piece of land used as collateral would have a higher value from the perspective of banks since its seizure cost is lower. Farmers can invest in adopting the improved seeds subject to a credit constraint. The cap of how much a household can borrow to finance their input expense in the first period is  $\frac{\rho(R_1) \times T}{1+r}$ , in which *T* is the amount of land holdings, *r* is the interest rate, and  $\rho(R_1)$  is the collateral multiplier that depends on the land rights status. The better land rights, the higher this multiplier,  $\rho'(R_1) > 0$  and thus, the higher the borrowing capacity for the household.

Given its expropriation risk, the household chooses its adoption decisions to maximise its discounted profit stream subject to its credit constraint:

$$\max_{A_1,A_2} \Pi = f(A_1) - c_1(A_1) + \beta(1 - \tau(R_1))[f(A_2) - c_2(A_1, A_2)]$$
(1)

w.r.t 
$$c_1(A_1) \leq \frac{\rho(R_1)T}{1+r} + s$$
 (2)

where  $\beta$  is the discounted factor and s is the household's monetary savings. Here,  $1 - \tau(R_1)$  is the probability that the farmer keeps the land and collects profit in the second period. Thus, we can think of  $\beta(1 - \tau(R_1))$  as an effective discount factor.

Lagrangian equation:

$$\mathcal{L} = f(A_1) - c_1(A_1) + \beta(1 - \tau(R_1)) [f(A_2) - c_2(A_1, A_2) + \mu \left[\frac{\rho(R_1)T}{1 + r} + s - c(A_1)\right]$$
(3)

First-order conditions and complementary slackness give us the optimal choices for adoption:

$$f'(A_1) - \frac{\partial c_1}{\partial A_1} - \beta(1 - \tau(R_1))\frac{\partial c_2}{\partial A_1} - \mu^* \frac{\partial c_1}{\partial A_1} = 0$$
(4)

$$\beta(1 - \tau(R_1)) \left[ f'(A_2) - \frac{\partial c_2}{\partial A_2} \right] = 0$$
(5)

$$\mu^* \left( \frac{\rho(R)T}{1+r} + s - c(A_1) \right) = 0 \tag{6}$$

If  $\mu^* = 0$ , the credit constraint is not binding; the third term in Equation (4) drops out. To see the effect of land rights on the adoption decision, differentiate both sides of the first-order conditions with respect to  $R_1$ . We then obtain the comparative static between  $A_1$  and  $R_1$ :<sup>7</sup>

$$\frac{\partial A_1}{\partial R_1} > 0 \tag{7}$$

The intuition is that there is an investment component to adopting improved seeds in the first period because it not only increases yields in the first period but lowers costs in the second period. However, this investment payoff is realised with a greater probability when land rights are secure. Hence, increasing tenure security would encourage farmers to adopt improved seeds.

increasing tenure security would encourage farmers to adopt improved seeds. If  $\mu^* > 0$  then  $c_1(A_1) = \frac{\rho(R_1)T}{1+r} + s$ , the credit constraint is binding. The implicit function theorem tells us that:

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$$\operatorname{sign}\left(\frac{\partial A_1}{\partial R_1}\right) = \operatorname{sign}\left[\left(\frac{1}{1+r}\right)\frac{\rho'(R_1)}{c_{1'}(A_1)}\right] = (+)\frac{(+)}{(+)} > 0$$

Therefore, a higher level of land rights would imply more adoption of improved varieties through the relaxation of credit constraints when they are binding.

Both tenure security and credit channels suggest increasing adoption at household level. To distinguish these two channels, consider a household cultivating multiple plots. The tenure security channel, which works through decreased risk of expropriation, guaranteeing collection of profit on your land, matters at the plot level. When choosing which plot to invest in planting with improved seeds, the farmer prefers the plot with LUC. Note that, however, the credit channel implies that a having land-use certificate is only important at the household level rather than the plot level because the farmer can use any plot as collateral to get credit.

#### 4. Data

The data sets in this study come from two surveys, the Vietnam Household Living Standards Survey (VHLSS) and the Vietnam Access to Resources Household Survey (VARHS). The VHLSS is a version of the Living Standard Measurement Study (LSMS), conducted by the General Statistical Office of Vietnam with technical assistance from the World Bank and UNDP in 1992, 1998, and every 2 years since 2002. The advantage of this data set is that it is nationally representative, covering all 64 provinces in Vietnam. I use the VHLSS 2004 in particular because it has detailed information about the history of seeds adoption and land ownership status at the household level. Specifically, households were asked to list all varieties of rice that they had used since 1998, when they adopted it, and when they stopped using it, as well as, when they got the land-use certificate for each of their plots. This retrospective questionnaire allows us to build a profile of 5,229 rice farmers from 1998–2004. I call this data set 'quasi-panel' in the sense that it is based on retrospection and has some disadvantage of recall, but it still allows me to control for fixed effects and use general panel methods.

The VARHS is a later survey, first piloted in 2002 and conducted every other year since 2006. Even though the VARHS data is not nationally representative, the sample of VARHS households resembles, to a large extent, the samples in the representative VHLSS datasets. It covers 12 provinces (Dak Lak, Dak Nong, Dien Bien, Ha Tay, Khanh Hoa, Lai Chau, Lam Dong, Lao Cai, Long An, Nghe An, Phu Tho, and Quang Nam), focusing mostly on the rural areas, which are of most relevance to the question of land tenure and high-yield rice varieties adoption. Details about the samples surveyed each year in the VARHS are discussed in Appendix B. In addition to information about crop production, inputs use, and land ownership status provided in the VHLSS, the VARHS also provides detailed information about farmers' access to credit including their borrowing activities. These data help me to identify the credit channel through which land certification can affect the adoption decision by giving them the ability to use land as collateral to borrow. Moreover, the VARHS 2006 has all this information at the plot level, which enables me to examine within-household adoption decisions with regard to multiple plots owned by a particular household. I form a panel data set of 1,306 rice-farming households in the period 2006–2012, while for each pair of years, the number of observations can be higher.

The explanatory variable of interest is a measurement of land rights ownership. I look at whether a household has any land-use certificates (LUCs) and the share of household's total land area that is certificated.<sup>8</sup> In the VARHS, answers about the varieties that farmers use fall into one of the three categories: hybrid variety, ordinary improved variety (improved open-pollinated variety), and old local variety. I combine the former two into the group of high-yield varieties (HYV) or modern varieties because both of the types intend to have higher yields in compared to the traditional local variety.<sup>9</sup> In the VHLSS 2004, the respondents only give the names of the seed without categorisation. To get consistency, the seeds in VHLSS 2004 are manually categorised in the same way.<sup>10</sup> These categorisations are subject to potential measurement error in some cases when recycled hybrid seeds, though having lost yield advantages, are still misreported as hybrid.

Table 1 presents summary statistics for 5,229 rice-planting households in the VHLSS 2004 and the balanced panel data of rice-planting households for every two-year pair in the VARHS 2006–2012. In each column of the VARHS data, the variables' mean values for the first year in the pair are presented with information about the changes in the key variables. For example, in the second column of the panel 2006–2008, the numbers are 2006 mean values, and *change in 'have any LUC'* is the change in the percentage of households that have any LUCs between 2008 and 2006. We see that the mean of household characteristics is very similar across both data sets. Households in the VHLSS 2004 are slightly more educated and have more durable assets. The fraction of households that have LUCs increases over time. Even though the change in households that have any LUCs increases more than 4%. The adoption of high-yield rice varieties also increases from 2004 to 2008.

As mentioned, the VARHS 2006 has plot-level data on which types of seeds are used. I utilise three alternative measures of high-yield seed usage: a dummy variable for whether HYV are used; percentage of plots utilising HYV, and percentage of area utilising HYV. In contrast, the VARHS 2008 only has household-level data, in which households are asked '*What type of rice seed do you normally use?*' I interpret the answer to this question as the type of seed that they use for at least 50% of the cultivated area. The variable *Using HYV* reported in Table 1 reflects this interpretation: the

Table 1. Summary statistics					
	VHLSS 2004	Panel VARHS 2006–2012 pairwise			
	2004	2006–2008	2008-2010	2010–2012	
HH size	4.62	4.72	5.04	4.97	
	(1.71)	(1.70)	(1.97)	(1.92)	
Head of HH's age	48.04	50.11	48.13	48.97	
	(13.59)	(13.14)	(13.34)	(12.78)	
Head's gender	0.83	0.83	0.85	0.86	
	(0.38)	(0.38)	(0.35)	(0.34)	
Head's marital status	0.85	0.84	0.86	0.87	
	(0.35)	(0.37)	(0.35)	(0.34)	
Head's literacy		0.90	0.79	0.76	
		(0.30)	(0.41)	(0.43)	
Head's primary school completion	71%	66%	63%	61.9%	
	(0.45)	(0.42)	(0.48)	(0.49)	
Head's high school completion	10%	9.2%	7.3%	7.6%	
	(0.30)	(0.29)	(0.26)	(0.27)	
HH's savings (mil VND)		9.86	6.67	10.00	
		(32.76)	(23.96)	(25.74)	
HH's durable asset (mil VND) <sup>a</sup>	17.53	16.58	11.97	13.53	
	(44.26)	(39.26)	(27.39)	(24.32)	
HH's agricultural land area $(m^2)$	8,350	9,914	9,964	10,546	
	14,914	(32,289)	(14,984)	(14,189)	
Have any LUC	83%	87.4%	71.0%	70%	
Change in 'have any LUC'		0.5%	8.9%	7.8%	
Share of LUC area <sup>b</sup>	71.8%	78.2%	77.5%	79.5%	
Change in 'share of LUC area'		4.4%	5.4%	0.2%	
Using HYV (at least 50%) <sup>c</sup>	76.4%	81.2%	73.6%	75.2%	
Change in 'using HYV'		4.7%	1.7%	1.5%	
Number of households	5,229	1,253	1,939	1,976	

Table 1. Summary statistics

*Notes*: For panel VARHS, statistics are for the first year of the pair and 'change' variables are changes between the 2 years in the pair. <sup>a</sup>Adjusted by inflation, current value in 2008; <sup>b</sup>This is conditional on having at least 1 LUC; <sup>c</sup>For 2004: whether use any improved seeds.

share of households that use high-yield seeds for at least 50% of the cultivated area. For VHLSS 2004, the data indicate whether a household plants any HYV.

Figure 1 displays the fraction of households that have LUC and adopt high-yield rice varieties over time from the two balanced panel data we got from the VHLSS (for every year in the period 1998–2004) and VARHS (every 2 years in the period 2006–2012). In the first year, we have in the data set, 1998, 45.8% of the rice-planting households plant some type of improved seeds, and 41.4% of them have some formal land title. These numbers increase to 68.5% and 74.3%, respectively, 6 years later. On average, every year the fraction of households that adopts some high-yield seed increases by 3.78%. For the VARHS sample, the fraction of improved seeds adopters and LUC holders rises from 80.5% and 88.3% to 84% and 95% from 2006 to 2012, respectively. In this later period, the changes are smaller given a very high percentage of people have already adopted the high-yield varieties, and the process of land titling is almost done.

Panel data about loans taken by households are from the VARHS 2008, 2010, and 2012. They include lending sources, applied and received amounts, interest rates, purpose of loans, and collateral associated with the loans. Table B2 presents basic descriptive statistics of households' credit activities. Taking loans is relatively common among rural households in the 12 surveyed provinces. In the 2008 survey, for example, 43% of the households in the sample reported that they took out a loan during 2007–2008, among which, 35% of them have to offer assets as collateral for the loans. Land and house with LUC is the most common type of collateral, accounting for 90% of the cases in 2008, and it is even higher for later years. About four out of five households that take out loans are households that have LUC. In 2008, 12% of all taken loans are for the purpose of rice production.

The largest lenders for farmers are Vietnam Bank for Social Policies (VBSP) and Vietnam Bank for Agriculture and Rural Development (VBARD), which provide more than half of the reported loans. The VBARD, established in 1988, is a state-owned commercial bank that is specialised in giving loans for agricultural households in rural area, with more than 2,200 branches covering 63 provinces have provided credit access to farmers since the very early 1990s. The VBSP, founded in 2002, is a not-for-profit bank run by the state, targeting poor and underpriviledged households. In the VARHS 2008, 75% of communes have at least one branch of VBSP or VBARD within the commune itself. Both these banks on average have lower interest rates and usually less strict borrowing



Figure 1. Fraction of households that have LUC and adopt high-yield rice varieties adoption over time (VHLSS 1998–2004 and VARHS 2006–2012).

conditions than other commercial banks, which plays an important role in making credit available for people in the rural area. The rest of the lending sources is friends/relatives, private traders, organisations such as Farmer's, Women's, and Veteran's unions, and other commercial banks.

#### 5. Empirical analysis

Our empirical analysis focuses first on determining the impact of land certification on improved seed adoption by using the sets of panel data discussed above. After establishing the relationship, we explore the channels through which land ownership status affects the adoption decision.

#### 5.1. Link between land rights and high-yield seed adoption

I first want to investigate the effects of land certification on improved seeds adoption. I estimate the impact of land rights on adoption decision of household *i* in commune *c* at time *t*,  $A_{ict} \in \{0, 1\}$ , using the following regression equation:

$$A_{ict} = \beta L U C_{it} + \mu_i + \gamma_{ct} + \epsilon_{ict} \tag{8}$$

where  $A_{ict}$  is the dummy variable of whether the household adopts/plants any high-yield rice varieties and  $LUC_{it}$  is the status of formal land title holdings, which can be a dummy variable of whether the household has an LUC or the fraction of the household's land holdings that has an LUC. This characterisation links back to our theoretical model, with  $A_{ict}$  as the now discrete adoption decision  $A_t$ and  $LUC_{it}$  represents land rights. Holding land titles can be viewed as having better land rights; it both increases the tenure security level and provides collateral for borrowing. As discussed, the equation is a linearisation where  $\beta$  is expected to be positive as the comparative statics show that better land rights encourages adoption.

Here the identifying assumption is that LUC is uncorrelated with the error term. Again, the choice of our adoption decision eliminates the issue of reverse causality, while the panel data allows us to control for household fixed effects  $\mu_i$  and commune-time fixed effects that captures the time and household varying productivity and cost characteristics. Household fixed effects can account for household-specific characteristics such as household size, productivity, level of education, risk aversion, or political connection.<sup>11</sup> The interaction term of commune-time fixed effects  $\gamma_{ct}$  can take care of any input price shocks, season's weather and any natural disasters such as flood, drought, unusual cold weather specific to the region. In addition,  $\gamma_{ct}$  can also control for variation of local agricultural promotion activities between communes over time.<sup>12</sup> I will show regressions with both year fixed effects and a more stringent commune-year fixed effects; the latter is the most consistent with my theoretical specification.

The large number of controls makes it unlikely that my results are driven by omitted variables. The variables that I do not control for have to be very particular, namely time-varying household-specific variables. I did a robust check that additionally controlled for several potential time-variant household characteristics such as asset holdings, savings, political connection of any household members, and household head's marital status and education. I found no change in results.

Since most other papers on the same topic have only cross-sectional data, I also use the same set of data to run a similar cross-sectional regression to compare the findings. To check for the selection bias that households that want to plant improved seeds also invest in getting the LUC, I also examine if changes in land rights can be explained by adoption decisions in the previous periods.

#### 5.2. Identifying the channels through which land rights affect high-yield seed adoption

I also want to test the channels through which land titles affect improved variety adoption decisions. As presented in Section 3, I consider the tenure security channel and the credit/collateral channel. As

discussed, the credit channel implies that land rights at the household level rather than the plot level matter to investment decisions because they can mortgage any plot to get credit. This gives us a testable hypothesis about which channel is in place. I will test whether land rights at the plot level have any effect on farmer's seed adoption given plot characteristics. In plot-level data from VARHS 2006, many households operate multiple plots, some with and some without LUCs. For each plot *j* of household *i*, I estimate the determinants of adopting HYV in that plot using the following equation:

$$A_{ij} = \alpha + \beta L U C_{ij} + \gamma Z_{ij} + \mu_i + \epsilon_{ij} \tag{9}$$

where  $A_{ij}$  is the HYV adoption status of the plot (a dummy variable if plot *j* of household *i* is planted with high-yield seeds),  $LUC_{ij}$  is the plot-level LUC status,  $Z_{ij}$  is a set of plot characteristics including: plot size, distance to home, slope, and irrigation, and  $\mu_i$  is the household fixed effects. Any effect of land rights is now identified from variation in the adoption decision across plots cultivated by a given farmer. If  $\beta > 0$ , the HYV adoption decision at the plot level depends on whether the plot itself is titled or not; it will suggest that land titles give secure tenure for the individual plots, thus making farmers more willing to invest in new varieties in the plot with LUC. If  $\beta = 0$ , we suspect the adoption decision at the plot level does not depend on whether the plot has LUC or not, but is based on the overall status of household LUCs instead of plot-based LUCs.

To check directly for the credit channel, we examine households' borrowing behaviour as the outcome variable. For each household *i*, I estimate the effect of having LUC on its loan-taking activities using the following regression equation:

$$y_{it} = \beta L U C_{it} + u_i + \theta_t + \epsilon_{it} \tag{10}$$

where  $y_{it}$  are the variables of interest regarding household's credit activities, most importantly the dummy variable of whether they take any loans for rice production. More generally,  $y_{it}$  can be a dummy variable of whether they take any loan or use collateral to borrow, the number of loans they take, average interest rates, interest rate on the most recent loan, or whether they got approved for an amount less that what they applied for. The model predicts that if a household has binding credit constraints, then holding LUC will relax them by providing higher value collateral for borrowing, thus,  $\beta$  is expected to be positive.

#### 6. Results

#### 6.1. Effects of land rights on high-yield seed adoption

This section presents the empirical results for the impact of land use on high-yield seed adoption and the channels of impact.

Table 2 displays the regression estimates of Equation (8) using the VHLSS data 1998–2004. Columns (1) and (3) include household fixed effects and time fixed effects while columns (2) and (4) include both these fixed effects plus commune-year fixed effects. Standard errors are clustered at household levels. The dependent variable in columns (1) to (4) is a dummy variable of whether the household planted any high-yield seeds at all. The coefficients are positive and significant in both ways of measuring land rights: having any LUC and the fraction of the area that has an LUC in the household's total land holdings. The magnitudes are higher when additionally controlling for commune-year fixed effects. Households that have LUCs for at least one of their plots are 3.5% more likely to plant high-yield seeds. The results are very similar for the increase in the fraction of area with LUC. Since the percentage of households who plant any high-yield rice varieties in 1998 is 45.8%, these effects are certainly nontrivial.

Table 3 presents the regression results for the VARHS 2006–2012. Note that the data for 2006–2012 is what type of seeds that the household *normally* uses, so the outcome variable here is

	(1)	(2)	(3)	(4)
Variables	Plant HYV	Plant HYV	Plant HYV	Plant HYV
Have any LUC	0.029*** (0.009)	0.035** (0.014)		
Fraction of LUC area	()		0.020* (0.010)	0.035** (0.015)
Household FE	YES	YES	YES	YES
Year FE	YES	YES	YES	YES
Commune x Year FE		YES		YES
Observations	36,603	34,090	36,603	34,090
No. of households	5,229	4,870	5,229	4,870
R-squared	0.758	0.882	0.758	0.882

Table 2. Effect of LUC on HYV adoption decision, VHLSS 1998-2004

*Notes*: Dependent variable is whether household planted any improved seeds in year t, in which t is in between 1998–2004. Standard errors are clustered at household level. Standard errors in parentheses. \*\*\* p < 0.01, \*\* p < 0.05, \* p < 0.1.

a dummy of whether improved seeds are mainly used, not whether they are used at all. Panel A of Table 3 is the regression results using data from the full panel of 2006–2012. Similar to Table 2, columns (1) and (3) are the estimation of Equation (8) with household fixed effects and year fixed effects while columns (2) and (4) additionally include commune-year fixed effects. When controlling for all these fixed effects, the estimated coefficients are positive but not statistically significant.

I next break down the analysis into two-year panels: 2006–2008, 2008–2010, and 2010–2012. Panel B presents the estimated coefficients of the regressions in pairwise years, with panel B1 including household fixed effects and year fixed effects and panel B2 additionally controlling for commune-year fixed effects. The effects are actually different across periods. For 2006–2008, the estimated coefficients are positive and significant at 10% level for the 'fraction of LUC area': an increase from 0 to 100% in the fraction of LUC area raises the chance of planting high-yield varieties by 6.4%. The estimates are insignificant for other pairs of years. When additionally accounting for the time-varying commune characteristics, the estimated  $\beta$ 's all become insignificant, however. The key takeaway here is that I do not find a clear effect in the VARHS sample, unless it was split into smaller periods, where it shows up significantly positive in the earlier years. The effects become lower over the years as the overall level of land-titling increases. Since almost everyone has got LUC, there is little variation in LUC across households in the later years.<sup>13</sup>

One concern is that the adoption of modern varieties may need planning in advance. If the farmer gets LUC in time t, she may not be able to invest in HYVs in the same period since she might not have known at the beginning of the season that she would get LUC. Generally, this should not be a serious issue as rice is an annual crop (usually two seasons per year in Vietnam); the planning for each season should not be longer than a few months. It is indeed not a problem for the VARHS 2006–2012 because these surveys are biennial. As a robustness check, for the VHLSS 1998–2004, I include a lagged term of LUC measure ( $LUC_{t-1}$ ) in the regression of Equation (8). I find that the estimated coefficients for the current LUC term remain positive and statistically significant with slightly larger magnitude.<sup>14</sup>

Finally, I examine whether selection bias may be driving the results by estimating Equation (8) to see if past adoption decisions can predict the acquisition of land titles. I find that selection bias does not appear to be an issue with the lagged terms of planting HYV is small in magnitude and insignificant, or even negative.<sup>15</sup>

#### 6.2. Exploring the channels

I now present the evidences for the channels that drive the positive effect of land rights on improved rice varieties adoption. As explained in the empirical analysis, the tenure security view implies that

	Pa	anel A: Full Pa	anel			
	(1)	(2)	(3)	(4)		
Plant HYV Have any LUC	06-12 -0.035 (0.040)	06-12 0.017 (0.042)	06–12	06–12		
Fraction of LUC area	(0.010)	(0.012)	0.006 (0.029)	0.048 (0.034)		
No. of obs.	4,020	3,612	4,020	3,612		
R-squared	0.41	0.70	0.41	0.70		
Household FE	YES	YES	YES	YES		
Year FE	YES	YES	YES	YES		
Commune x Year FE		YES		YES		
	Pa	anel B1: Two-y	ear Panel			
	(1)	(2)	(3)	(4)	(5)	(6)
Plant HYV	06–08	06–08	08–10	08–10	10-12	10-12
Have any LUC	0.058		0.031		-0.075	
, and a graduate	(0.049)		(0.037)		(0.044)	
Fraction of LUC area		0.064*	()	0.008	(*** )	-0.031
		(0.037)		(0.035)		(0.041)
No. of obs.	2,778	2.778	3,870	3.870	4.128	4.128
R-squared	0.66	0.66	0.62	0.62	0.59	0.59
Household FE	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES
	Panel B2.	· Two-year Par	iel (with comm	une-year FE)		
	(1)	(2)	(3)	(4)	(5)	(6)
Plant HYV	06–08	06–08	08–10	08–10	10-12	10-12
Have any LUC	0.050		0.017		-0.075	
5	(0.044)		(0.048)		(0.048)	
Fraction of LUC area	· · · ·	0.038	. ,	0.013		-0.021
		(0.038)		(0.045)		(0.047)
No. of obs.	2,344	2,344	3,706	3,706	3,952	3,952
R-squared	0.83	0.83	0.76	0.76	0.74	0.74
Household FE	YES	YES	YES	YES	YES	YES
Commune-Year FE	YES	YES	YES	YES	YES	YES

Table 3. Effect of LUC on HYV adoption decision, VARHS 2006–2012

*Notes*: Dependent variable is whether household normally planted improved seeds in year t, in which t is in between 2006–2012. Standard errors are clustered at household level. Standard errors in parentheses. \*\*\* p < 0.01, \*\* p < 0.05, \* p < 0.1.

land rights at the plot level matter to investment decisions while they do not for the credit channel. The fact that a particular plot is registered with a land-use certificate or not should not affect the decision to cultivate improved seeds in only that plot because households can collateralise any of their plots to borrow money. Thus, I will examine the adoption choices across plots within households to distinguish the channels.

Table 4 displays the result of the plot-level regression using VARHS 2006. The first column is a general regression of all plots across households, in which we see that having LUC for each plot increases the chance high-yield rice varieties are planted in that plot. The regression reported in second column includes household fixed effects, which means that any effect of land rights is now identified by variation in adoption decision across plots cultivated by a given farmer. The estimated coefficient of land rights (LUC) is positive and significant here, even though smaller in

	(1)	(2)	(3)	
VARIABLES	Plant HYV	Plant HYV	Plant HYV	
LUC	0.039**	0.027***	0.025***	
	(0.018)	(0.010)	(0.009)	
plot size	-1.03e-05*	-1.63e-06**	-1.63e-06**	
-	(5.45e-06)	(7.01e-07)	(7.43e-07)	
distance	-1.86e-05***	-7.68e-06**	-9.05e-06**	
	(7.00e-06)	(3.71e-06)	(3.95e-06)	
slope	-0.042***	-0.085***	-0.098***	
	(0.015)	(0.020)	(0.027)	
irrigation	0.191***	0.074***	0.086***	
	(0.026)	(0.017)	(0.025)	
'best plot'			-0.004	
			(0.004)	
deviation from best			0.002	
			(0.003)	
Household FE	NO	YES	YES	
Observations	6,717	6,717	6,717	
Number of households		1,736	1,736	
R-squared	0.093	0.107	0.108	

Table 4. Effect of having an LUC on HYV adoption decision at plot level, VARHS 2006

*Notes*: Standard errors are clustered at household level. Standard errors in parentheses. \*\*\* p < 0.01, \*\* p < 0.05, \* p < 0.1.

magnitude compared to column (1). Within a household, a plot with LUC is 2.74% more likely to be planted with high-yield seeds. Since this result shows that having land titles is important at the plot level, it suggests the strong presence of the tenure security channel.

If we look at other determinants of high-yield seed adoption, it appears that they are more likely to be planted in smaller, closer, flatter and better-irrigated plots<sup>16</sup>. It is possible that when choosing which plots to cultivate with high-yield seeds, households will consider the most suitable plot compared with other plots they own. In addition to controlling for the plot's own characteristics, I will also control for its relative suitability for HYV in comparison to the rest of the household's plots. I build an *index of suitability* (for planting HYV), which takes into account all of the plot's characteristics mentioned above. In other words, I calculate the weighted sum of *plot size, distance, slope*, and *irrigation* into one index to determine the 'best plot' among all plots owned by the household. The weights are estimated coefficients from the regression of the adoption decision on all these plot-specific features. I will also compute 'deviation from best' as how far away this plot is from the 'most suitable plot'.

Column (3) of Table 4 presents the results of the same regression, with the plot's own characteristic variables and a dummy variable for whether this plot is the 'best plot' by the above definition and its 'deviation from best'. When controlling for relative quality of the plot compared with other plots and the 'best plot' owned by the household, the coefficients for LUC are still positive and significant again, with similar magnitude. This finding reinforces the importance of the tenure security channel.

I next test for the credit/collateral channel by examining the effect of land titles holdings on households' borrowing activities. At the core of the theoretical framework, the credit channel is only present if farmers can both borrow money to finance their adoption investment and they also have demand for credit. As stated in the Data section, taking loans is fairly common among Vietnamese farmers. The extensive coverage of VBSP and VBARD in rural area besides many other sources of finance provides easier credit access to households in agriculture.

I look directly at the loans for rice production taken by a household, which accounts for 12% of all the loans reported in the sample. Table 5 reports the regression results of Equation (11) using the panel data of VARHS 2008–2012. The dependent variable here is a dummy variable of whether households take a loan for the purpose of rice production. Columns (1) and (2) display a positive

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	(1)	(2)	(3)	(4)
VARIABLES	Rice loans	Rice loans	Rice loans	Rice loans
Have any LUC	0.017**	0.015**		
-	(0.007)	(0.006)		
Fraction of LUC area			0.017**	0.016**
			(0.008)	(0.008)
Take out any loan		0.109***	· · · · ·	0.109***
2		(0.007)		(0.007)
Observations	8,676	8,676	8,675	8,675
R-squared	0.500	0.531	0.500	0.531
Household FE	YES	YES	YES	YES
Year FE	YES	YES	YES	YES

Table 5. Effect of having LUCs and taking loans for rice production, VARHS 2008-2012

*Notes*: Standard errors are clustered at commune level. Standard errors in parentheses. \*\*\* p < 0.01, \*\* p < 0.05, \* p < 0.1.

and statistically significant coefficient for the dummy variable for having any LUC. Having land titles increases the likelihood of getting such loans by 1.7% (column 1). Conditional on taking any type of loans, the effect remains positive, significant and of similar magnitude (column 2). Almost identical results are obtained for the fraction of land that households have LUC for (columns 3 and 4). This finding suggests a strong link between having LUC and taking loans for rice production, in which seed purchases can be an important source of expenditure. It provides evidence of the credit channel.

In general, having LUC is positively correlated with whether a household takes any loan, whether it takes any loan with collateral, and the overall number of loans it has taken. Households with LUC are also offered lower interest rates. Even though these results are not statistically significant, they point to the same direction that having LUC encourages people to borrow.

With the evidences presented above, land rights appear to affect high-yield rice seeds adoption through both tenure security and credit channels.

#### 7. Conclusion

Using two panel data sets that allow for household level fixed effects and region-time fixed effects to control for selection, I have demonstrated a positive link between land rights and high-yield seed adoption. Having any LUC on average increases the likelihood of HYV adoption by 3.5% during 1998–2004. I also find suggestive evidences of the positive relationship in 2006–2008 though they are not as clear. I do not observe a significant effect in the later years. The increase in high-yield rice varieties planting can translate into higher agricultural profit as a result of higher yields.<sup>17</sup> The findings comply with the literature that suggests land rights encourage agricultural investment and thus reinforces the role of land-titling programs in enhancing agricultural productivity. Given that many countries in Asia and Africa, especially Sub-Saharan Africa, both lack well-defined land rights and have a low adoption rate of improved varieties, the results of this study have important policy implications for these nations.

The effect of having land titles is also significant at the plot level, which supports the importance of the tenure security channel. Additionally, having an LUC increases the likelihood that a household takes out loan for rice production, suggesting evidence of the credit channel. The positive link between better land rights and borrowing may imply that in order to encourage agricultural investment, the government should also improve the credit market, in addition to liberalising the land market. Providing easier access to credit might amplify the effect of improving land rights on technology investment.
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No potential conflict of interest was reported by the author.

## Notes

- 1. See Brasselle et al. (2002); Place and Otsuka (2002); Place (2009).
- 2. See Evenson and Gollin (2003); Shiferaw, Kassie, Jaleta, and Yirga (2014); Verkaart, Munyua, Mausch, and Michler (2017).
- 3. See Walker and Alwang (2015).
- 4. Foster and Rosenzweig (1995) found that lack of knowledge about new seeds prevents farmers from adopting them. As they have more experience with the new technologies, this barrier diminishes.
- 5. The recent 2013 land law now allows individuals to apply for LUCs in this type of situation.
- 6. 'A third channel studied by Besley can be called the transferability channel: because of better land rights, the transaction cost of selling or renting out land is reduced, and when there is a negative shock to the owner's productivity (such as health issues or income shock), farmers can easily sell or rent their land to other cultivators. For the type of investment that improves land quality, the lower trading cost will incentivise households to invest more to increase the value of the land. Since the productivity-enhancing investment here, planting improved seeds, does not boost the land value, this third channel is not especially relevant.
- 7. See Appendix A for a complete derivation.
- 8. When tracking down households' LUC status at plot level, we see some inconsistency in households' self-report. A number of households reported that some of their plots did not have LUCs in the current survey but claimed to have LUC for the same slots in the previous round of the survey. These plots make up about 3% of the total plots. To avoid any discrepancy and inconsistency of the report, we take out these plots and the households that cultivate them.
- 9. In the Supplementary Materials, I provide results for another variety identification: only considered hybrid seeds highyield varieties.
- 10. See Appendix for a more detailed note on variety identification.
- 11. Goldstein and Udry (2008) show that in Ghana, individuals that have position in the political hierarchy have more tenure security rights and invest more in land.
- 12. The introduction of newly developed high-yield rice varieties in Vietnam is often promoted by state officials, local government and local Farmers' Union since agricultural crop cultivation, especially rice planting, is considered important to the state's socio-economic agenda. Information and suggestions about the type of varieties that should be planted each season are often given to farming households by officials, members of supporting groups at the commune level.
- 13. Land certification appears to have more effect on seed adoption in earlier years than in later years. To see that this is indeed the case, we break down the effect of LUC holdings in each year on planting high-yield seeds for the period 1998–2004. Figure 1 displays the estimated coefficients for the impact of having LUC (and the fraction of LUC area) in each year on farmers' choice of seed adoption with 95% confidence intervals. The effect starts out substantial and statistically significant in the earlier years and then fades out in the later years, becoming very close to zero for 2003 and 2004. The fact that we see a diminishing effect is understandable given that in the 2004 sample, 76% of households already used high-yield seeds and 83% of the households have LUCs. One way to think about it is when households get more exposure to improved seeds and planting them is popular within their communes, it is much less of a learning curve to try these new types. Thus, improving land rights plays a less significant role in encouraging people's decision to adopt.
- 14. The table of results is presented in the Supplementary Materials.
- 15. See Supplementary Materials.
- 16. This is consistent with the literature's findings. SeeCameron (1999), for example.
- 17. Hossain et al. (2003) find that the net return of hybrid rice cultivation is 34% to 46% higher than that of inbred HYV cultivation. Although we do not find information about how much more profitable improved open-pollinated varieties are compared with local varieties, the combination of hybrid and inbred HYV planting certainly has higher returns than planting these traditional varieties.

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#### Appendix A. Theoretical model

I present a simple two-period model, in which households maximise the profits in their agricultural production. Both return and cost are functions of  $\mu_i$ , household characteristics (such as productivity, size, level of risk aversion) and  $\gamma_{ci}$ , time-variant commune characteristics (season's weather, regional price shocks, and so forth). Denote the adoption decision of the household  $A_t \in [0, 1]$ , a continuous variable. Each period, the household choose how much improved seed to plant among all the cultivated area. The return on production  $f = f(A_t, \mu_i, \gamma_{ct})$  is a concave function of adoption choice,  $\frac{\partial f_t}{\partial A_t} > 0$ ,  $\frac{\partial^2 f_t}{\partial A_t^2} < 0$ . While the cost is a function of the adoption decision both in the current period and the previous period. The idea is that with a higher level of adoption in the previous period, farmers accumulate knowledge and experience of improved seed cultivation, that leads to a decrease in the cost of planting improved seed next period. Since we only have 2 periods, the cost of period 1 is  $c_1 = c_1(A_1, \mu_i, \gamma_{c1})$ , where  $\frac{\partial c_1}{\partial A_1} > 0$  and that of period 2 is  $c_2 = c_2(A_1, A_2, \mu_i, \gamma_{c2})$ , where  $\frac{\partial c_2}{\partial A_1} < 0$ . The cost function is weakly convex in current adoption (can be linear),  $\frac{\partial c_i}{\partial A_i} < 0$ ,  $\frac{\partial^2 c_i}{\partial A_i^2} \ge 0$ . In the model below, returns and costs will be written only in terms of adoption decisions because they are the only varying arguments. In the second period, there is a probability of being expropriated,  $\tau \in [0, 1]$ , which depends on the property rights of that current period,  $R_2$  that in turns depends on the property rights of the previous period,  $R_1$ . Thus, we can write  $\tau$  as a function of  $R_1$ :  $\tau = \tau(R_1)$ , and the more rights you have the smaller chance of expropriation, hence  $\frac{\partial r}{\partial R_1} < 0$ . The household, therefore, considers its expropriation risk and chooses its adoption decisions to maximise

discounted profit stream subject to its credit constraint:

$$\max_{A_1,A_2} \Pi = f(A_1) - c_1(A_1) + \beta(1 - \tau(R_1))[f(A_2) - c_2(A_1, A_2)]$$
(A1)

w.r.t 
$$c_1(A_1) \leq \frac{\rho(R_1)T}{1+r} + s$$
 (A2)

where  $\beta$  is the discounted factor and s is household's monetary savings.

Lagrangian equation:

$$\mathcal{L} = f(A_1) - c_1(A_1) + \beta(1 - \tau(R_1))[f(A_2) - c_2(A_1, A_2) + \mu \left[\frac{\rho(R_1)T}{1 + r} + s - c(A_1)\right]$$
(A3)

First-order conditions and complementary slackness give us the optimal choices for adoption:

$$f'(A_1) - \frac{\partial c_1}{\partial A_1} - \beta (1 - \tau(R_1)) \frac{\partial c_2}{\partial A_1} - \mu^* \frac{\partial c_1}{\partial A_1} = 0$$
(A4)

$$\beta(1 - \tau(R_1)) \left[ f'(A_2) - \frac{\partial c_2}{\partial A_2} \right] = 0$$
(A5)

$$\mu^* \left( \frac{\rho(R)T}{1+r} + s - c(A_1) \right) = 0$$
(A6)

If  $\mu^* = 0$ , the credit constraint is not binding, the third term in Equation (4) drops out. To see the effect of land rights on the adoption decision, differentiate both sides of the FOCs with respect to  $R_1$ :

$$[f''(A_1 - c_1''(A_1)] \times \frac{\partial A_1}{\partial R_1} + \beta \tau'(R_1) \frac{\partial c_2}{\partial A_1} - \beta (1 - \tau(R_1)) \frac{\partial^2 c_2}{\partial A_1^2} \times \frac{\partial A_1}{\partial R_1} - \beta (1 - \tau(R_1)) \frac{\partial^2 c_2}{\partial A_1 \partial A_2} \times \frac{\partial A_2}{\partial R_1} = 0$$
(A7)

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$$-\beta\tau'(R_1)\left(f'(A_2) - \frac{\partial c_2}{\partial A_2}\right) + \beta(1 - \tau(R_1))\left[f''(A_2) - \frac{\partial^2 c_2}{\partial A_2^2}\right] \times \frac{\partial A_2}{\partial R_1} -\beta(1 - \tau(R_1))\frac{\partial^2 c_2}{\partial A_2 \partial A_1} \times \frac{\partial A_1}{\partial R_1} = 0$$
(A8)

or in matrix form:

$$\begin{bmatrix} f''(A_1 - c_1''(A_1)) - \beta(1 - \tau(R_1))\frac{\partial^2 c_2}{\partial A_1^2} & -\beta(1 - \tau(R_1))\frac{\partial^2 c_2}{\partial A_1 \partial A_2} \\ -\beta(1 - \tau(R_1))\frac{\partial^2 c_2}{\partial A_2 \partial A_1} & \beta(1 - \tau(R_1)) \Big[ f''(A_2) - \frac{\partial^2 c_2}{\partial A_2^2} \Big] \end{bmatrix} \times \begin{bmatrix} \partial A_1 / \partial R_1 \\ \partial A_2 / \partial R_1 \end{bmatrix} \\ = \begin{bmatrix} -\beta \tau'(R_1)\frac{\partial c_2}{\partial A_1} \\ \beta \tau'(R_1) \Big( f'(A_2) - \frac{\partial c_2}{\partial A_2} \Big) \end{bmatrix}$$

From the first-order condition (A3), we know that  $\left(f'(A_2) - \frac{\partial c_2}{\partial A_2}\right) = 0$  thus the right-hand side becomes  $\begin{bmatrix} -\beta \tau'(R_1) \frac{\partial c_2}{\partial A_1} \\ 0 \end{bmatrix}$ . The first item in the left-hand side is the Hessian matrix from the second-order condi-

tions, thus its determinant is positive.

$$\begin{split} \frac{\partial A_1}{\partial R_1} &= \frac{1}{det(H)} \left[ \beta (1 - \tau(R_1)) \left( f''(A_2) - \frac{\partial^2 c_2}{\partial A_2^2} \right) \times \left( -\beta \tau'(R_1) \frac{\partial c_2}{\partial A_1} \right) \right] \\ \frac{\partial A_1}{\partial R_1} &= \underbrace{\frac{1}{-det(H)}}_{(-)} \left[ \underbrace{\beta^2 (1 - \tau(R_1))}_{(+)} \underbrace{\left( f''(A_2) - \frac{\partial^2 c_2}{\partial A_2^2} \right)}_{(-)} \underbrace{\tau'(R_1)}_{(-)} \frac{\partial c_2}{\partial A_1} \right] > 0 \end{split}$$

Thus, increasing tenure security would encourage farmers to adopt improved seeds. If  $\mu^* > 0$  then  $c_1(A_1) = \frac{\rho(R_1)T}{1+r} + s$ , the credit constraint is binding. The implicit function theorem tells us that:

$$\operatorname{sign}\left(\frac{\partial A_1}{\partial R_1}\right) = \operatorname{sign}\left[\left(\frac{1}{1+r}\right)\frac{\rho'(R_1)}{c_1'(A_1)}\right] = (+)\frac{(+)}{(+)} > 0$$

Therefore, higher level of land rights would imply more improved varieties adoption, through the relaxation of credit constraints when they are binding.

# Appendix B. Additional tables

### B.1. VARHS data set

The VARHS enables me to build a panel data set of more than 2,162 households surveyed biennially from 2006 and onwards. The 2008 and 2010 survey rounds reached more than 1,000 new households, interviewing more than 3,200 households in total. The 2012 survey added another 553 new households, 'chosen with a view to ensuring better representativeness of the rural population in the surveyed provinces'.<sup>18</sup> Table B1 presents the number of households overall and the number of rice planters within them surveyed in each wave of the VARHS. I form a panel data set of 1,306 rice-farming households in the period 2006–2012.

	2006	2008	2010	2012	All years	
All households						
Old		2266	3208	3151		
New	2324	1011	0	553		
Total	2324	3277	3208	3704	2162	
Rice planting households						
Old		1559	2286	2176		
New	1751	961	0	443		
Total	1751	2520	2286	2619	1306	

Table B1. Data: VARHS 2006–2012

### B.2. VHLSS data on rice varieties

In the VHLSS data, households were asked to list all type of seeds that they used since 1998. The modern highyield varieties, which include both hybrid seeds and improved open-pollinated seeds, are developed by government institutes as well as private companies. A large amount of the improved open-pollinated seeds are imported from China or developed based on available seeds from the International Rice Research Institutes (IRRI). Hybrid seeds are usually cross bred from a high-yield variety from IRRI and a local variety that is suitable for a region. In the data, there are about 60 main types of seeds: Khang dan, Q5, CR 203, Ai 32, Nhi uu 838, 13/2 (ordinary improved varieties); OM, Tap giao, C70, C71, Nep N97 (hybrid varieties); and Bao thai, Tai nguyen, Doan ket, Gao tam (local varieties), to name a few of the most popular. Across the 1998–2004 period, of all varieties that households use (including the ones that they stopped using by 2004), about 25% are hybrid seeds, 50% are ordinary improved seeds, and 25% are local varieties.

# **B.3.** Households' borrowing activities

	2008	2010	2012
Fraction of HH that takes loan	43%	51%	40%
Fraction of loan-taking HH with LUC	79%	74%	76%
Fraction of HH that offers collateral <sup>a</sup>	35%	26%	28%
Land + house with LUC as collateral <sup>b</sup>	90%	94%	95%
Loans for rice production purpose <sup>c</sup>	12%	10%	9%
Loans by VBSP and VBARD	51%	59%	57%

*Notes*: <sup>a</sup>Conditional on having loans; <sup>b</sup>conditional on taking loans with collateral; <sup>c</sup>fraction out of all loans.