SUPPLEMENTARY MATERIALS

1 Cross-sectional regression

Since most of the papers of the same topic in the literature only have cross-sectional data, I also run a cross-sectional regression of equation (8). Table S1 presents the regression results using data from VARHS 2006-2012. All standard errors are clustered at the commune level to account for the correlation between households within a commune. The estimated coefficients of land rights are positive and of much larger magnitude than the panel regression. Without households fixed effects, the estimation suggests changing from not having any land titled to fully titling your land increases the chance of planting high-yield seeds by 15 percent, 2 times bigger than the effect we found above. The cross-sectional regression shows that high-yield rice was more likely to be adopted by older and more educated farmers, in smaller households with smaller land holdings and less assets. My results are similar to the findings of Hossain et al. (2003) on the pattern of hybrid rice adoption in a small sample of farming households in Vietnam. Being a member of the Farmers' Union also increases the likelihood of using modern seeds since the organization promotes information about advanced cultivation technology and encourages farmers to share their cultivation experiences.

2 Selection bias

To check for the selection bias that households that want to plant improved seeds also invest in getting the LUC, I examine whether changes in land rights can be explained by adoption decisions in the previous periods. Specifically, I check if lagged HYV adoption can predict land registration by estimating the following equation:

$$LUC_{it} = \sum_{1}^{k} \beta y_{i,t-k} + u_i + \theta_t + \epsilon_{it} \tag{1}$$

where all variables are defined the same as above and k is the number of lagged terms for high-yield seeds adoption. If the adoption decisions in previous periods do not have any predictive power over the act of households' obtaining land use certificates, then the simultaneity problem is minimized.

Table S1: Effect of having LUC on planting high-yield seeds, cross-sectional VARHS 2006-2012

Plant HYV	(1)	(2)
Having LUC	0.114***	
	(0.0331)	
Fraction of LUC area		0.148***
		(0.0301)
HH size	-0.0119**	-0.0109**
	(0.00506)	(0.00490)
gender	-0.0289	-0.0257
	(0.0214)	(0.0211)
age	0.00155***	0.00123**
	(0.000523)	(0.000497)
marital status	0.0180	0.0189
	(0.0234)	(0.0233)
literate	0.0698**	0.0653**
	(0.0339)	(0.0330)
middleschool	0.0582***	0.0578***
	(0.0128)	(0.0126)
political party member	-0.0234	-0.0189
	(0.0194)	(0.0187)
farmer union member	0.0959***	0.0947***
	(0.0164)	(0.0165)
savings	2.61e-07*	2.31e-07*
	(1.39e-07)	(1.37e-07)
asset	-7.33e-08***	-7.33e-08***
	(1.47e-08)	(1.47e-08)
land holdings	-1.07e-06***	-9.59e-07***
	(3.95e-07)	(3.50e-07)
No of households	9,008	9,008
R-squared	0.066	0.074

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

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

The regression using panel VHLSS 1998-2004 is displayed in Table S2. Columns (1) and (2) present regression results where the dependent variable is whether you get your first LUC in this period. The dependent variable in columns (3) and (4) is the change in fraction of LUC area. I include 3 lagged terms of adopting and planting HYV because it may take a while for households to obtain LUCs after they realise they need the titles. All the estimated

coefficients are very close to zero and not significant, except for 'adopt new HYV' in 1-period lagged and 'plant HYV' in 3-period lagged, which are significant but negative. Table S3 reports the analogous results of the regression from VARHS 2006-2012. Since we only have 4 years here, the regression only includes 2 lagged terms of the decision to adopt HYV. Again, the coefficients are very close to zero, negative and insignificant. In sum, selection bias does not appear to be an issue.

Table S2: Does lagged HYV adoption/planting predict LUC registration? (1998-2004)

VARIABLES	Getting first LUC	Change in fraction of LUC area
	(1)	(2)
$Plant\_HYV_{t-1}$	-0.00736	-0.0129
	(0.00916)	(0.00817)
$Plant\_HYV_{t-2}$	-0.000930	0.00373
	(0.00924)	(0.00760)
$Plant\_HYV_{t-3}$	-0.0194**	-0.0103
	(0.00792)	(0.00679)
Household FE	YES	YES
Year FE	YES	YES
Observations	20,916	20,916
No. of households	5,229	5,229
R-squared	0.225	0.226

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

3 Effect of LUC status in previous period on current improved seed adoption

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 this survey is 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

Table S3: Does HYV planting in lagged years predict LUC registration? (2006-2012)

VARIABLES	(1) Getting first LUC	(2) Change in fraction of LUC area
$Plant\_HYV_{t-1}$	0.0279	0.00744
	(0.0195)	(0.0275)
$Plant\_HYV_{t-2}$	0.0234	-0.0286
	(0.0206)	(0.0263)
Household FE	YES	YES
Year FE	YES	YES
Observations	2,004	2,004
No. of households	1,002	1,002
R-squared	0.490	0.403

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

equation (8). Table S4 presents the result of this regression. The estimated coefficients for the current LUC term remain positive and statistically significant with slightly larger magnitude, compared to the main results without lagged terms. The lagged terms do not appear to have any significant effect on the current adoption.

4 Effects of having LUC over the years

I 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 percent 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 percent of households already used high-yield seeds and 83 percent of the households have LUCs. One way to think about that is when households get more exposure to improved seeds and planting them is popular within their communes then 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.

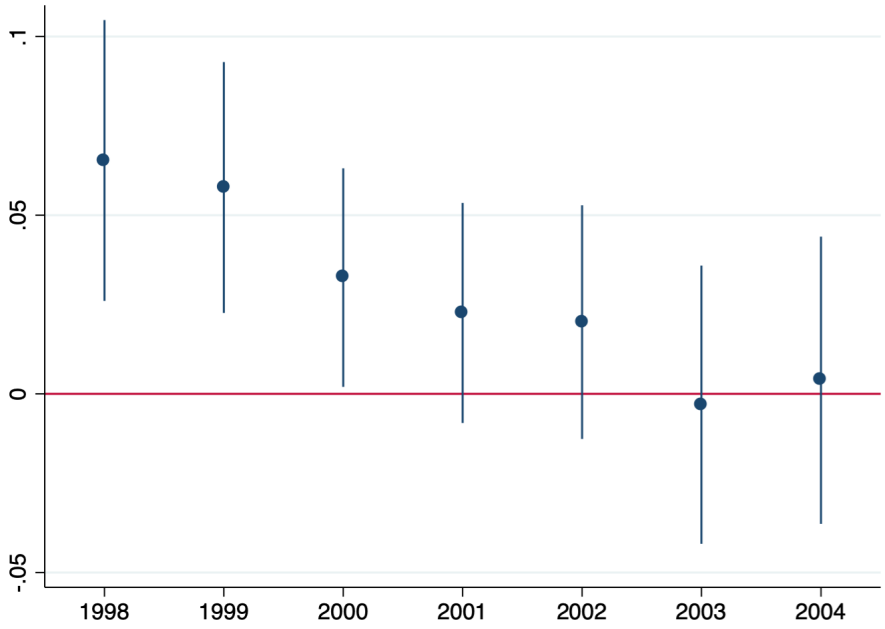
Table S4: Does LUC status in previous period affect current improved seed adoption? - VHLSS 1998-2004

VARIABLES	(1) $Plant\_HYV_t$	(2) $Plant\_HYV_t$	(3) $Plant\_HYV_t$	(4) $Plant\_HYV_t$
Have any LUC at t	0.0299***	0.0329**		
	(0.0091)	(0.0136)		
Have any LUC at t-1	-0.0061	-0.0043		
	(0.0075)	(0.0114)		
Fraction of LUC area at t			0.0249**	0.0448***
			(0.0099)	(0.0147)
Fraction of LUC area at t-1			-0.0109	-0.0113
			(0.0085)	(0.0129)
Observations	31,374	29,220	31,374	29,220
R-squared	0.798	0.901	0.798	0.901
Household FE	YES	YES	YES	YES
Year FE	YES	YES	YES	YES
Commune x Year FE		YES		YES

Standard errors are clustered at household level.

Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Figure 1: Effect of having LUC in each year on planting HYVs



Estimated coefficients with 95% confidence interval. Standard errors are clustered at household level.

5 Different high-yield varieties identification

In the main text, I define both improved inbred seeds (improved open-pollinated) and hybrid seeds as high-yield varieties (HYV). Since the cost of planting hybrid seeds is higher than that of the open-pollinated seeds (Hossain et al. (2003)), adopting hybrid varieties can be a larger investment for farmers. In this section, I look only at the adoption of hybrid seeds as the outcome variable. Table S5 reports regression results of equation (8) with this new definition. Columns (1) and (3) only include household fixed effects and year fixed effects while columns (2) and (4) also include commune-year fixed effects. The coefficients in columns (2) and (4) are positive and of slightly smaller magnitude than the main results in the text. The coefficients of the dummy variable of having any LUC is significant at 10% level. As a larger investment, the result for hybrid seed adoption is not as strong as both types of improved seeds but it certainly points to the same direction.

Table S5: Effect of having LUC on planting hybrid seeds - VHLSS 2004

	(1)	(2)	(3)	(4)
VARIABLES	Plant hybrid	Plant hybrid	Plant hybrid	Plant hybrid
Have any LUC	0.00171	0.0249*		
	(0.00933)	(0.0140)		
Fraction of LUC area			0.00528	0.0238
			(0.0104)	(0.0150)
Observations	36,603	34,090	36,603	34,090
R-squared	0.720	0.868	0.720	0.868
Household FE	YES	YES	YES	YES
Year FE	YES	YES	YES	YES
Commune x Year FE		YES		YES

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

References

Hossain, M., Ut, T. T., and Janaiah, A. 2003. Vietnam's experience with hybrid rice. *Economic and Political Weekly*, 38(25):2523–2529.