Factors of Vertical Farming adoption: Japan as an example

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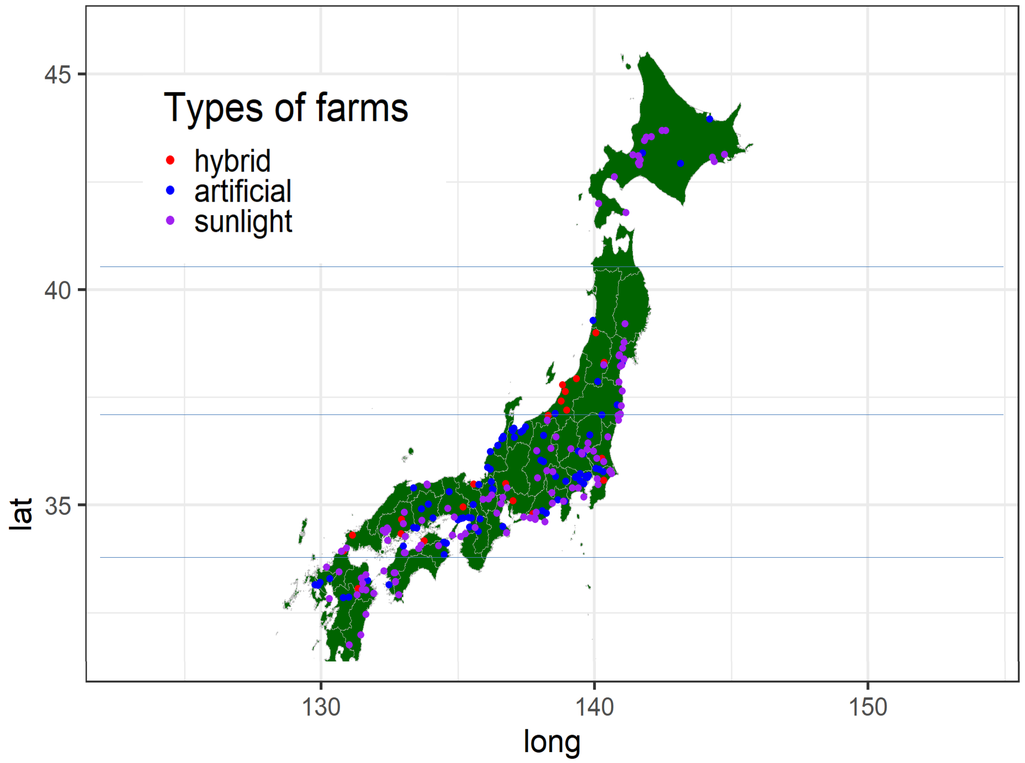
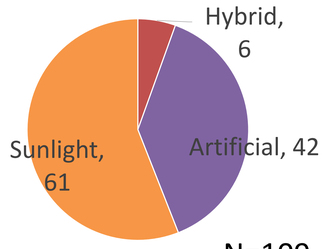
Introduction

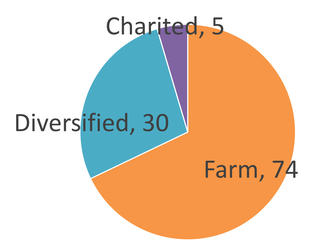
- Vertical farming can increase productivity per unit of land and support urban population.
- A conventional greenhouse is a special case of stacked horizontal systems with only a single layer.
- Energy efficiency and land cost are the main concerns when farmers adopt vertical farming, but there has no empirical evidences for the research.

Data

Vertical farm survey data in 2013 is from Japan Greenhouse Horticulture Association, including farms' sizes, vertical farming types, addresses, etc. The energy efficiency of vertical farming data is from Weidner et al. (2021). Prices of land is from National Chamber of Agriculture, Japan.







Methods

- To analyze the factors, a multinomial logit model is adopted.
- Firm *i* makes a choice *j* among three different types of farming: greenhouse farming with natural sunlight (s), controlled environment agriculture with artificial lighting (a), or hybrid (h).
- Firm i's systemic utility V_{ij} derived from choice alternative *j*, *j*=1,…,*J*. (*J*=3) is

$$V_{ij} = X'_{ij}\beta + \varepsilon_{ij}$$

where the vector of attributes X_i contains factors that influence the utility, including land cost and energy efficiency. β is the vector of coefficient, and ε_{ij} is the random error term.

Results

Variable	Hybrid		Artificial		Hybrid	Artificial
	Coef. (Std. Err.)	$\frac{\partial y}{\partial x}$	Coef. (Std. Err.)	$\frac{\partial y}{\partial x}$	Coef. (Std. Err.)	Coef. (Std. Err.)
Ln(Land cost)	-1.14** (0.50)	-0.02 (0.01)	-2.26*** (0.48)	-0.16*** (0.02)	-1.18** (0.56)	-3.30*** (0.86)
Ln(Energy cost)	0.68 (0.51)	0.02 (0.02)	1.03** (0.42)	0.07** (0.03)	0.62 (0.59)	2.36*** (0.79)
Business Type						
Diversified					-13.85 (1713)	4.91*** (1.63)
Charitable					-15.21 (5027)	-0.79 (8.41)
Cons	9.26*** (5.33)		24.79*** (5.08)		10.93* (5.94)	26.86*** (7.24)
Log likelihood	-45.61				-35.58	

(a) Sunlight is the base case. (b) Level of significance: *** 1%,** 5%, *10%. (c) Business types are pure farm, diversified company (e.g. LED company), and charitable organization.

Conclusions

- When considering the land and energy costs, the probability of adopting artificial vertical farms (a) or hybrid (h) instead of conventional greenhouses (sunlight) decreases with increased land costs and increases with increased energy costs.
- The marginal effects reflect the magnitude change of probabilities. When the natural log land cost increased by one unit, the probability of choosing an artificial vertical farm instead of conventional vertical farms increased by 16%.
- If considering the type of business, diversified businesses have a higher chance to choose vertical farming with artificial lighting instead of conventional greenhouses than farms. For example, LED companies adopt vertical farming with artificial light to demonstrate LED products. Selling fresh produce is not the priority of the business.

References

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