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行動モデル夏の学校

Modeling and Case Study of Land Transaction Mechanism with Gale-Shapley Algorithm

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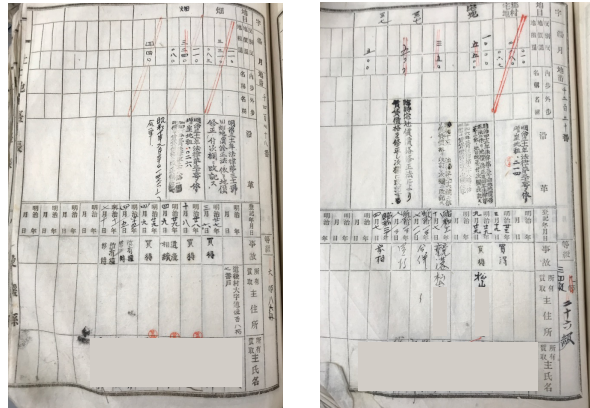
My Research Scope and Purpose

- Purpose = Proposing landholding behavior empirical analysis framework

Landholding behavior

Landowners' data

Time series data = Trajectory data



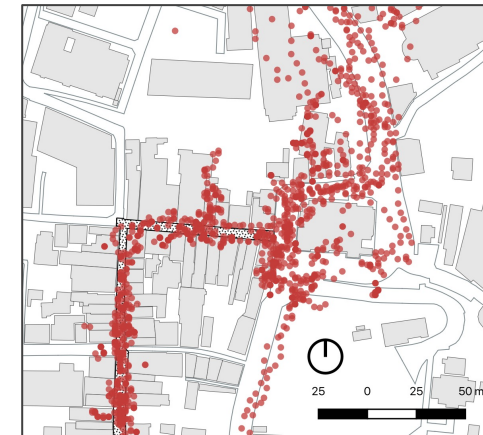
Model

Landholding pattern choice

Land transaction

Travel behavior

Person trajectory data

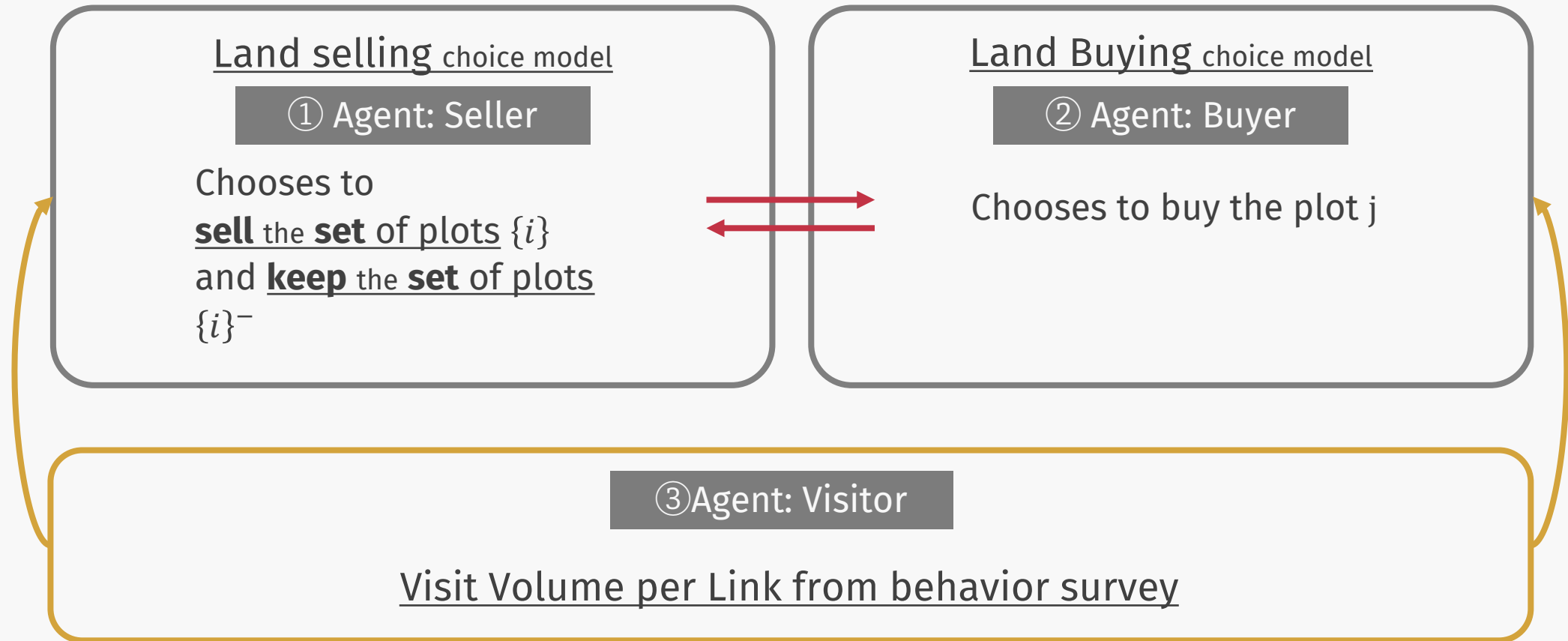


Model

Sequential route choice

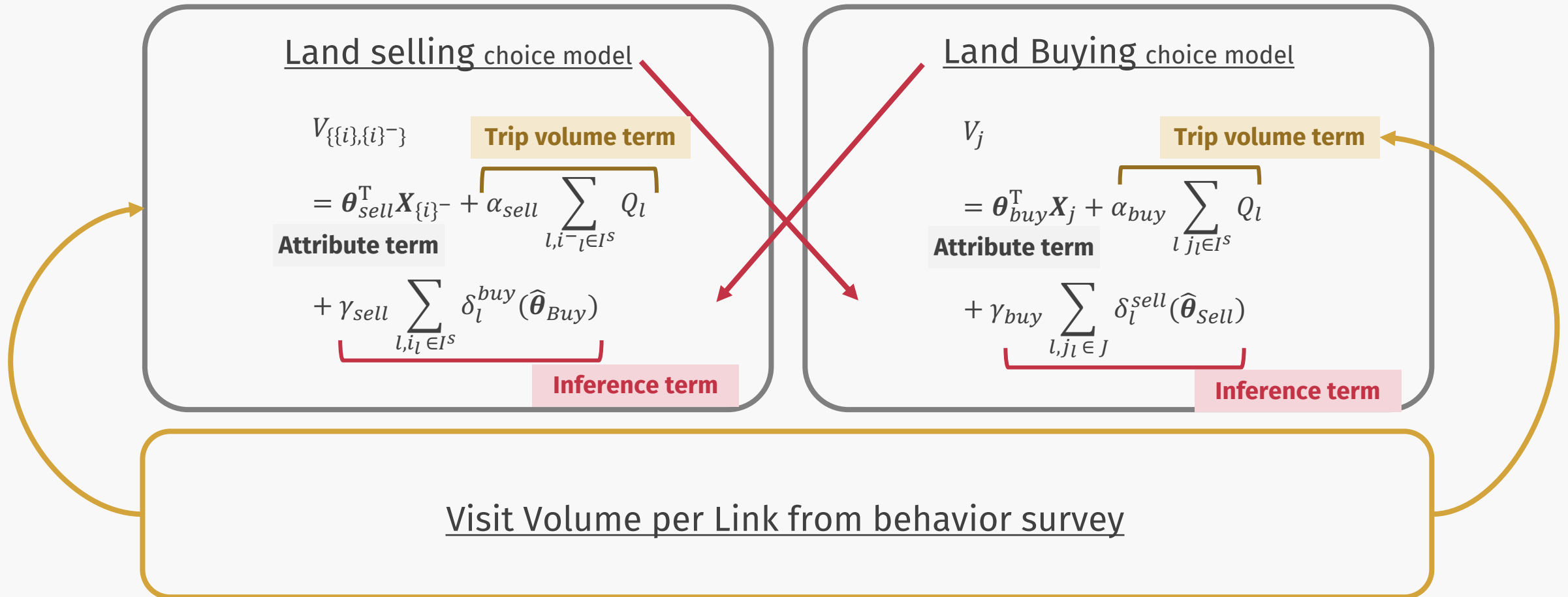
Land Transactions Model

- Purpose : Propose a micro land-transportation interaction model consisting of three agents



Land Transactions Model

- Consider interaction between selling and buying transaction



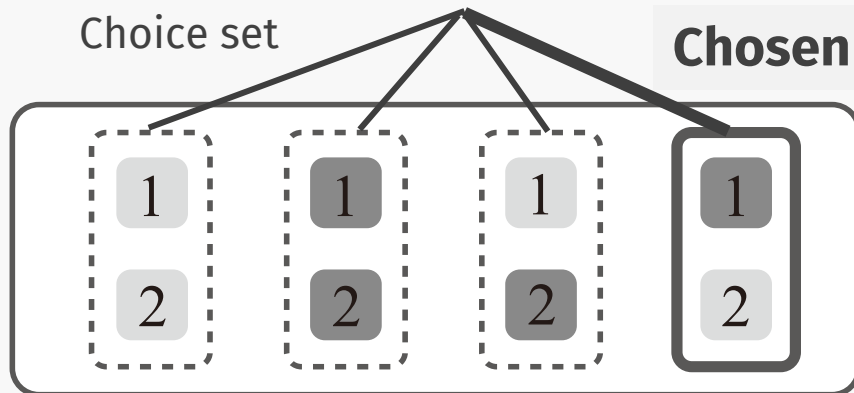
Land Selling Choice Model

- Choice behavior

Seller chooses to “sell the set of plots $\{i\}$ ” and “keep the set of plots $\{i\}^-$ ”

- Choice set

Choice set is owned land combination.



- Deterministic term of utility function

$$V_{\{\{i\},\{i\}^-\}}$$

Attribute term

$$= \theta_{sell}^T X_{\{i\}^-} + \alpha_{sell} \sum_{l, i_l^- \in I^S} Q_l$$

Trip volume term

Inference term

$$+ \gamma_{sell} \sum_{l, i_l \in I^S} \delta_l^{buy} (\hat{\theta}_{Buy})$$

- l refers to link
- $\hat{\theta}_{Buy}$ is estimates of the buy model
- Parameter is $\theta_{sell} = (\theta_{sell}, \alpha_{sell}, \gamma_{sell})$

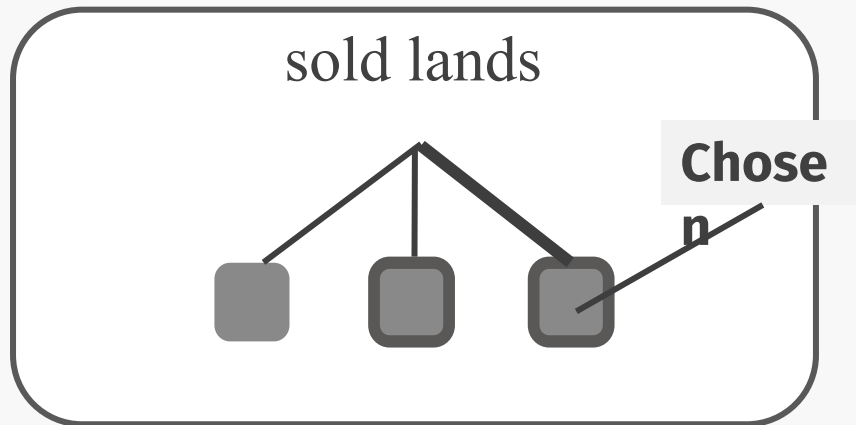
Land Buying Choice Model

- Choice behavior

Buyer chooses to buy the plot j

- Choice set

randomly sampled from sold land



- Deterministic term of utility function

$$V_j$$

Attribute term

Trip volume term

$$= \theta_{buy}^T X_j + \alpha_{buy} \sum_{l, j_l \in I^s} Q_l$$

Inference term

$$+ \gamma_{buy} \sum_{l, j_l \in J} \delta_l^{sell}(\hat{\theta}_{sell})$$

- l refers to link
- $\hat{\theta}_{sell}$ is estimates of the sell model
- Parameter is $\theta_{Buy} = (\theta_{buy}, \alpha_{buy}, \gamma_{buy})$

Matching Algorithm: Summary

- Formulate matching of selling and buying using the estimation results of a land transaction model.
- Using the estimation results, it is possible to determine the order of preference of the two economic agents, the seller and the buyer.
- Aim for “stable matching” by applying **Gale-Shapley's DA algorithm**
- Assume that the seller and the buyer are either in a state in which both are not matched or in a state in which matching is tentatively established

Matching Algorithm: Detail

1. The free buyer makes an offer for the land with the highest probability of selection among his choices.
2. Next, if the seller who owns the land is free, he or she accepts the offer, and a tentative match is established.
3. If the seller who owns the land is already provisionally matched, the selection probabilities of the provisionally matched buyer and the newly offered buyer are compared, and the buyer with the higher selection probability is provisionally matched.
4. If the provisional matching with the seller is resolved, the buyer removes the resolved seller's land from his preference list and becomes free.
5. The above procedure is repeated until there are no more buyers who are not tentatively matched.

Digitize Method for Real Estate Registration Data

➤ Two types of data converted for disaggregated and network data

- **Owner and land attributes for each lot number** per year for disaggregated data
- **Transaction graph list** for the clarification of transaction

2021/01/19 14:46 現在の情報です。

表題部 (土地の表示)		調製	平成6年5月26日	不動産番号	5000000143690
地図番号	1374 S4・21-2	筆界特定	[余白]		
所在	松山市道後湯之町 [余白]				
①地番	②地目	③地積	㎡	原因及びその日付〔登記の日付〕	
甲 [余白]	宅地	99	17	[余白]	
[余白]	[余白]	[余白]	...	昭和63年法務省令第37号附則第2条第2項の規定により移記 平成6年5月26日	
[余白]	[余白]	107	39	③錯誤 地図作成 〔平成18年3月14日〕	
権利部 (甲区) (所有権に関する事項)					
順位番号	登記の目的	受付年月日・受付番号	権利者	その他の事項	
1	所有権移転	昭和23年5月10日 第4959号	原因 昭和23年3月19日売買 所有者 松山市 [余白]	"売買" 順位1番の登記を移記	
[余白]	[余白]	[余白]	[余白]	昭和63年法務省令第37号附則第2条第2項の規定により移記 平成6年5月26日	
2	所有権移転	平成11年2月5日 第4711号	原因 平成10年4月5日相続 所有者 松山市 [余白]		
3	所有権移転	平成24年12月5日 第38990号	原因 平成18年7月30日相続 所有者 松山市 [余白]		
4	所有権移転	平成27年12月17日 第36914号	原因 平成27年8月6日買取 所有者 松山市		

Fig. Real Estate Registration Data

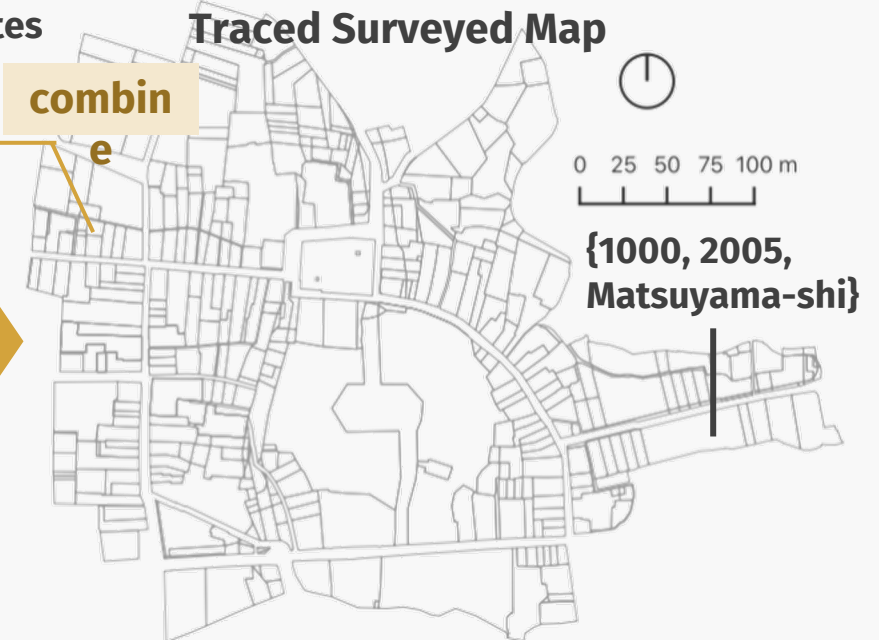
List of Owner and Land Attributes

Lot. No	Year	Name
1517-1	2004	Xxx, xxx
1517-1	2005	Mastuyama-shi
1517-1	2006	Mastuyama-shi
...
1517-2	2005	Mastuyama-shi

Transaction Graph

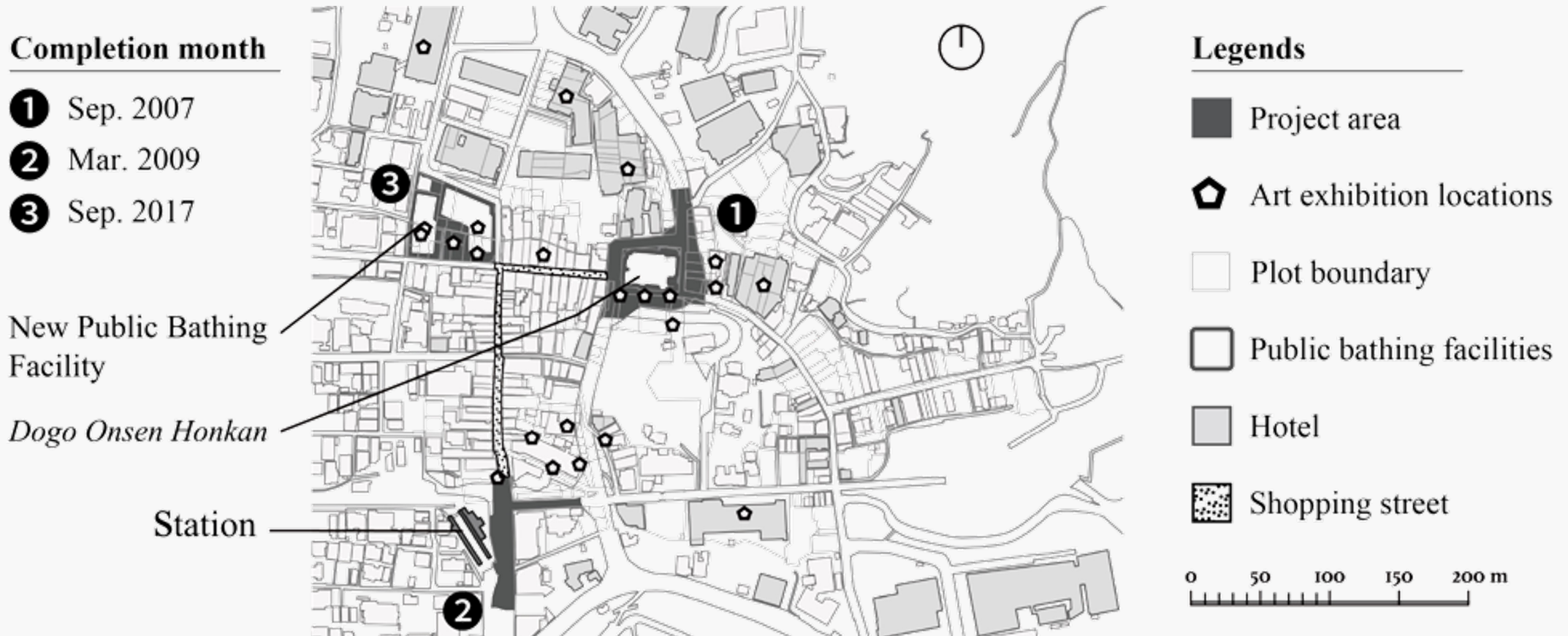
Year	Seller	Buyer
2004	Xxx, xxx	Mastuyama-shi
...

Traced Surveyed Map



Case Study Area : Dōgo Onsen District

- Dōgo held some major urban development in 2004-2009, 2013-2017.
- Both land-related and travel-related data exist.



Model Specification

Parameter	Variable Name	Description
	Cluster Size (/10m)	Average distance from the center of gravity of clusters obtained by clustering already owned plot by Ward's method to the center of gravity of maintained/purchased plot polygons
$\theta_{sell}^T, \theta_{buy}^T$	Length of Frontage (/10m)	Average length of the plot boundary that intersects the perpendicular line from the center of gravity of the maintained/purchased plot polygon to the road link. If the perpendicular line intersects another plot polygon, it is assumed to be 0m as it is not tangent to the road.
$\alpha_{sell}, \alpha_{buy}$	Volume of Visits	Number of visitors per link revealed by migratory behavior data
γ_{sell}	Estimated Selling Volume	Estimated sale volume per link calculated from the sold land choice model
γ_{buy}	Estimated Buying Volume	Estimated purchases per link calculated from the purchased land choice model

Estimation Result

		2004-2009		2009-2013		2013-2017		2017-2021	
		Sell	Buy	Sell	Buy	Sell	Buy	Sell	Buy
Cluster Size	Est.	-1.974	-0.684	-2.341	-1.175	-0.528	-0.894	-0.243	-1.496
	t-value	-5.184**	-5.608**	-4.678**	-4.130**	-6.240**	-4.147**	-0.310	-2.507**
Length of Frontage	Est.	0.459	0.382	1.680	0.695	-3.818	1.047	1.690	0.381
	t-value	5.064**	3.505**	10.801**	2.514**	9.066**	3.001**	8.772**	1.751*
Volume of Visits	Est.	3.023	-0.306	2.894	-0.737	1.486	4.183	2.127	-1.875
	t-value	3.096**	-0.566	2.651**	-0.419	1.803*	0.632	2.440**	-0.622
Estimated Buying Volume	Est.	-0.308	-	-0.565	-	0.708	-	-0.907	-
	t-value	-14.872**	-	-10.714**	-	-10.484**	-	-8.760**	-
Estimated Selling Volume	Est.	-	-0.009	-	-0.167	-	-0.063	-	-0.026
	t-value	-	-0.308	-	-2.731**	-	-0.916	-	-0.322
LL(0)		-1393.707	-220.606	-1275.413	-136.680	-980.078	-122.293	-718.381	-100.712
LL		-894.267	-160.307	-643.540	-71.166	-508.008	-83.927	-357.748	-66.255
ρ^2		0.355	0.269	0.492	0.472	0.478	0.306	0.496	0.332
Number of Sample		1717	92	1607	57	1230	51	884	42

Estimation Result

		2004-2009		2009-2013		2013-2017		2017-2021	
		Sell	Buy	Sell	Buy	Sell	Buy	Sell	Buy
Cluster Size	Est.	-1.974	-0.684	-2.341	-1.175	-0.528	-0.894	-0.243	-1.496
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Tendency to maintain high visits plots.

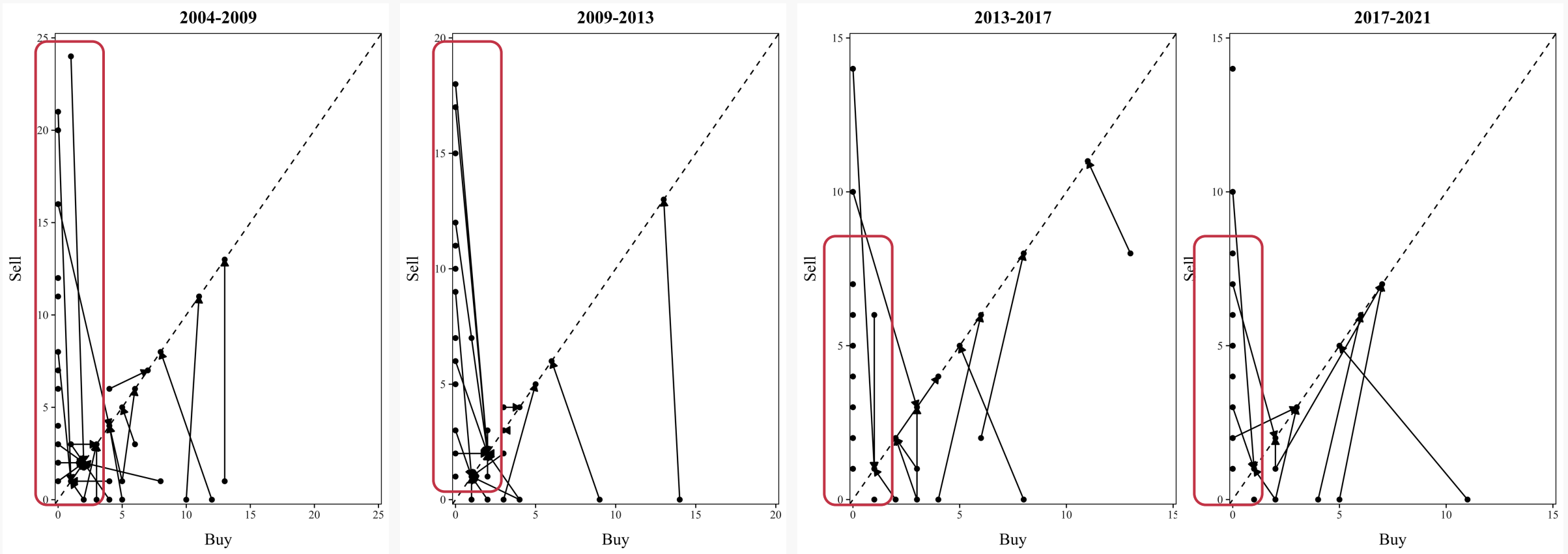
2009-2013 shows buying behavior with an eye on selling

Estimation Result

		2004-2009		2009-2013		2013-2017		2017-2021	
		Sell	Buy	Sell	Buy	Sell	Buy	Sell	Buy
Cluster Size	Est.	-1.974	-0.684	-2.341	-1.175	-0.528	-0.894	-0.243	-1.496
	t-value	-5.184**	-5.608**	-4.678**	-4.130**	-6.240**	-4.147**	-0.310	-2.507**
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	t-value	5.064**	3.505**	10.801**	2.514**	9.066**	3.001**	8.772**	1.751*
Volume of Visits	Est.	Tendency to maintain high visits				1.486	4.183	2.127	-1.875
	t-value	volumes over all time periods				1.803*	0.632	2.440**	-0.622
Estimated Buying Volume	Est.	Selling behavior predicts buying				0.708	-	-0.907	-
	t-value	behavior, whereas buying				-10.484**	-	-8.760**	-
Estimated Selling Volume	Est.	selling behavior				-	-0.063	-	-0.026
	t-value					-	-0.916	-	-0.322
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Matching Result

- 2004-2013 results are best matched
- 2013-2017 results show an overselling and an increase in unmatched links



Conclusion and Future works

Conclusion

- **Modeling interaction of landowners by discrete choice model**
- **Proposing the specific methods for efficient land matching**
 - ✓ Using DA algorithm and estimation results
 - ✓ Matching computation time was less than 0.1 second: practical
 - ✓ Matching result shows seller's dissatisfaction

Future works

- Seller's dissatisfaction → Implementation of seller-proposed matching algorithm
- Introduction of indicators of matching efficiency