Regional Disparities on Healthcare Expenditure in Japan: Evidences from Spatial Panel Data Analysis in Deflationary Period

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Outline

- Backgrounds & objectives
- Methodologies
- Regional disparities of healthcare cost and # of doctors
- Model estimation results
- Prediction of healthcare cost and prospects of shortage of doctors
- Discussions

Backgrounds & Objectives

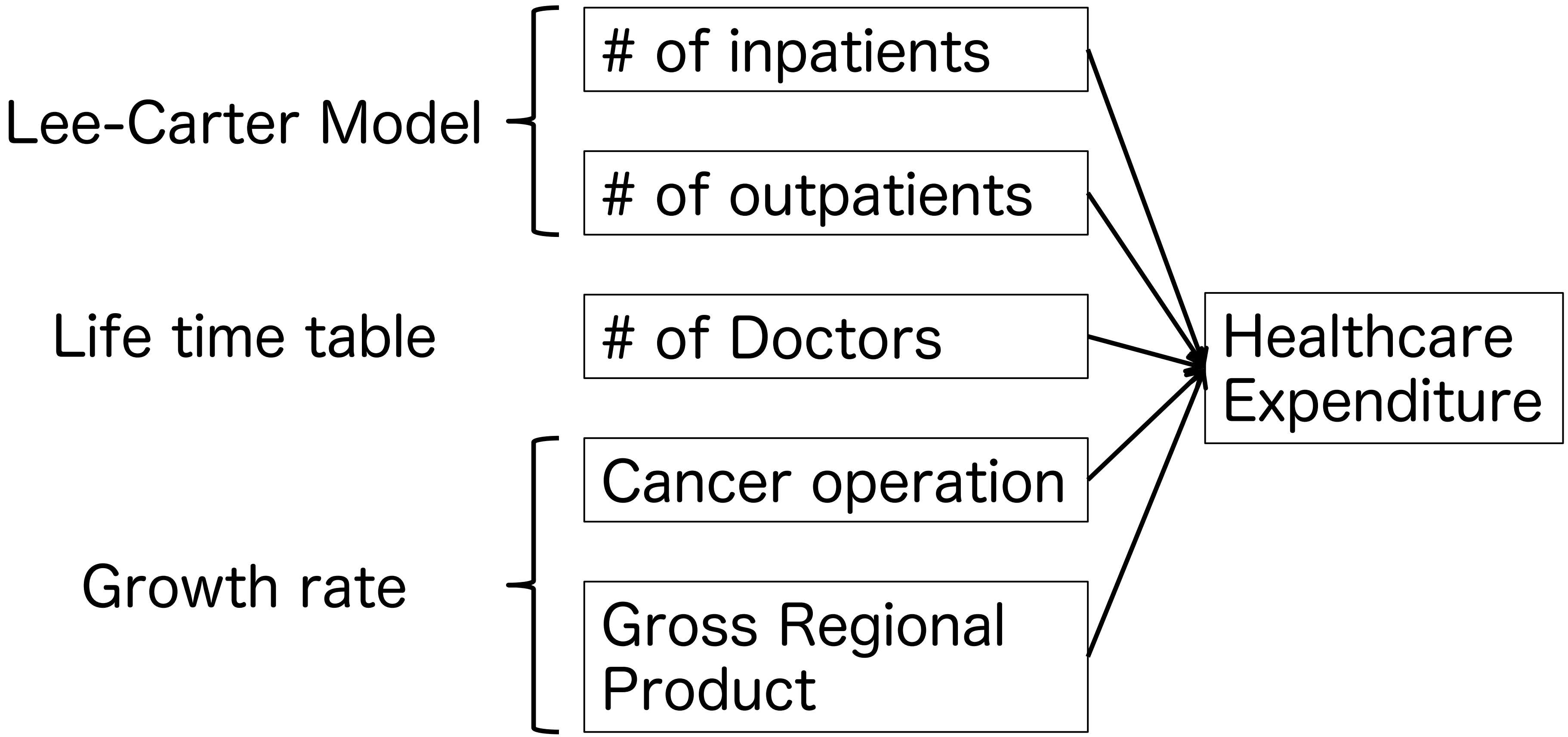
- Regional disparities on healthcare in Japan (cost, doctors, patients, etc.)

- Estimating spatial panel/ geographically weighted panel data models to explain healthcare cost
- Prospecting next few decade's healthcare cost and doctor shortage

Methodologies

- Local Moran's I
  - Regional imbalances of healthcare cost and doctors
- Lee-carter model
  - Predicting in-&out-patients
- Lifetime table
  - Predicting the number of doctors
- (Geographically weighted) Spatial panel data model
  - Estimating healthcare cost models

Structure of Models

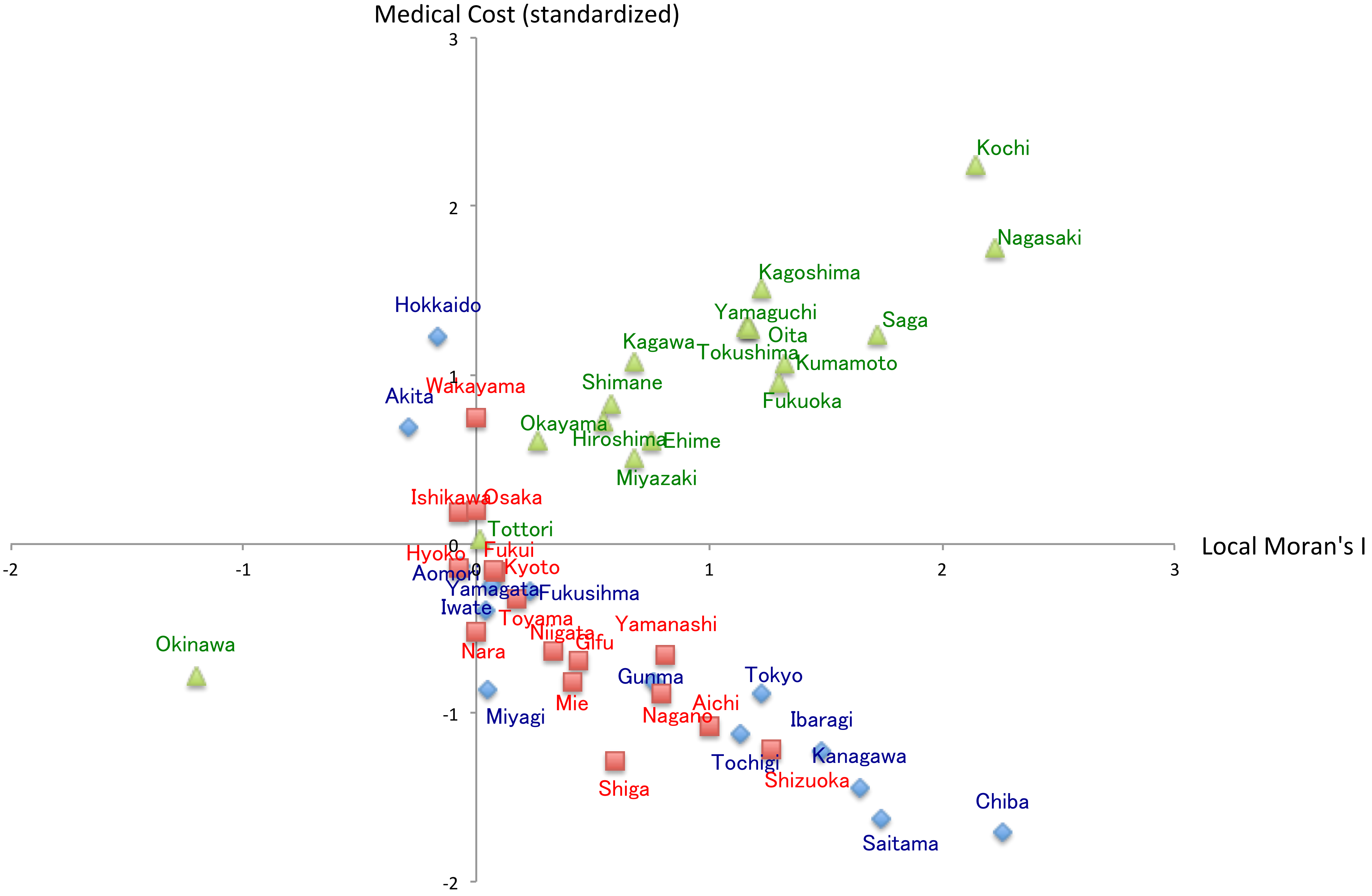


Data set

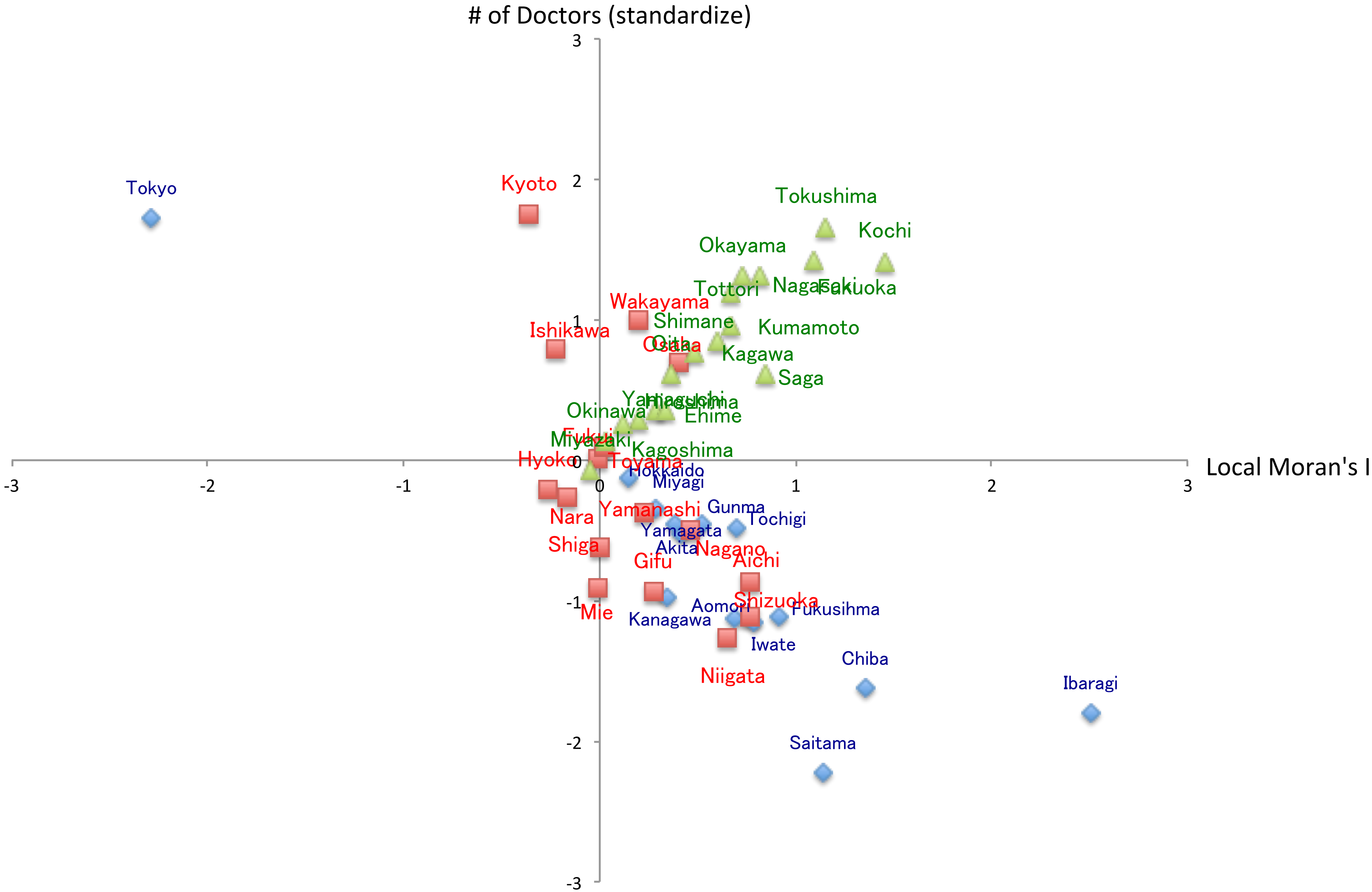
Data	Units	Sources
Medical cost	Yen/10^5 persons	National Medical Survey
Gross Regional Product (GRP)	10^3Yen/persons	Regional Economic Accounting
The number of outpatients	Per/10^5 persons	Patient Survey
The number of inpatients	Per/10^5 persons	Patient Survey
The number of doctors	Per/10^5 persons	Survey on doctor, dentist and nurse
The number of cancer operation	# operations/10^3 per.	Medical Facility Survey

Period: 1998-2008 (deflationary period of Japan)

Regional Disparity of Healthcare Cost



Regional Disparity of # of Doctors



Lee Carter model

Lee Carter model : $\log(\mu_{xt}) = \alpha_x + \beta_x \kappa_t + \varepsilon_{xt},$

$$\sum \beta_x = 1, \sum \kappa_t = 0.$$

μ_{xt} : mortality rate of age x at time t

α_x : age-specific constant

β_x : age-specific deviation of mortality change

κ_t : trend in mortality

$$\varepsilon_{xt} \sim N(0, \sigma^2)$$

(Lee and Carter, 1992)

Generalized Lee Carter model
(Renshaw and Haberman, 2006)

- GLC model $\mu_{xt} = \exp\left(\alpha_x + \beta_x^{(0)}\iota_{t-x} + \beta_x^{(1)}\kappa_t\right)$

  α_x : age effect (main effect)

  ι_{t-x} : cohort effect (interaction effect)

  κ_t : period effect

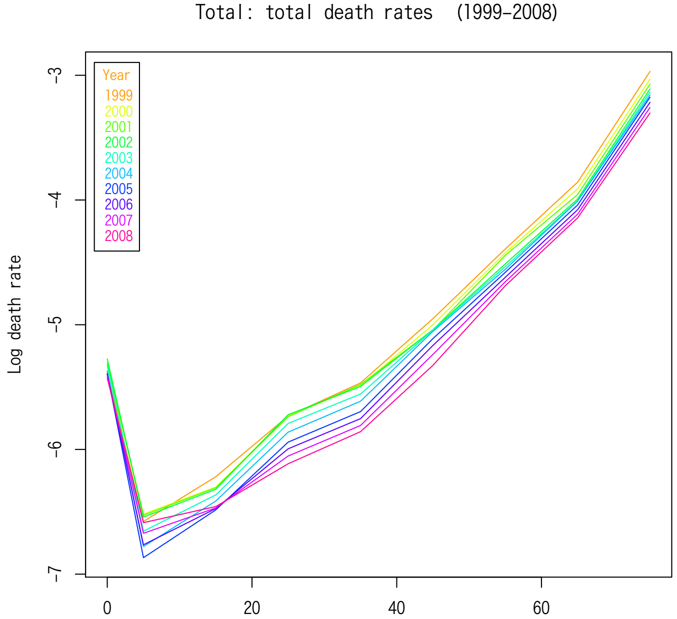
- Forecast $\dot{\mu}_{x,t_n+s} = \exp\left(\hat{\alpha}_x + \hat{\beta}_x^{(0)}\dot{\iota}_{t_n+s-x} + \hat{\beta}_x^{(1)}\dot{\kappa}_{t_n+s}\right),\ s > 0$

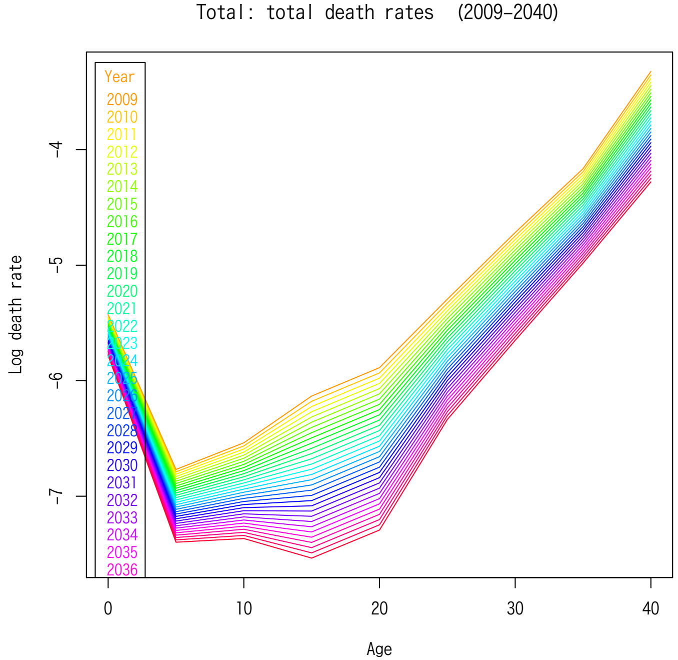
  $\dot{\iota}_{t_n+s-x}$: forecast cohort

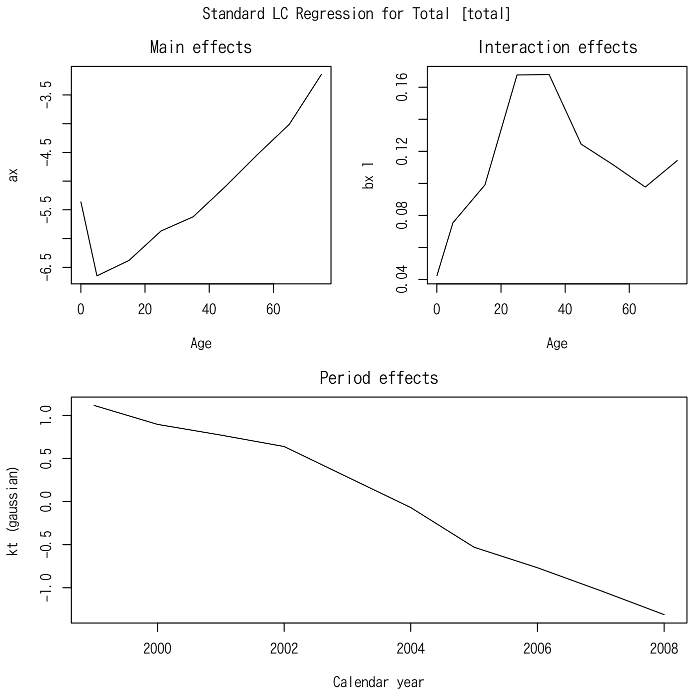
  $\dot{\kappa}_{t_n+s}$: forecast period

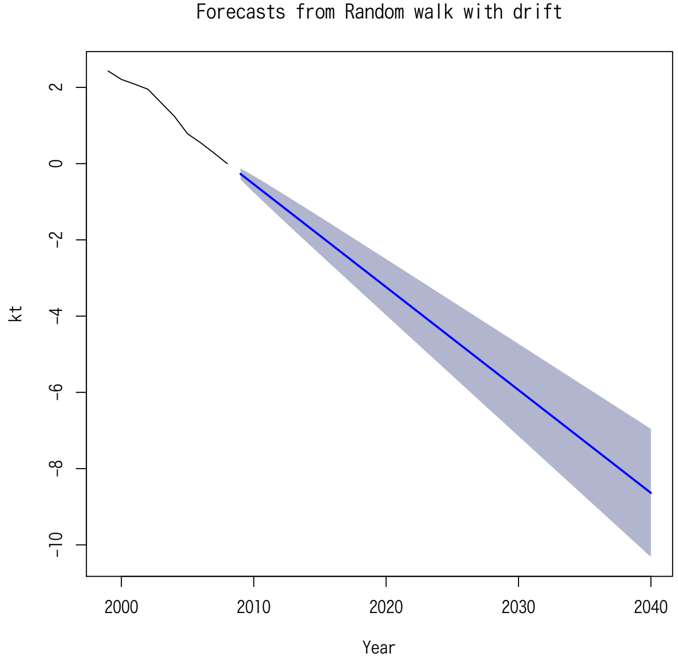
  s : future period (2011-2035)

Lee-carter model (Tokyo, inpatients)

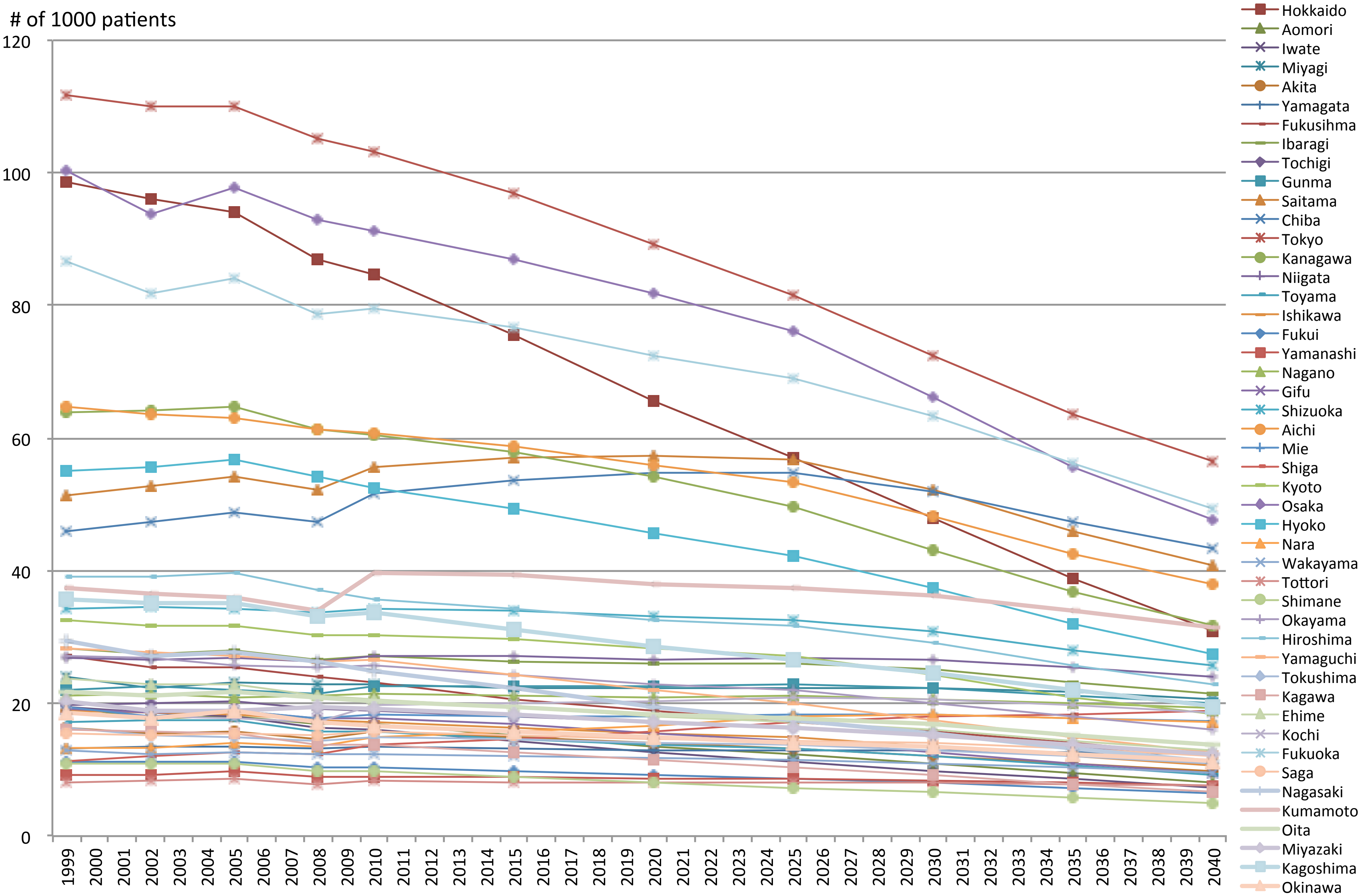




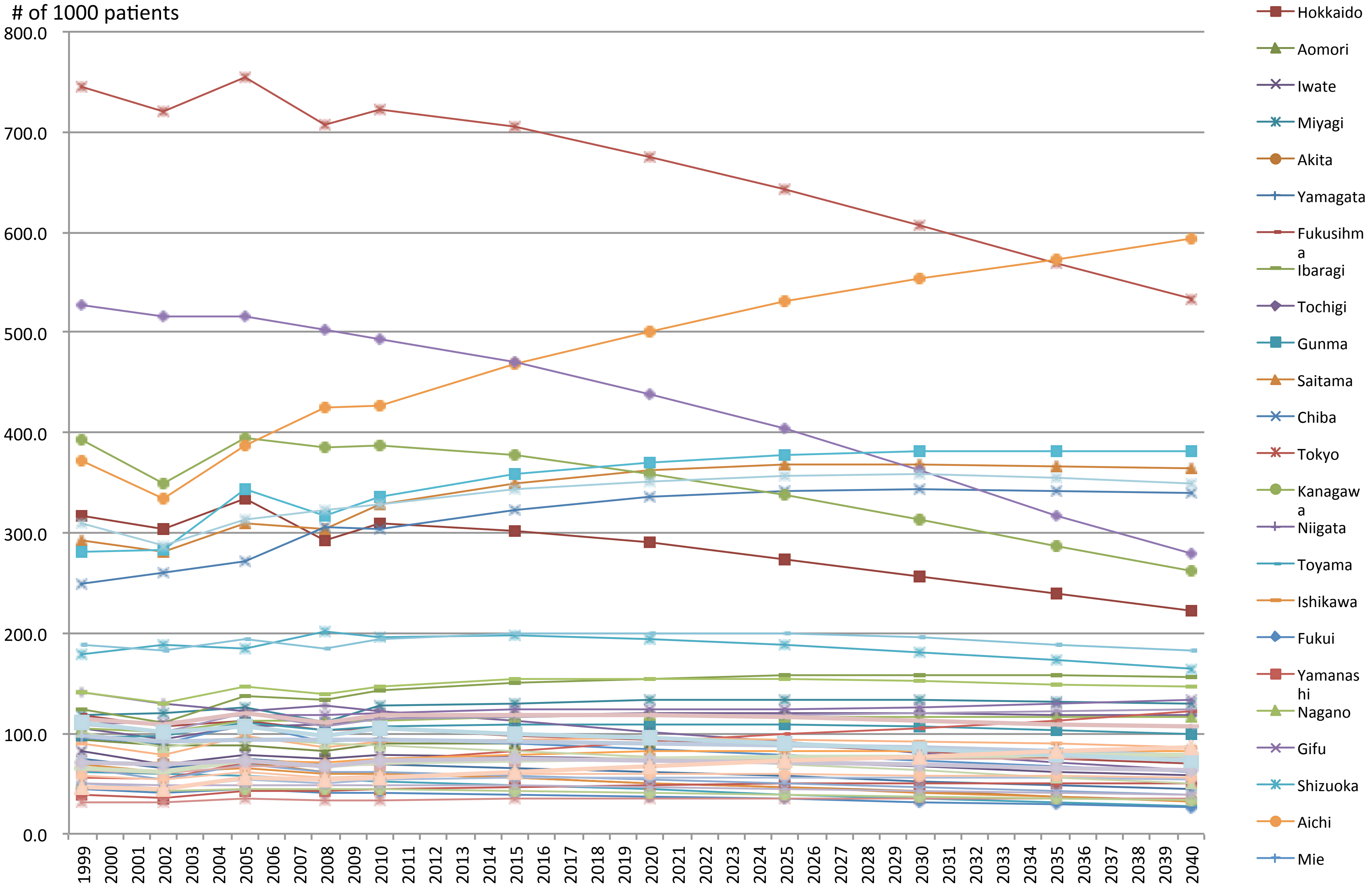




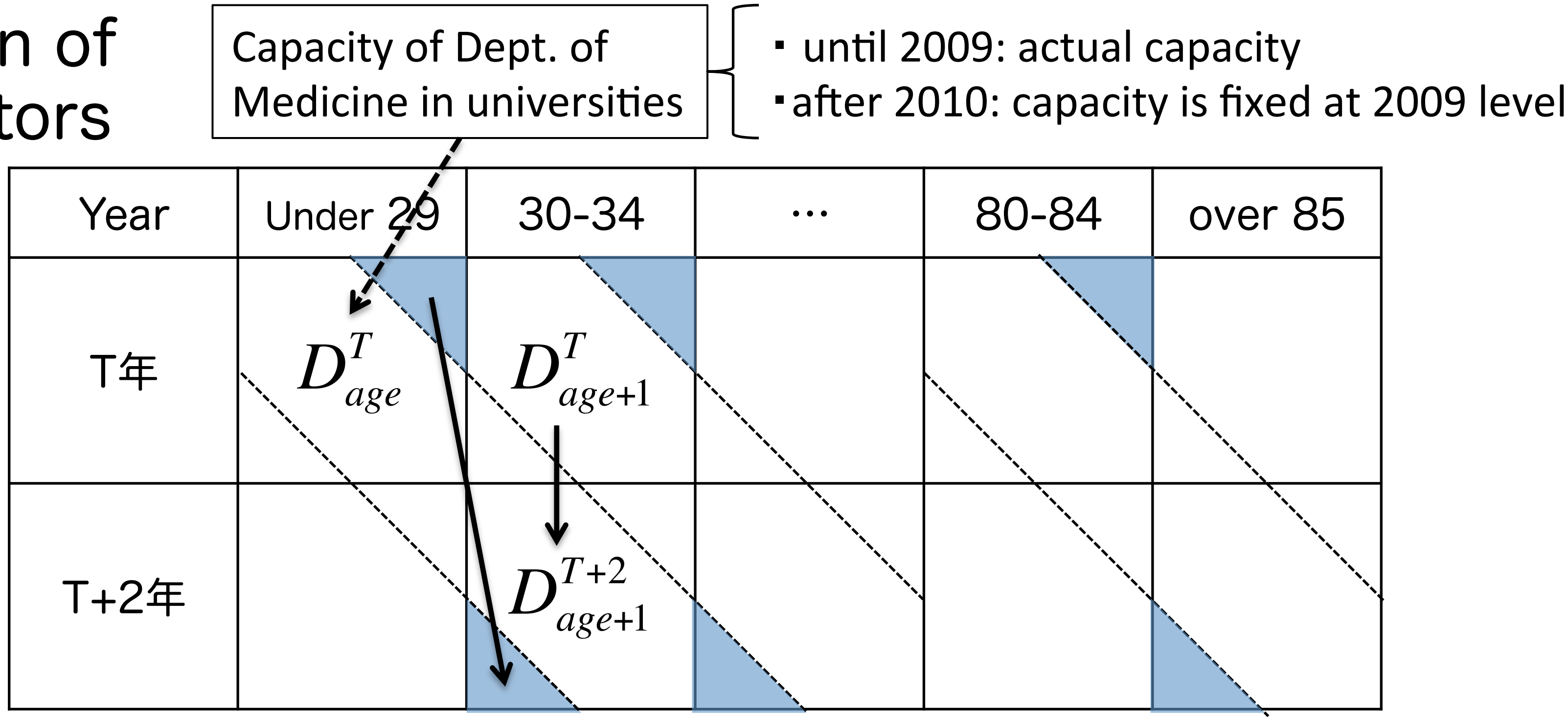
Prediction: Inpatients



Prediction: Outpatients



Prediction of # of Doctors

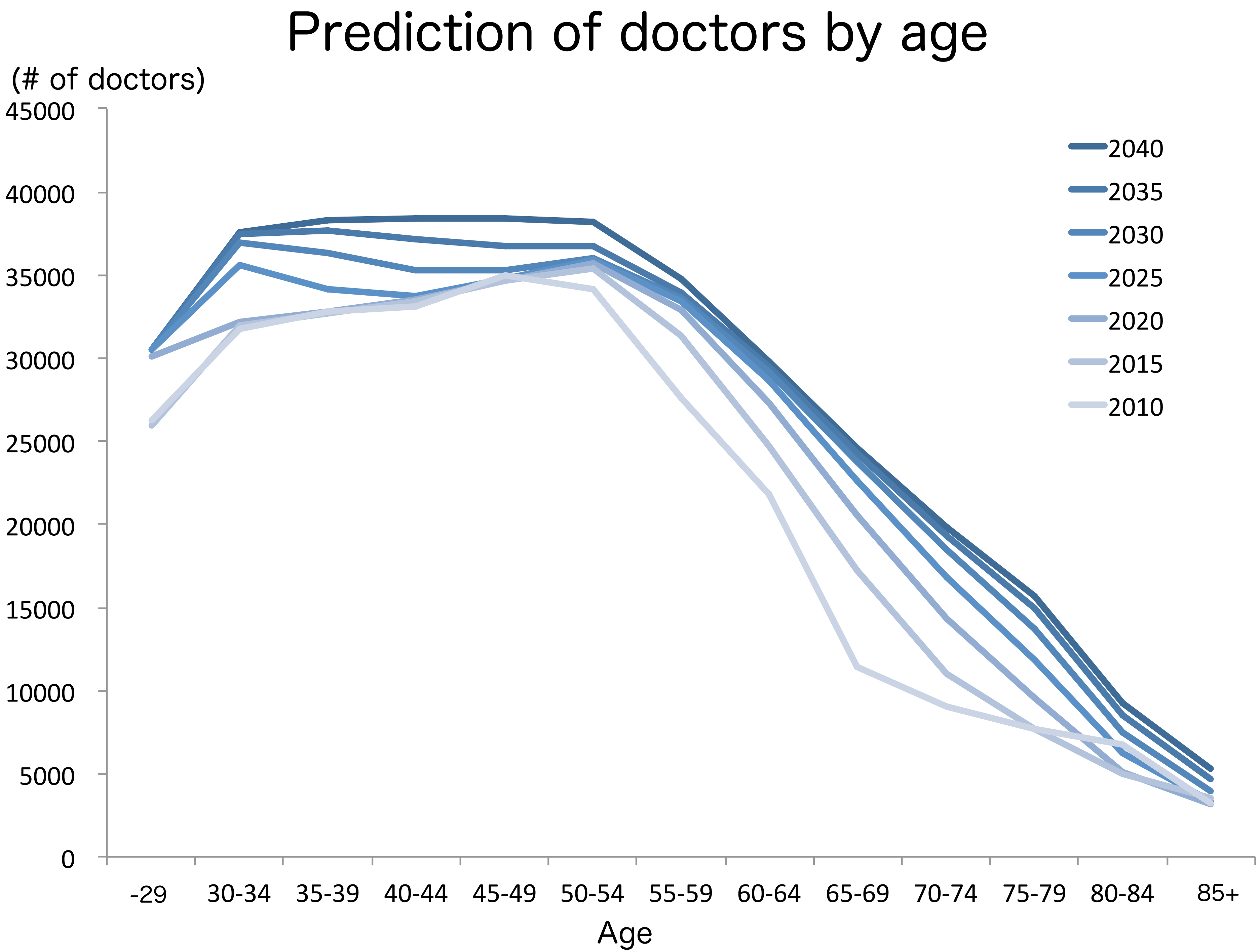


b_{age} : Continue rate from age to age +1

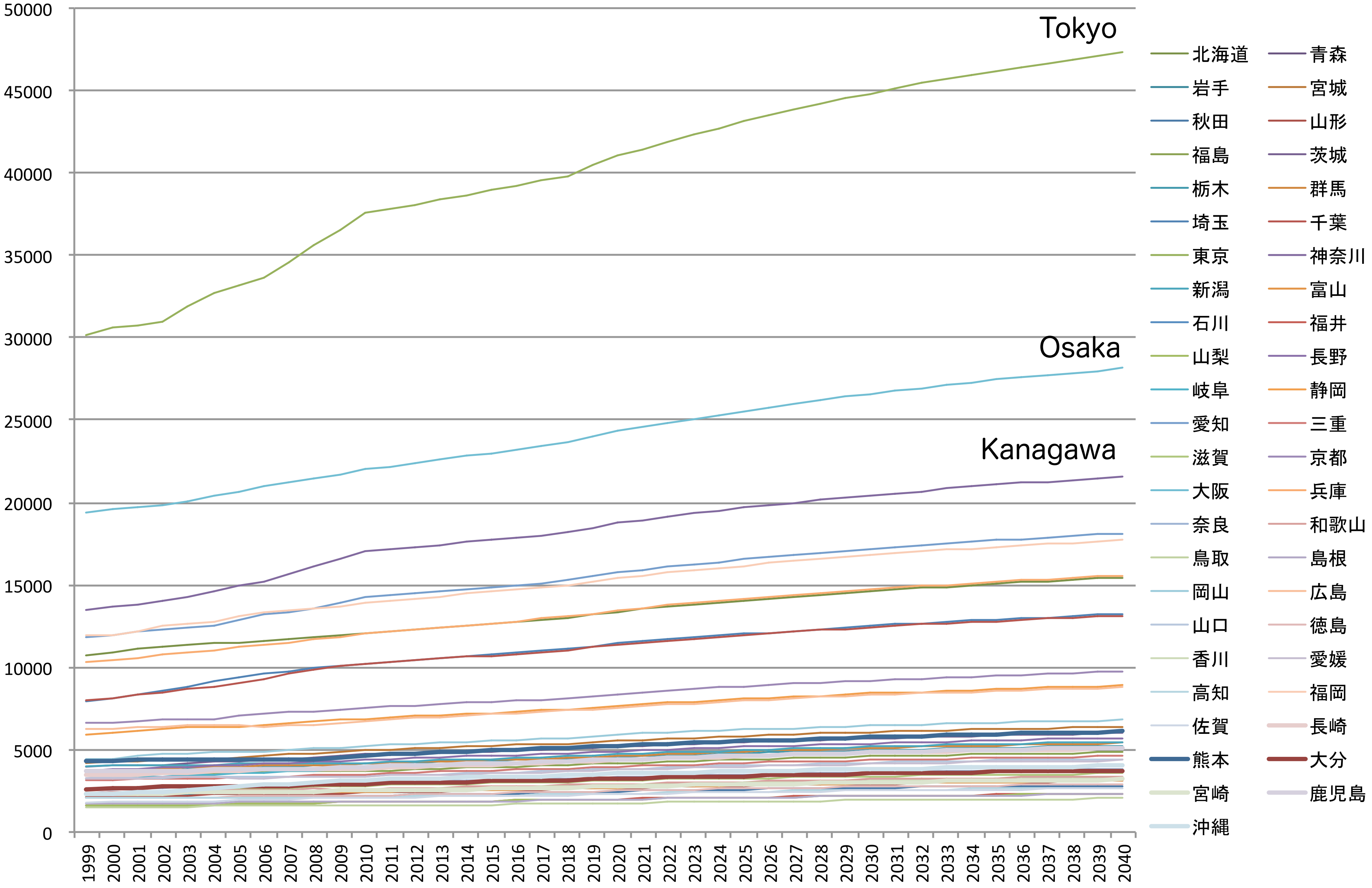
Under 29: $$D^{T+2}_{age+1} = b_{age} \cdot S^{T}_{age}$$

Age 34-84: $$D^{T+2}_{age+1} = b_{age} \cdot \left(2/5 \cdot D^{T}_{age} + 3/5 \cdot D^{T}_{age+1}\right)$$

Over 85: $$D^{T+2}_{age+1} = b_{age} \cdot \left(2/5 \cdot D^{T}_{age} + D^{T}_{age+1}\right)$$


Prediction of doctors by age
(# of doctors)
45000
40000
35000
30000
25000
20000
15000
10000
5000
0
-29
30-34
35-39
40-44
45-49
50-54
55-59
60-64
65-69
70-74
75-79
80-84
85+
Age
2040
2035
2030
2025
2020
2015
2010

Prediction of doctors by prefecture



Models

	Panel data model	Spatial panel data model	Individual effects		GWP
			Spatial	Temporal	
Model 1					
Model 2.1	○		○		
Model 2.2	○			○	
Model 2.3	○		○	○	
Model 3.1		○	○		
Model 3.2		○		○	
Model 3.3		○	○	○	
Model 4					○

Spatial Panel Data Model

- Panel data model with spatial dependencies both for dependent and independent variables

Spatial lag

$$y_i = \rho W y_i + X_i \beta + W X_i \theta + \alpha_i j_T + u_T$$

$$\alpha_i = \bar{\alpha} + \eta_i + \mu$$

$$u_T = \lambda W u_T + \varepsilon$$

Spatial lag

α_i : Individual effect ~ N($\bar{\alpha}$, η_i)

ρ, θ, λ : unknown parameters

→ here, $\theta = \lambda = 0$

Prediction with SPD model

Predictive value of healthcare expenditure — $\hat{y}_i$

Predictive value of dependent variables — $X_{i,T+\tau}$

Parameters — $\hat{\beta}$

$$\hat{y}_i = \rho W \hat{y}_i + X_{i,T+\tau}\hat{\beta} + \hat{\varepsilon}_{iT}$$

$$\left(I_N - \rho W\right)\hat{y}_i = X_{i,T+\tau}\hat{\beta} + \hat{\varepsilon}_{iT}$$

$$\hat{y}_i = \left(I_N - \rho W\right)^{-1}\left(X_{i,T+\tau}\hat{\beta} + \hat{\varepsilon}_{iT}\right)$$

$$= \left(I_N - \rho W\right)^{-1} X_{i,T+\tau}\hat{\beta} + \left(I_N - \rho W\right)^{-1}\hat{\varepsilon}_{iT}$$

Here,

$$\left(I_N - \rho W\right)^{-1}\hat{\varepsilon}_{iT} = \sum_{i=1}^{T}\hat{\varepsilon}_{it} \Big/ T$$

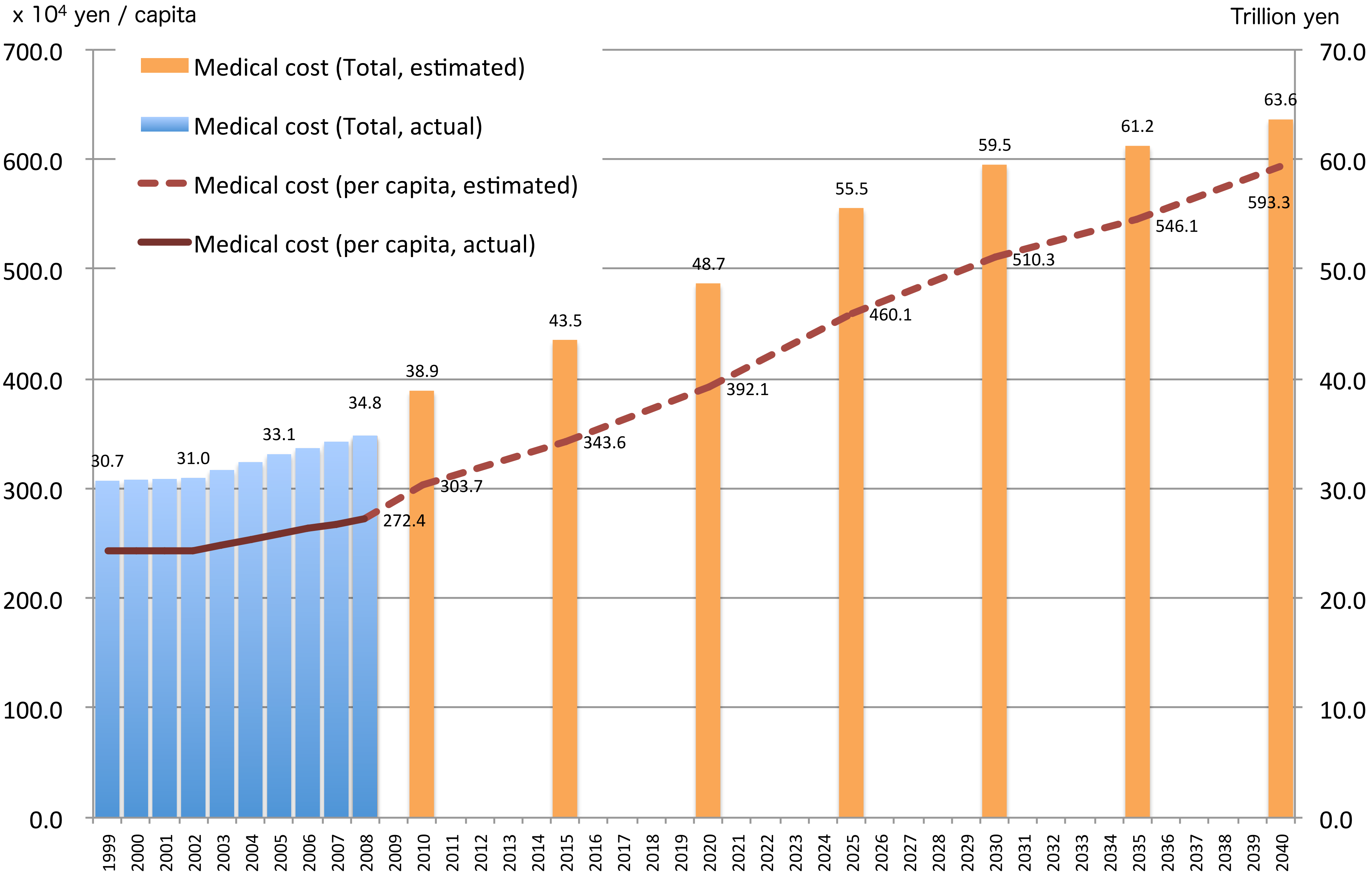
Error term obtained by the estimated model — $\hat{\varepsilon}_{it}$

Baltagi et al. (2013)

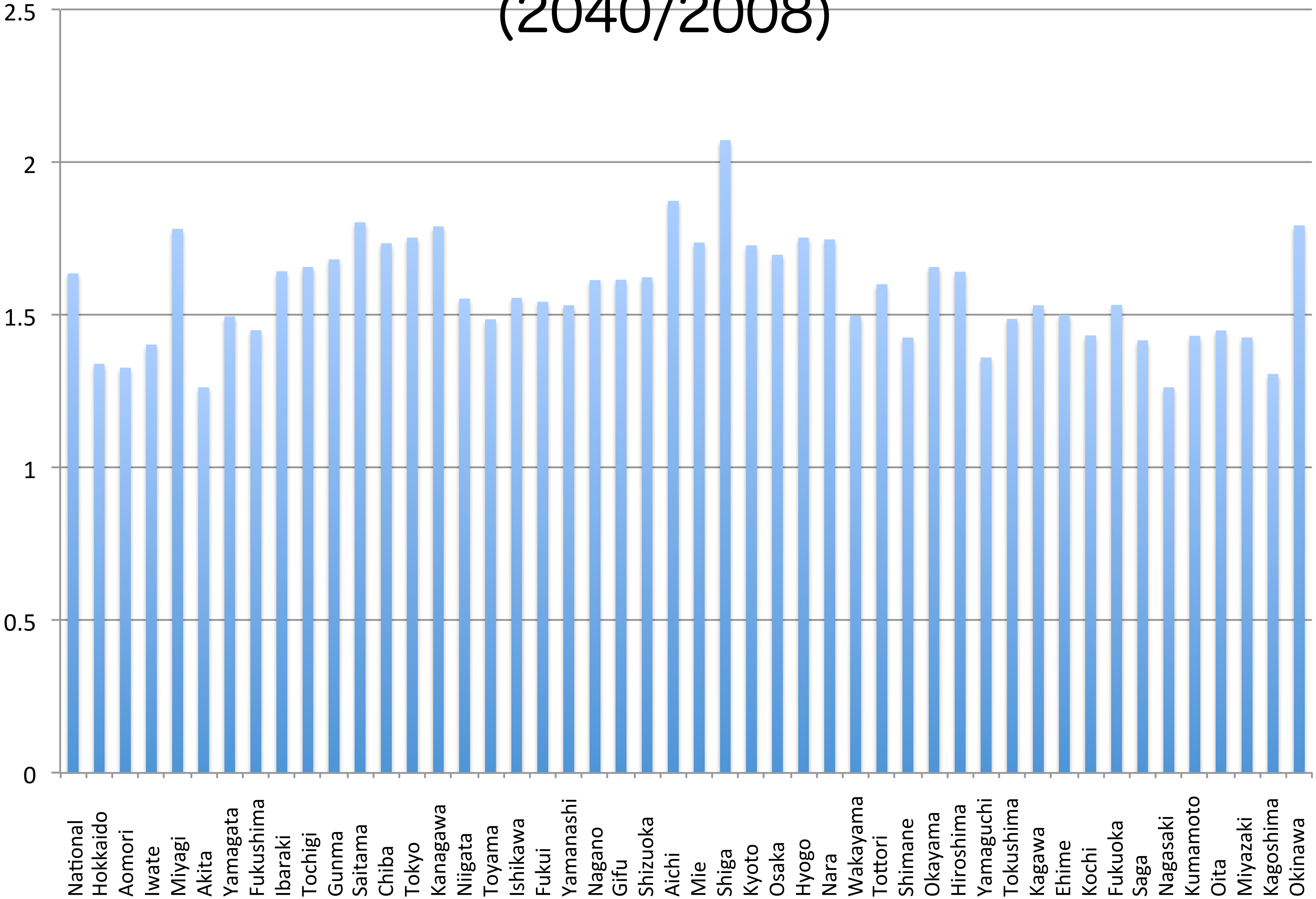
Estimation Results (Fixed Effects of Model 3.1-3)

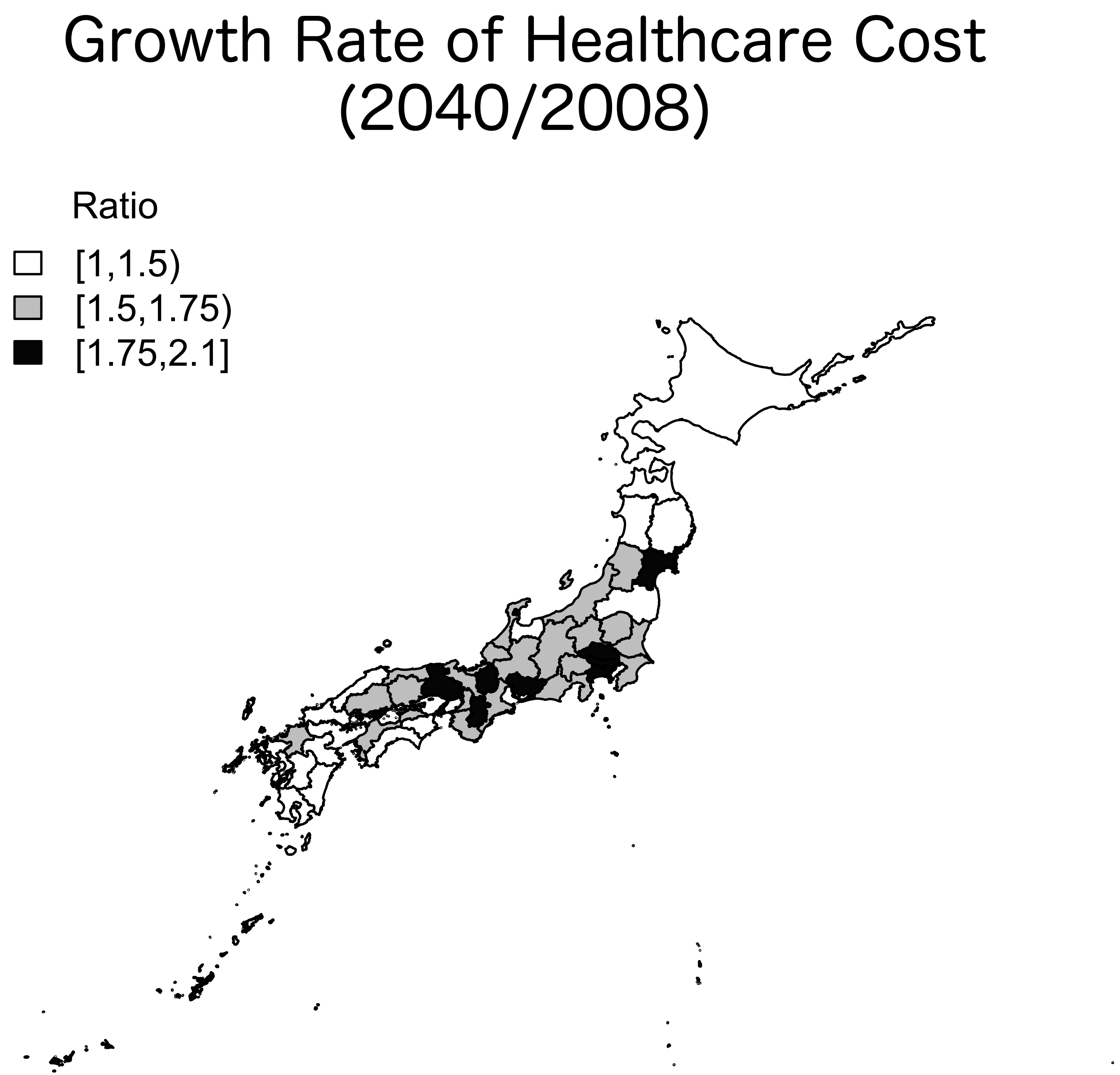
Variables	Model 3.1			Model 3.2			Model 3.3		
	Parameter	t-value		Parameter	t-value		Parameter	t-value	
rho	0.92	87.01	***	−0.38	−4.86	***	0.44	8.79	***
GRP	−0.0024	−1.57		−0.0049	−7.47	***	−0.0008	−0.51	
Inpacients	0.18	4.62	***	0.16	11.45	***	0.12	2.92	**
Outpatients	44.61	10.08	***	46.34	30.69	***	49.71	10.72	***
Doctors	3.13	5.52	***	14.92	19.52	***	3.40	5.67	***
Cancer operations	0.02	4.70	***	0.02	2.45	*	0.02	4.67	***
	R^2=0.96			R^2=0.97			R^2=0.99		

Prediction: Healthcare cost

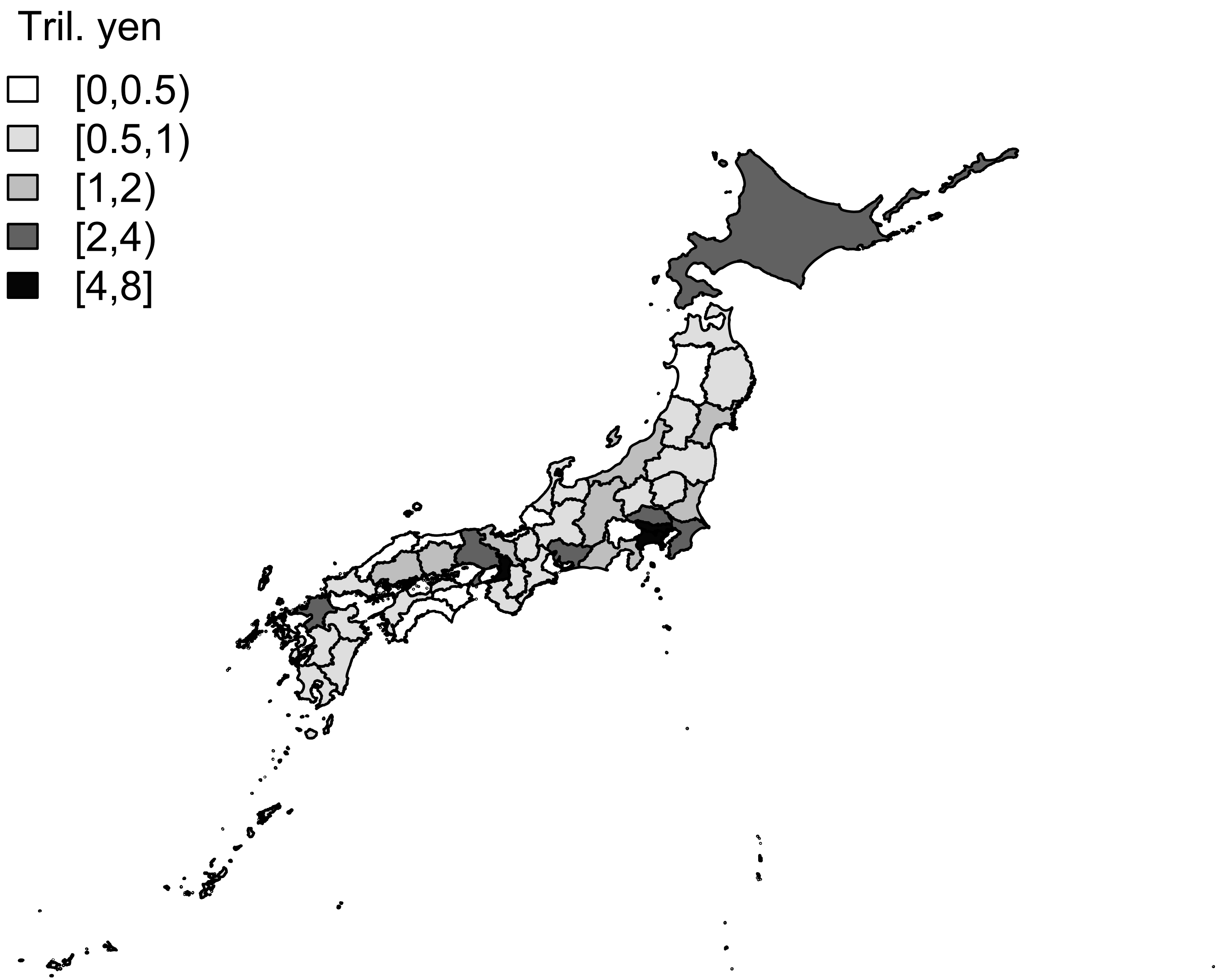


Growth rate of healthcare expenditure (2040/2008)

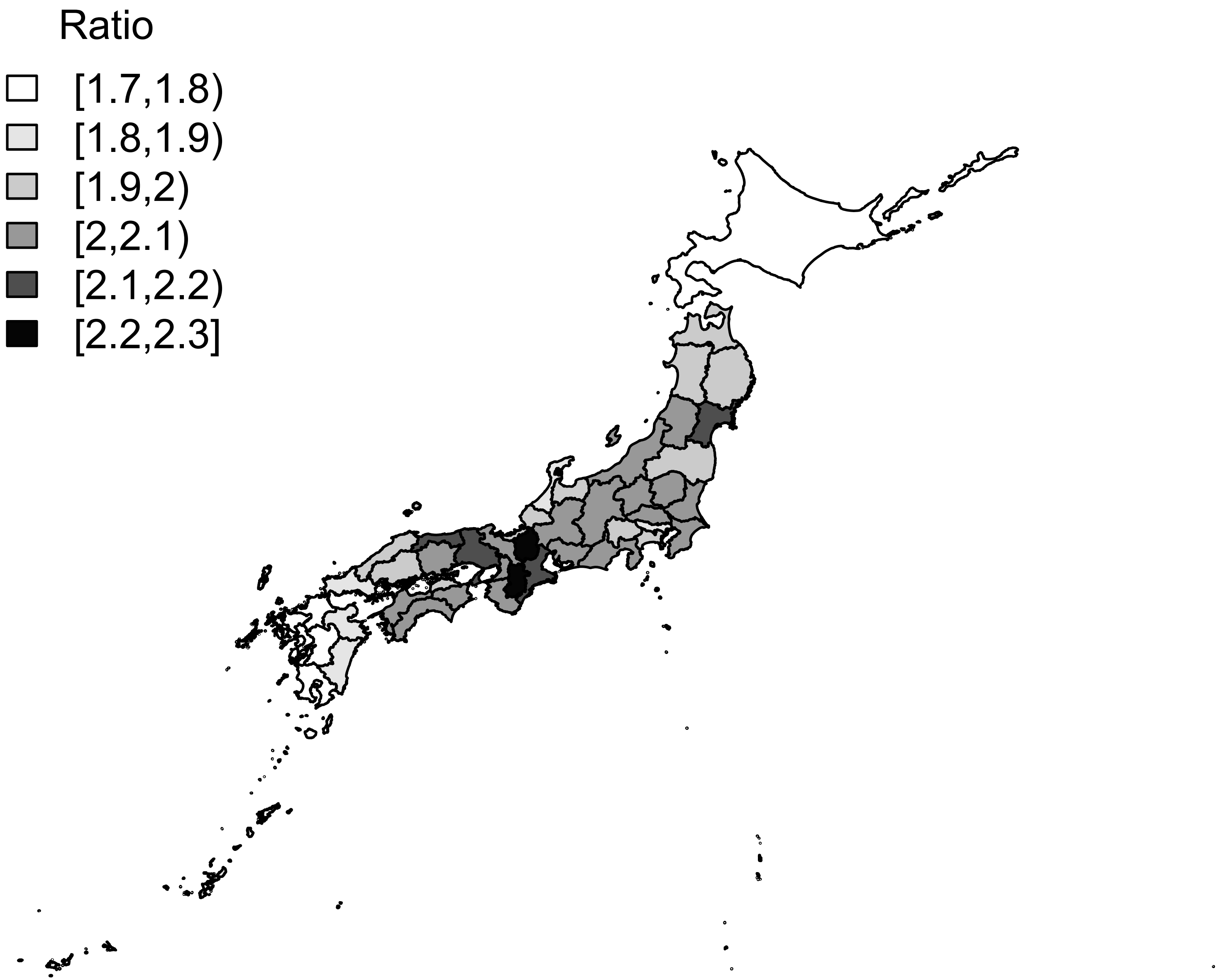



Growth Rate of Healthcare Cost
(2040/2008)
Ratio
[1,1.5)
[1.5,1.75)
[1.75,2.1]

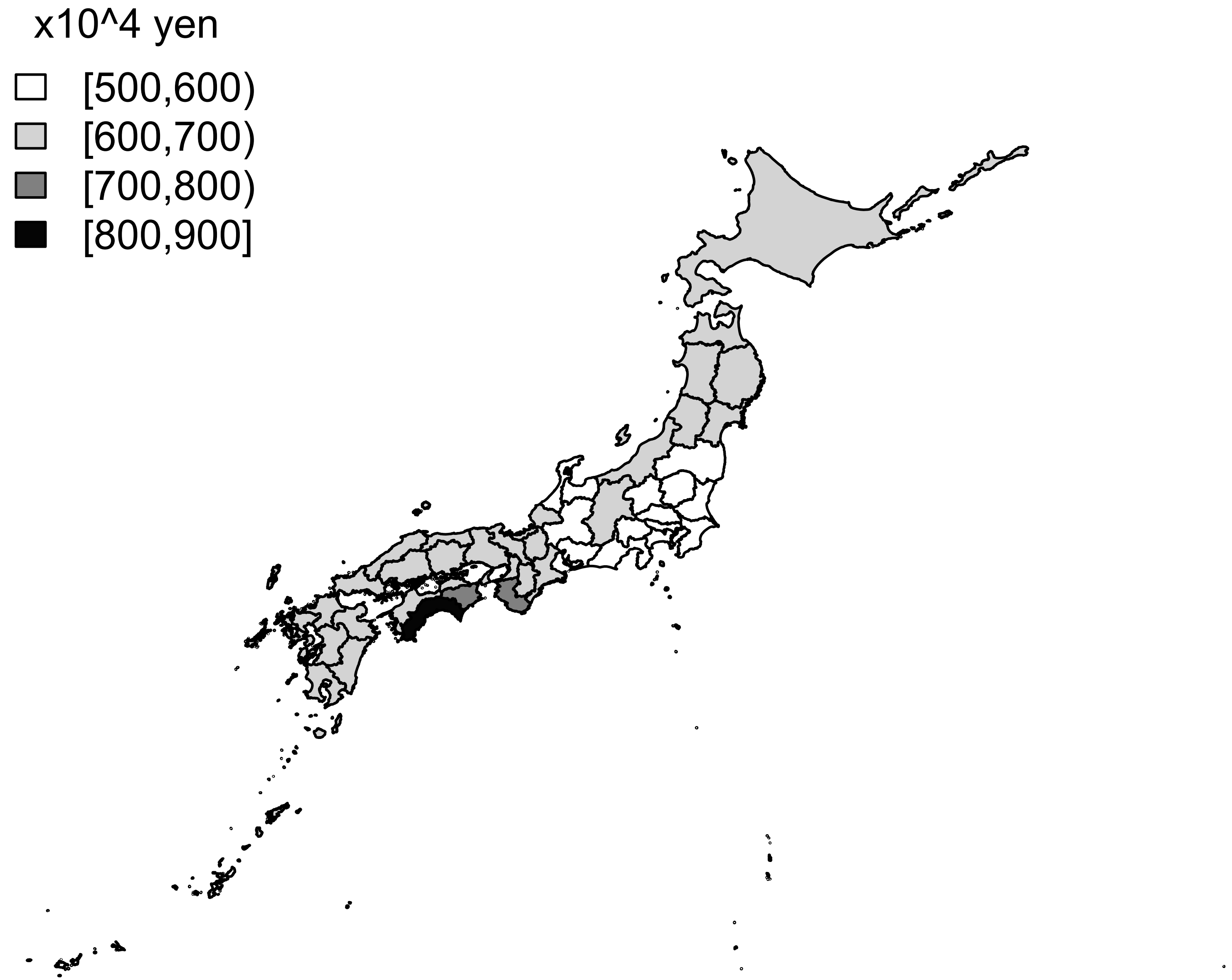
Healthcare Cost (2040)



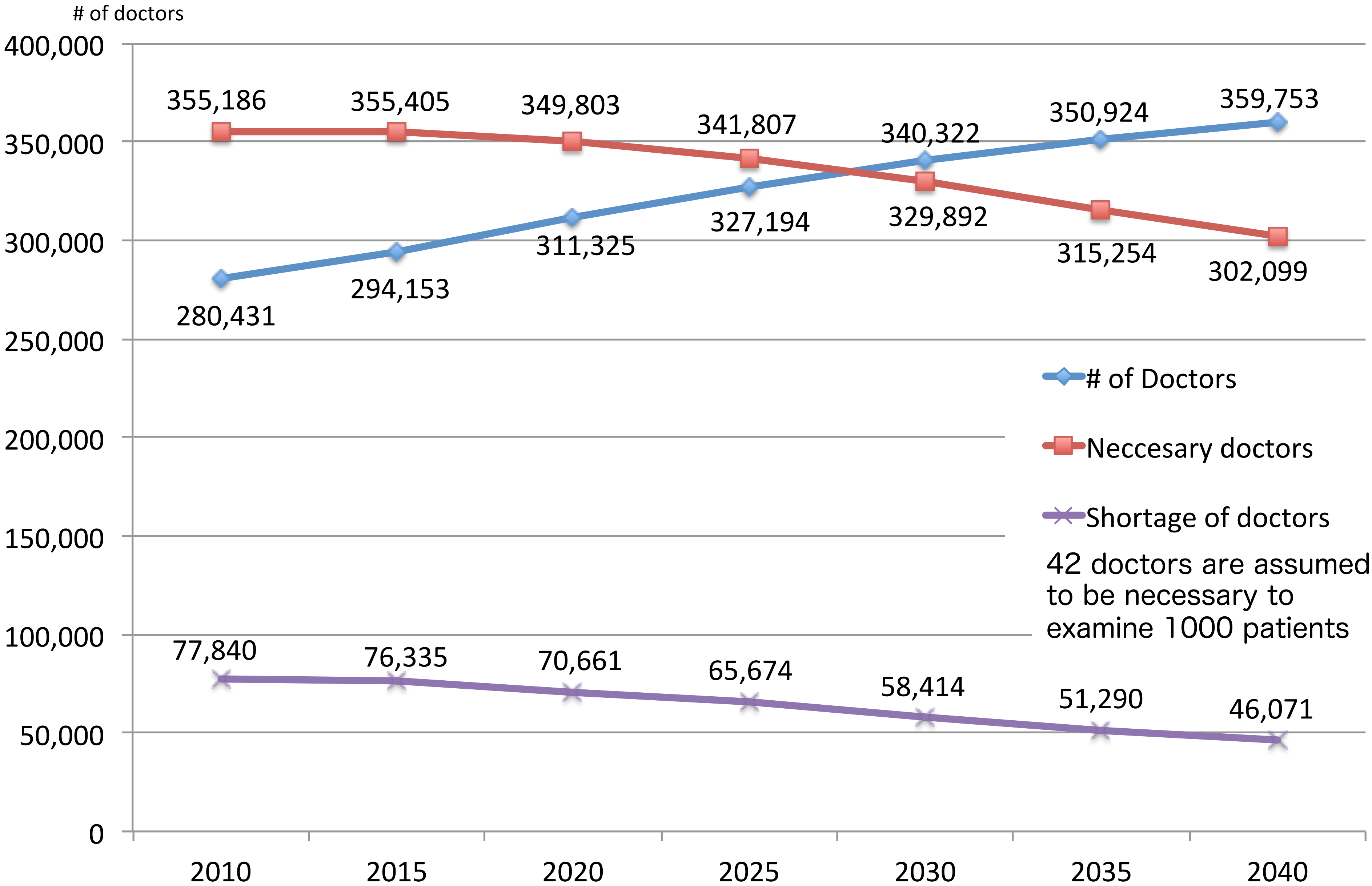
Growth Rate of Healthcare Cost/capita (2040/2008)



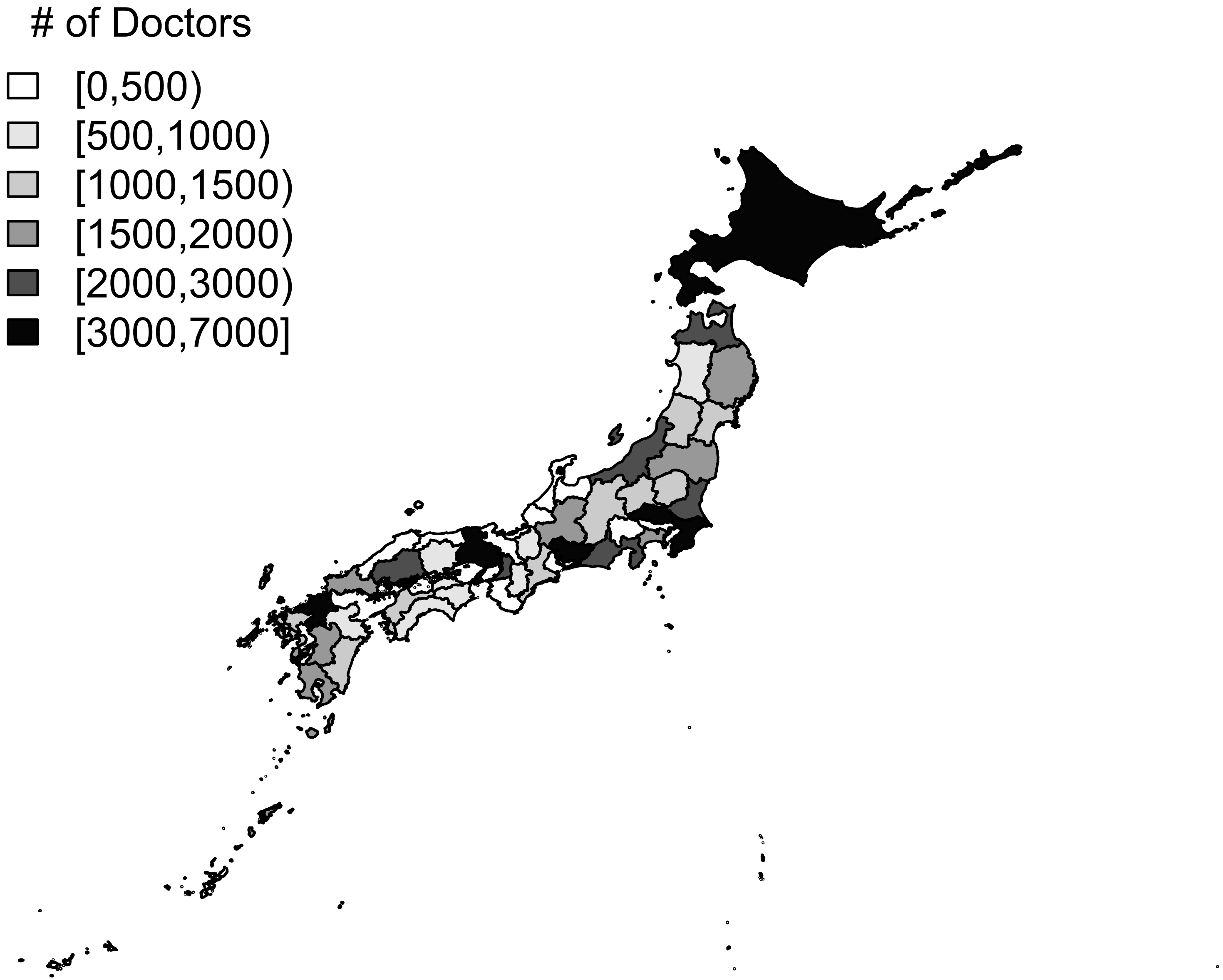
Healthcare Cost/capita (2040)



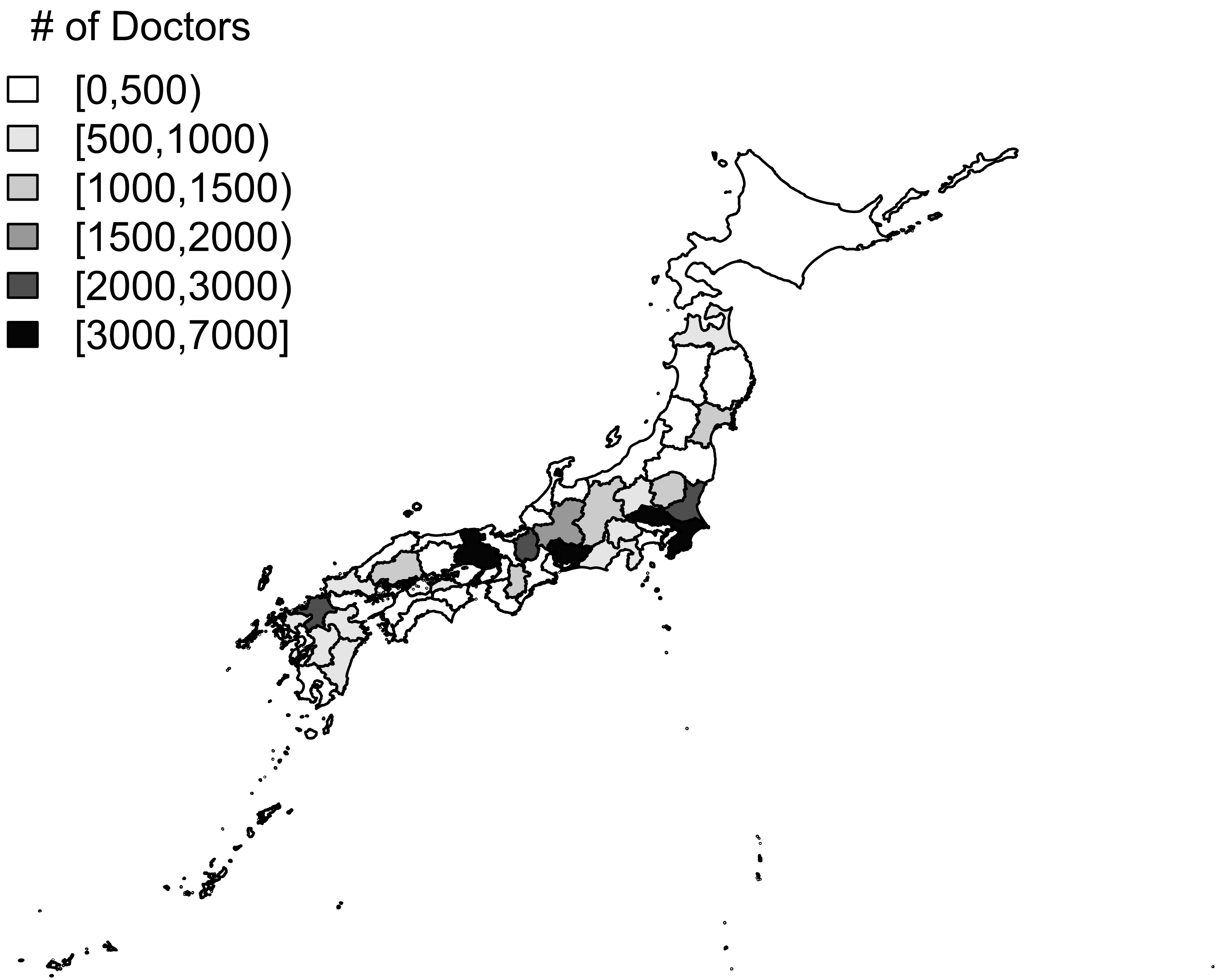
Prospects: Shortage of doctors



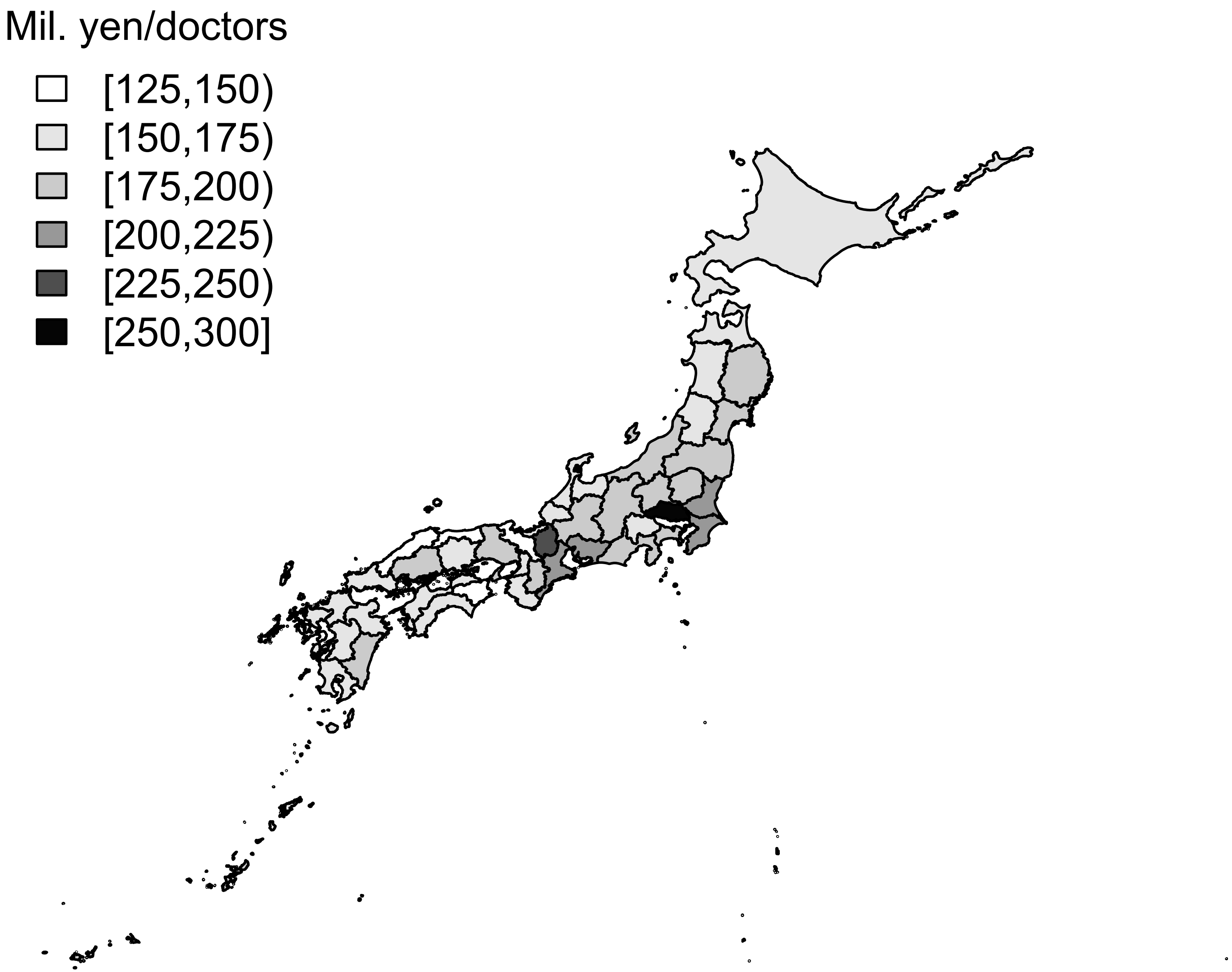
Shortage of Doctor (2010)



Shortage of Doctor (2040)



Healthcare Cost per Doctor (2040)
⇒ Doctor's Income



Discussions

- Growth of healthcare expenditure is significant... But regional gap of doctor’s income also should be redressed
- Regional disparity of doctors rather than shortage of doctors -> how to allocate doctors to rural areas?
- Long-term panel data modeling... next step