The Effect of Speculative Zoning Policy on the Distribution of The Housing Price in Korean Real Estate Market

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1 Introduction

The real estate accounts for a large portion of the assets of Koreans. By the Consumer Expenditure Survey in Korea, the real estate accounts for 70% of total assets in 2017. Which is much larger than that of the U.S.(34%), Japan(60%), etc. Hence, the real estate market will surely be a big concern for Koreans.

There has been evidence that the real estate market is inefficient. The ineffectiveness of the real estate market often leads to bubbles, which, when burst, cause massive economic recession, such as the global financial crisis in 2008. To prevent these problems, some government policy is needed.

Indeed, the policy to the real estate market is a crucial part of each government. The main purpose of the policy should be stabilizing the real estate market. These policies can be roughly categorized into two categories, one is the supply-side policy, and the other is the demand side. The former is mainly restrict construction, and the later is mainly restrict the speculative demand. Adjusting various tax rate has been used in both cases.

However, these policies not always effective. Rather, it seems to be difficult to achieve the desired result. For example, figure 1 shows that the Home Price Index (hereafter "HPI") in Korea from 2006 to 2018. From 2004 to 2008 (dotted boxed periods in Figure 2), the government strived to reduce housing price growth and implement many restrictive policies. However, the

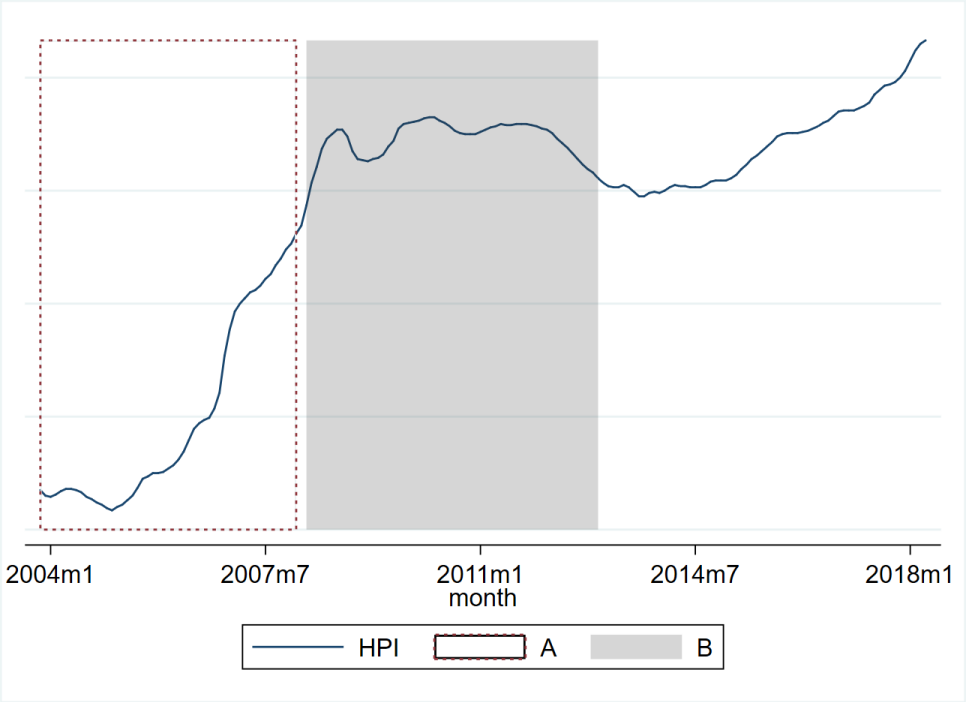


Figure 1: HPI trend

trend of HPI shows that housing prices are the fastest rising in those periods. In fact, this is the almost fastest time for Seoul home prices in Korea's history. On the other hand, from 2008 to 2012 (shaded periods in Figure 2), the government has implemented policies to revitalize the real estate market. But in these periods, the HPI is almost not changed.

Moreover, evaluating the effectiveness of policy is not straightforward. This is mainly because many policies are implemented by indirectly, and they also have some time lag. Hence, in this paper, we focused on the speculative zoning policy. The speculative zone is the area designated by the Minister of Strategy and Finance after deliberation by the committee for real estate price stabilization that is thought to possibly surge in real estate prices. This policy restricts the demand side. The main restriction is imposing or increasing income transfer tax to each trade, lowering LTV(Loan-to-value) ratio to 40%, and setting DTI(Debt-to-income) ratio as 40%. Since this effect is immediately applied, it may be less depending on the policy lag than that of other policies.

There are many studies to evaluate various real estate policies. Many of these studies focused on the estimated mean prices. However, a policy may affect the distribution of housing prices

in the target region even if it has no effect on the mean of prices. The opposite situation is also possible. The contribution of this paper is to analyze the effect of policy in terms of the entire distribution of housing prices by using a stochastic dominance test. Even though we analyze only the speculative zoning policy, this framework may be applied in many other policies.

The outline of this paper is as follows. Section 2 is some literature reviews. In section 3, the data used in this paper is introduced and described The main model and hypothesis in this paper is described in section 4, and the results are in section 5. Section 6 is conclusions and limitations. Since we consider the whole cities in Korea, many figures of specific regions are included in the appendix.

1.1 Literature review

There are many studies to evaluate the policy effect of various periods, in various regions. An approach is by estimating the structural model. Choi [2010] evaluated the real estate policy effect by using the VAR model. He estimated an index of policy level, and use it as a policy variable. The results showed that the policies had their desired effects on most cities, except for the regulative policy from 2009 to 2012. Choi [2017] found a cointegration relation between housing price, transaction tax, and interest rate, and concluded that transaction tax is more effective in the long run housing price than the interest rate by using VECM. Kim [2012] focused on the 'Jeonse' prices as leverage of purchasing home and showed that macroeconomic variables have a significant effect on the Jeonse price by using the VAR model, and especially the effort of reducing inflation is important to stabilize Jeonse prices.

Another popular approach is to estimate the policy treatment effect by the difference in difference method. Kim and Yu [2014] analyzed the effect of speculative zoning policy. They set the regions designated at least one time as a treatment group, and others as the control group, and estimate the policy effect as panel difference-in-difference method. They concluded that the de-zoning is not directly increasing the housing prices. Kim [2015] analyzed the policy effect of adjusting DTI level as various criteria such as short-run and long-run, small home size and large home size, and so on. Overall, these studies commonly show that the policy effect is limited.

2 Data

2.1 Home market prices

Figure 2: HPI, ATP trend

Figure 2 shows the trend of a housing price index(HPI) of Apartment from 2016 to 2018. This index is calculated from the Whole Country Housing Price Trend Survey by Korea Appraisal Board. Since HPI is an index of each region, the data has no information about the distribution of housing prices within the region. This distributional information can be obtained in the data of Actual Transaction Prices(hereafter "ATP") publically released by the Korea Ministry of Land, Infrastructure, and Transport from 2006. This data contains the contract price of each house, and characteristics such as an address, floor, size of living area, built year, and so on. Even though the ATP is not exactly the same as HPI, their trend is similar, and so we shall

use ATP without representativeness issues. Table 1 is descriptive statistics of home prices and per-area prices(PPA) by each region.

City	N	Mean		Median		Variance	
		Price	PPA	Price	PPA	Price	PPA
BS	553,044	20,219	251	17,000	236	13,892	109
CB	240,823	11,705	165	9,490	150	8,361	74
CN	328,109	12,933	177	10,500	168	8,337	72
DG	371,405	20,374	242	17,000	227	13,191	100
DJ	243,105	17,610	226	16,000	217	10,247	82
GB	334,258	11,276	150	9,000	139	7,470	66
GG	1,801,206	25,233	330	22,000	308	15,264	145
GJ	313,588	14,003	178	11,700	165	8,781	75
GN	504,275	14,750	199	12,900	185	8,826	89
GW	237,364	10,535	147	8,600	137	6,633	60
IC	413,001	20,619	278	18,500	268	11,402	88
JB	278,784	11,126	149	8,900	135	7,409	65
JJ	41,258	15,669	222	13,000	197	10,344	119
JN	220,591	9,949	135	8,239	121	6,442	60
SJ	22,749	19,494	249	18,860	219	12,247	127
US	203,922	18,452	233	15,650	223	11,402	95
SU	941,493	47,128	601	38,500	517	34,059	305
Total	7,048,975	22,227	288	17,200	241	20,000	204

Table 1: Descriptive statistics

2.2 Speculative zone

This policy firstly implemented in 2003 and expanded from 2006 to 2008 on almost every city in Korea. And almost every region de-zoned at the end of 2009 except three areas in Seoul: Gangnam-gu, Seocho-gu, and Songpa-gu. At the end of 2011, every region is de-zoned and there is no speculative zone until 2017. Figure **??** describes the designated status of the speculative zone in Seoul. The designation status of the rest of cities is in appendix B.*

In August 2017, 11 regions in Seoul and Sejong city is designated as speculative zone again. To distinguish past zoning policy to new one, and to reduce computational burden, we use the sample in periods from January 2006 to January 2008 as zoning period, and from January 2012 to January 2014 as de-zoning.†

*For simplicity, the abbreviation of names of each city and region is used. Exact names of cities and regions are in table 5 in appendix A

†The result of subsequence tests are similar when I use full data set except for the cities in GG. In GG, it is prohibitive to test by using full data of GG.

zoning	X	O	Total
BS	174,796	621	175,417
CB	67,026	6,274	73,300
CN	73,811	8,031	81,842
DG	339,267	21,324	360,591
DJ	223,688	19,417	243,105
GB	117,004	12,612	129,616
GG	1,398,755	363,334	1,762,089
GJ	93,102	14,256	107,358
GN	115,675	3,881	119,556
GW	117,382	5,440	122,822
IC	339,772	70,724	410,496
SU	722,341	219,152	941,493
US	147,668	16,015	163,683
Total	3,930,287	761,081	4,691,368

Table 2: Number of observations

3 Model

3.1 Policy effect as the Stochastic dominance

The main purpose of tightening policies on the real estate market such as speculative zoning is to stabilize the housing prices. The desired effect appears as stochastically dominated prices as well as the decreasing mean of overall prices. Thus, the effectiveness of policy can be evaluated by testing the stochastic dominance of prices given all other factors remained. Firstly, assume that the housing prices are determined as follows

$$P_{it}^c = m_j(X_{it}^c) + \epsilon_{jit}^c \tag{1}$$
$$E(\epsilon_{it}|X_{it}) = 0 \qquad \text{a.s.}$$

where $m_j(\cdot)$ is the functional form of every determinants of the price when zoning($j = 1$), de-zoning($j = 0$) respectively. The test of interest is comparing distributions of two groups regarding every house is homogeneous without whether policy implemented. To control the heterogeneity of each house, it can be used that testing following a Kolmogorov-Smirnov test

to residuals from estimating (1) for each j.

$$
\begin{aligned}
H_0 &: \sup_{x\in\mathcal{X}} \left\{ F_0^{(s)}(x) - F_1^{(s)}(x) \right\} \leq 0 \quad \text{for all } x \in \mathcal{X} \\
H_1 &: \sup_{x\in\mathcal{X}} \left\{ F_0^{(s)}(x) - F_1^{(s)}(x) \right\} > 0 \quad \text{for some } x \in \mathcal{X}
\end{aligned} \tag{2}
$$

Where $F_0^{(s)}$ denote the s-th order integrated distribution function of ϵ_{0it}, and $F_1^{(s)}$ is of ϵ_{1it}.

Linton et al. [2005] proposed testing stochastic dominance of residuals. And they also calculated the critical value of the test (2) by using a resampling method to control any dependence structure. This is suitable in our case since the housing price data(ATP) is not independently distributed in general because it is transaction data over time.

3.2 Model for Housing prices

To control the heterogeneity of houses, suppose that each price of houses(Apartment) is determined by the following specification.

$$
\begin{aligned}
\log(P_{it}^c) =& \beta_{j0} + AGE_{it}\beta_{j1} + AGE_{it}^2\beta_{j2} + AREA_{it}\beta_{j3} + FLOOR_{it}\beta_{j4} \\
&+ \log(Y_t)\gamma_{j1} + CPI_t\gamma_{j2} + r_t\gamma_{j3} + + \sum_{r=1}^{R} \alpha_r + \epsilon_{jit} \qquad c = 1, \cdots, C, \quad j = 1, 2
\end{aligned} \tag{3}
$$

where c denote specific each city, and r denote each area in the city such as "Gu", "Gun", or "Dong". α_r is heterogeneity of each regions. $j = 1$ if the region designated as speculative zone, and $j = 0$ otherwise. Y_t seasonal adjusted real GDP, CPI_t is Consumer Price Index (CPI), r_t is basis rate of BOK. AGE_{it} is the age of building, $AREA_{it}$ is the size of living area, and $FLOOR_{it}$ is the floor. Table 3 shows the estimate of (3) in whole country. Every coefficient is significant at 5% significant level. The estimation for each city is in Appendix C.

4 Main result

To evaluate the stochastic dominance relationship, construct hypothesis as follows

Variable	j=1	j=0
AGE	0.003129	-0.038868
	(0.000059)	(0.000053)
AGE^2	-0.000002	0.000774
	(0)	(0.000002)
$AREA$	0.003428	-0.000323
	(0.000014)	(0.000005)
$FLOOR$	0.007632	0.007521
	(0.000065)	(0.000022)
Y	0	0.000002
	(0)	(0)
CPI	0.032659	0.017886
	(0.000428)	(0.00009)
r	0.067345	-0.050481
	(0.000859)	(0.0002)
N	761081	3692204
r2	0.778357	0.793152

Table 3: Estimate in whole country

- Test1 : $H0 : F_0$ FSD F_1
- Test2 : $H0 : F_1$ FSD F_0
- Test3 : $H0 : F_0$ SSD F_1
- Test4 : $H0 : F_1$ SSD F_0

where "FSD" denotes the First-order stochastic dominance, and "SSD" denote the Second-order stochastic dominance. Since our data has a different number of observations for each j, the subsample size set by proportional to each obeservations[‡]. The grid points set by 40 and subsample size is chosen in a stable region. The full set of each test and p-value for each subsample size is described in Appendix D. Table 4 shows the result of the test.

"N" denotes non-dominance. The result shows that the zoning policy shifts the distribution of housing prices to the right in SU and the US, which is opposite to the desired result. In the second-order, it can be interpreted that the zoning policy decrease the variance of housing prices in GW, and IC. But in GG, GN, GJ, SU, US, and CN, the policy rather increase the variance of housing prices. In summary, this result implies that the effect of speculative zoning policy is limited to the distribution of housing prices.

[‡]Linton [2005] proposed resampling procedure when data has a different sample size as well as unbalanced timeseries

City	FSD	SSD	City	FSD	SSD
GW	$F_0 = F_1$	F_0 SSD F_1	GG	N	F_1 SSD F_0
GN	$F_0 = F_1$	F_1 SSD F_0	GB	N	$F_0^2 = F_1^2$
GJ	N	F_1 SSD F_0	DG	$F_0 = F_1$	$F_0^2 = F_1^2$
DJ	N	N	BS	$F_0 = F_1$	$F_0^2 = F_1^2$
SU	F_1 FSD F_0	F_1 SSD F_0	US	F_1 FSD F_0	F_1 SSD F_0
IC	N	F_0 SSD F_1	CN	$F_0 = F_1$	F_1 SSD F_0
CB	$F_0 = F_1$	$F_0^2 = F_1^2$	SJ	$F_0 = F_1$	$F_0^2 = F_1^2$
JN	$F_0 = F_1$	$F_0^2 = F_1^2$	JB	$F_0 = F_1$	$F_0^2 = F_1^2$
JJ	$F_0 = F_1$	$F_0^2 = F_1^2$			

Table 4: Result of the LMW test

5 Conclusion

In this paper, we evaluate the effect of speculative zoning policy on the distribution of housing prices in Korea. The result shows that the speculative zoning policy has no effect on the distribution of housing prices.

However, this analysis has no structural considerations. It may yield a different result when we consider structural facet in estimating equation (1). Moreover, the specification (3) has no theoretical base. To ameliorate this, one can use fully non-parametric methods to evaluate the distributional treatment effect by comparing distribution of interest to counterfactual distribution as proposed in Rothe [2010], and Rothe [2012].

The data used in this paper is transcation prices of apartment only. It is also needed the robustness check using the other similar data such as prices of multiplex housing and multi-family/multi-household house as well as Jeonse price.

References

C.-S. Choi. A study on the effect of the real estate policy on the real estate market. *Korea Real Estate Society*, 28(2):69–91, 2010.

C.-S. Choi. A study on the relationship between housing prices and transactions tax with vecm. *Asia-pacific Journal of Multimedia services convergent with Art, Humanities, and Sociology*, 7(10):121–130, 2017.

D. Kim and J. Yu. Measuring the effectiveness of the housing speculative zoning and de-zoning. *Journal of Korean Urban Management Association*, 27(3):191–212, 2014.

Y. Y. Kim. Macroeconomic determinants of housing and housing lease prices‘ dynamics in korea. *The Korean Journal of Economic Studies*, 60(3):127, 2012.

Y. Y. Kim. An analysis of housing finance regulatory effects using did(difference in difference) method -focused on the metropolitan dti regulation. *Korea Real Estate Analysis Association*, pages 31–51, 2015.

O. Linton. Nonparametric inference for unbalanced time series data. *Econometric Theory*, 21 (1):143–157, 2005.

O. Linton, E. Maasoumi, and Y.-J. Whang. Consistent testing for stochastic dominance under general sampling schemes. *The Review of Economic Studies*, 72(3):735–765, 2005.

C. Rothe. Nonparametric estimation of distributional policy effects, 2010.

C. Rothe. Partial distributional policy effects. *Econometrica*, 80(5):2269–2301, 2012.

Appendix

A. Name abbreviations

Abbreviation	City name	Abbreviation	City name
GW	Gangwon-do	SU	Seoul
GG	Gyeonggi-do	SJ	Sejong
GN	Gyeongsangnam-do	US	Ulsan
GB	Gyeongsangbuk-do	IC	Incheon
GJ	Gwangju	JN	Jeollanam-do
DG	Daegu	JB	Jeollabuk-do
DJ	Daejeon	JJ	Jeju
BS	Busan	CN	Chungcheongnam-do
		CB	Chungcheongbuk-do

Table 5: City name abbreviations

Abbreviation	gun, gu, dong name	Province	Abbreviation	gun, gu, dong name	Province
JR	Jongno-gu	Seoul	YW	Yeongwol-gun	Gangwon-do
J	Jung-gu	Seoul	PC	Pyeongchang-gun	Gangwon-do
YS	Yongsan-gu	Seoul	JS	Jeongseon-gun	Gangwon-do
SD	Seongdong-gu	Seoul	CW	Cheorwon-gun	Gangwon-do
GJ	Gwangjin-gu	Seoul	HC	Hwacheon-gun	Gangwon-do
DDM	Dongdaemun-gu	Seoul	YG	Yanggu-gun	Gangwon-do
JR	Jungnang-gu	Seoul	IJ	Inje-gun	Gangwon-do
SB	Seongbuk-gu	Seoul	GS	Goseong-gun	Gangwon-do
GB	Gangbuk-gu	Seoul	YY	Yangyang-gun	Gangwon-do
DB	Dobong-gu	Seoul	CJ_SD	Sangdang-gu	Chungcheongbuk-do
NW	Nowon-gu	Seoul	CJ_SW	Seowon-gu	Chungcheongbuk-do
EP	Eunpyeong-gu	Seoul	CJ_HD	Heungdeok-gu	Chungcheongbuk-do
SDM	Seodaemun-gu	Seoul	CJ_CW	Cheongwon-gu	Chungcheongbuk-do
MP	Mapo-gu	Seoul	CUJ	Chungju-si	Chungcheongbuk-do
YC	Yangcheon-gu	Seoul	JC	Jecheon-si	Chungcheongbuk-do
GS	Gangseo-gu	Seoul	BE	Boeun-gun	Chungcheongbuk-do
GR	Guro-gu	Seoul	OC	Okcheon-gun	Chungcheongbuk-do
GC	Geumcheon-gu	Seoul	YD	Yeongdong-gun	Chungcheongbuk-do
YD	Yeongdeungpo-gu	Seoul	JP	Jeungpyeong-gun	Chungcheongbuk-do
DJ	Dongjak-gu	Seoul	JC	Jincheon-gun	Chungcheongbuk-do
GW	Gwanak-gu	Seoul	GS	Goesan-gun	Chungcheongbuk-do
SC	Seocho-gu	Seoul	ES	Eumseong-gun	Chungcheongbuk-do
GN	Gangnam-gu	Seoul	DY	Danyang-gun	Chungcheongbuk-do
SP	Songpa-gu	Seoul	CA_DN	Dongnam-gu	Chungcheongnam-do
GD	Gangdong-gu	Seoul	CA_SB	Sebuk-gu	Chungcheongnam-do
J	Jung-gu	Busan	GJ	Gongju-si	Chungcheongnam-do
S	Seo-gu	Busan	BR	Boryeong-si	Chungcheongnam-do
D	Dong-gu	Busan	AS	Asan-si	Chungcheongnam-do
YD	Yeongdo-gu	Busan	SS	Seosan-si	Chungcheongnam-do
BSJ	Busanjin-gu	Busan	NS	Nonsan-si	Chungcheongnam-do
DR	Dongnae-gu	Busan	GR	Gyeryong-si	Chungcheongnam-do
N	Nam-gu	Busan	DJ	Dangjin-si	Chungcheongnam-do
B	Buk-gu	Busan	GS	Geumsan-gun	Chungcheongnam-do
HW	Haeundae-gu	Busan	BY	Buyeo-gun	Chungcheongnam-do
SH	Saha-gu	Busan	SC	Seocheon-gun	Chungcheongnam-do
GJ	Geumjeong-gu	Busan	CY	Cheongyang-gun	Chungcheongnam-do
GS	Gangseo-gu	Busan	HS	Hongseong-gun	Chungcheongnam-do
YJ	Yeonje-gu	Busan	YS	Yesan-gun	Chungcheongnam-do
SW	Suyeong-gu	Busan	TA	Taean-gun	Chungcheongnam-do
SS	Sasang-gu	Busan	JJ_WS	Wansan-gu	Jeollabuk-do
GJ	Gijang-gun	Busan	JJ_DJ	Deokjin-gu	Jeollabuk-do
J	Jung-gu	Daegu	GS	Gunsan-si	Jeollabuk-do

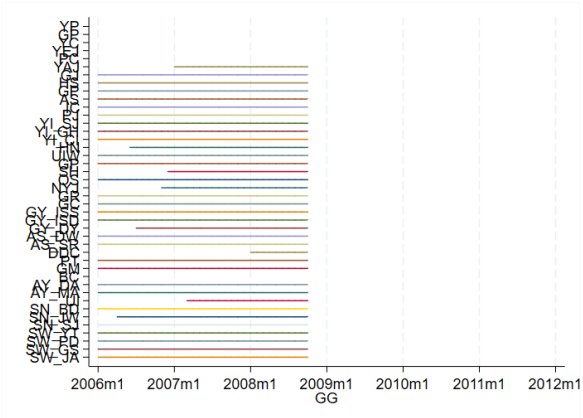
D	Dong-gu	Daegu	IS	Iksan-si	Jeollabuk-do
S	Seo-gu	Daegu	JE	Jeongeup-si	Jeollabuk-do
N	Nam-gu	Daegu	SW	Namwon-si	Jeollabuk-do
B	Buk-gu	Daegu	GJ	Gimje-si	Jeollabuk-do
SS	Suseong-gu	Daegu	WJ	Wanju-gun	Jeollabuk-do
DSE	Dalseo-gu	Daegu	JA	Jinan-gun	Jeollabuk-do
DSN	Dalseong-gun	Daegu	MJ	Muju-gun	Jeollabuk-do
J	Jung-gu	Incheon	JS	Jangsu-gun	Jeollabuk-do
D	Dong-gu	Incheon	IS	Imsil-gun	Jeollabuk-do
N	Nam-gu	Incheon	SC	Sunchang-gun	Jeollabuk-do
YS	Yeonsu-gu	Incheon	GC	Gochang-gun	Jeollabuk-do
ND	Namdong-gu	Incheon	BA	Buan-gun	Jeollabuk-do
BP	Bupyeong-gu	Incheon	MP	Mokpo-si	Jeollanam-do
GY	Gyeyang-gu	Incheon	YS	Yeosu-si	Jeollanam-do
S	Seo-gu	Incheon	SC	Suncheon-si	Jeollanam-do
GH	Ganghwa-gun	Incheon	NJ	Naju-si	Jeollanam-do
D	Dong-gu	Gwangju	GW	Gwangyang-si	Jeollanam-do
S	Seo-gu	Gwangju	DY	Damyang-gun	Jeollanam-do
N	Nam-gu	Gwangju	GS	Gokseong-gun	Jeollanam-do
B	Buk-gu	Gwangju	GR	Gurye-gun	Jeollanam-do
GS	Gwangsan-gu	Gwangju	GH	Goheung-gun	Jeollanam-do
D	Dong-gu	Daejeon	BS	Boseong-gun	Jeollanam-do
J	Jung-gu	Daejeon	HS	Hwasun-gun	Jeollanam-do
S	Seo-gu	Daejeon	WH	Jangheung-gun	Jeollanam-do
YS	Yuseong-gu	Daejeon	RJ	Gangjin-gun	Jeollanam-do
DD	Daedeok-gu	Daejeon	HN	Haenam-gun	Jeollanam-do
J	Jung-gu	Ulsan	YA	Yeongam-gun	Jeollanam-do
N	Nam-gu	Ulsan	MA	Muan-gun	Jeollanam-do
D	Dong-gu	Ulsan	HP	Hampyeong-gun	Jeollanam-do
B	Buk-gu	Ulsan	YG	Yeonggwang-gun	Jeollanam-do
UJ	Ulju-gun	Ulsan	JS	Jangseong-gun	Jeollanam-do
SJ	Jochiwon-eup	Sejong	WD	Wando-gun	Jeollanam-do
SW_JA	Jangan-gu	Gyeonggi-do	JD	Jindo-gun	Jeollanam-do
SW_GS	Gwonseon-gu	Gyeonggi-do	SA	Sinan-gun	Jeollanam-do
SW_PD	Paldal-gu	Gyeonggi-do	PH_N	Nam-gu	Gyeongsangbuk-do
SW_YT	Yeongtong-gu	Gyeonggi-do	PH_B	Buk-gu	Gyeongsangbuk-do
SN_SJ	Sujeong-gu	Gyeonggi-do	GJ	Gyeongju-si	Gyeongsangbuk-do
SN_JW	Jungwon-gu	Gyeonggi-do	GC	Gimcheon-si	Gyeongsangbuk-do
SN_BD	Bundang-gu	Gyeonggi-do	AD	Andong-si	Gyeongsangbuk-do
UI	Uijeongbu-si	Gyeonggi-do	GM	Gumi-si	Gyeongsangbuk-do
AY_MA	Manan-gu	Gyeonggi-do	YJ	Yeongju-si	Gyeongsangbuk-do
AY_DA	Dongan-gu	Gyeonggi-do	YC	Yeongcheon-si	Gyeongsangbuk-do
BC	Bucheon-si	Gyeonggi-do	SJ	Sangju-si	Gyeongsangbuk-do
GM	Gwangmyeong-si	Gyeonggi-do	MG	Mungyeong-si	Gyeongsangbuk-do

PT	Pyeongtaek-si	Gyeonggi-do	GS	Gyeongsan-si	Gyeongsangbuk-do
DDC	Dongducheon-si	Gyeonggi-do	GW	Gunwi-gun	Gyeongsangbuk-do
AS_SR	Sangnok-gu	Gyeonggi-do	USC	Uiseong-gun	Gyeongsangbuk-do
AS_DW	Danwon-gu	Gyeonggi-do	CS	Cheongsong-gun	Gyeongsangbuk-do
GY_DY	Deogyang-gu	Gyeonggi-do	YYG	Yeongyang-gun	Gyeongsangbuk-do
GY_ISD	Ilsandong-gu	Gyeonggi-do	YD	Yeongdeok-gun	Gyeongsangbuk-do
GY_ISS	Ilsanseo-gu	Gyeonggi-do	CD	Cheongdo-gun	Gyeongsangbuk-do
GC	Gwacheon-si	Gyeonggi-do	GRG	Goryeong-gun	Gyeongsangbuk-do
GR	Guri-si	Gyeonggi-do	SJG	Seongju-gun	Gyeongsangbuk-do
NYJ	Namyangju-si	Gyeonggi-do	CGG	Chilgok-gun	Gyeongsangbuk-do
OS	Osan-si	Gyeonggi-do	YCG	Yecheon-gun	Gyeongsangbuk-do
SH	Siheung-si	Gyeonggi-do	BHG	Bonghwa-gun	Gyeongsangbuk-do
GP	Gunpo-si	Gyeonggi-do	UJG	Uljin-gun	Gyeongsangbuk-do
UIW	Uiwang-si	Gyeonggi-do	URG	Ulleung-gun	Gyeongsangbuk-do
HN	Hanam-si	Gyeonggi-do	CW_EC	Uichang-gu	Gyeongsangnam-do
YI_CI	Cheoin-gu	Gyeonggi-do	CW_SS	seongsan-gu	Gyeongsangnam-do
YI_GH	Giheung-gu	Gyeonggi-do	CW_MSP	Masanhappo-gu	Gyeongsangnam-do
YI_SJ	Suji-gu	Gyeonggi-do	CW_MSH	Masanhoewon-gu	Gyeongsangnam-do
PJ	Paju-si	Gyeonggi-do	CW_JH	Jinhae-gu	Gyeongsangnam-do
IC	Icheon-si	Gyeonggi-do	JJ	Jinju-si	Gyeongsangnam-do
AS	Anseong-si	Gyeonggi-do	TY	Tongyeong-si	Gyeongsangnam-do
GP	Gimpo-si	Gyeonggi-do	SC	Sacheon-si	Gyeongsangnam-do
HS	Hwaseong-si	Gyeonggi-do	GH	Gimhae-si	Gyeongsangnam-do
GJ	Gwangju-si	Gyeonggi-do	MY	Miryang-si	Gyeongsangnam-do
YAJ	Yangju-si	Gyeonggi-do	GJ	Geoje-si	Gyeongsangnam-do
PC	Pocheon-si	Gyeonggi-do	YSS	Yangsan-si	Gyeongsangnam-do
YEJ	Yeoju-si	Gyeonggi-do	ERG	Uiryeong-gun	Gyeongsangnam-do
YC	Yeoncheon-gun	Gyeonggi-do	HAG	Haman-gun	Gyeongsangnam-do
GP	Gapyeong-gun	Gyeonggi-do	CNG	Changnyeong-gun	Gyeongsangnam-do
YP	Yangpyeong-gun	Gyeonggi-do	GSG	Goseong-gun	Gyeongsangnam-do
CC	Chuncheon-si	Gangwon-do	NHG	Gyeongsangnam-do	Gyeongsangnam-do
WJ	Wonju-si	Gangwon-do	HDG	Hadong-gun	Gyeongsangnam-do
GR	Gangneung-si	Gangwon-do	SCG	Sancheong-gun	Gyeongsangnam-do
DH	Donghae-si	Gangwon-do	HYG	Hamyang-gun	Gyeongsangnam-do
TB	Taebaek-si	Gangwon-do	GCG	Geochang-gun	Gyeongsangnam-do
SOC	Sokcho-si	Gangwon-do	HCG	Hapcheon-gun	Gyeongsangnam-do
SAC	Samcheok-si	Gangwon-do	JJ	Jeju-si	Jeju
HC	Hongcheon-gun	Gangwon-do	SGP	Seogwipo-si	Jeju
HS	Hoengseong-gun	Gangwon-do			

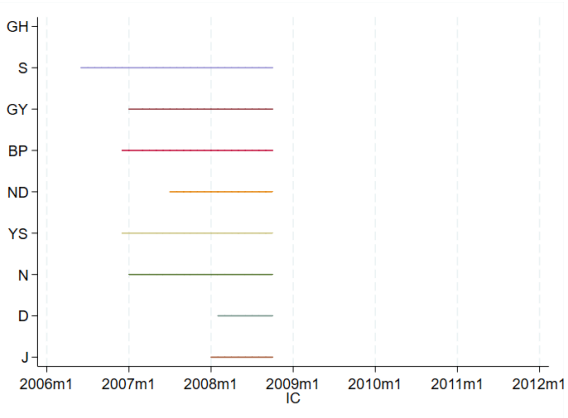
Table 6: gun and gu name abbreviations

B. Speculative zone designation status

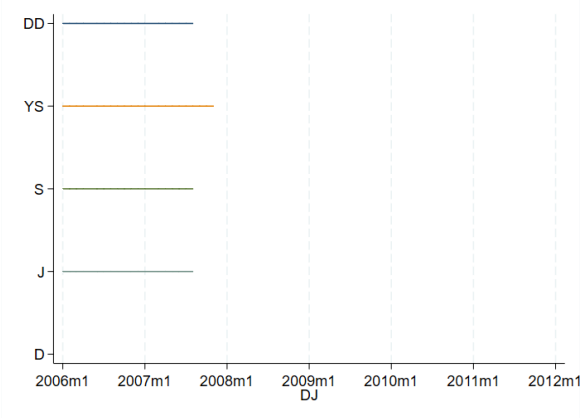
Following figures describe the zoning status in each cities except for Seoul. Note that SJ, JJ, JN, JB are omitted since these areas have never been designated as speculative zone.



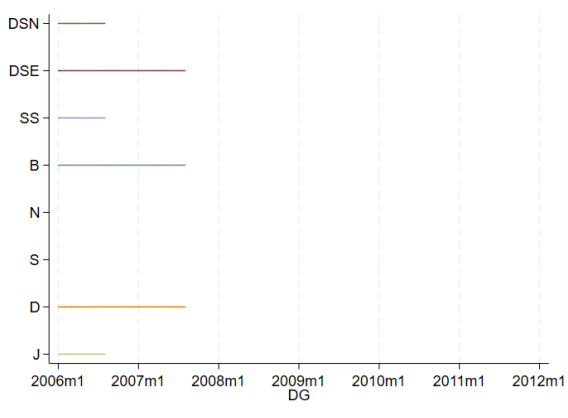
(a) Gyeong gi-do



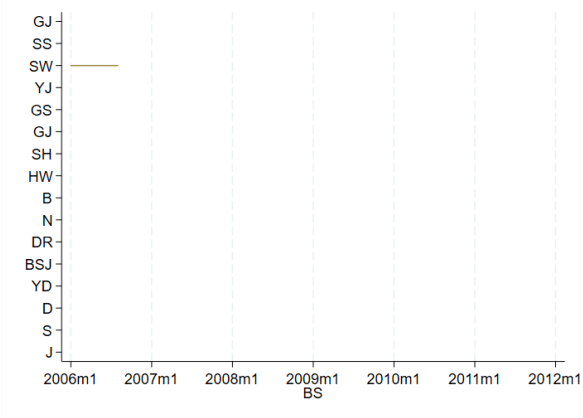
(b) Incheon



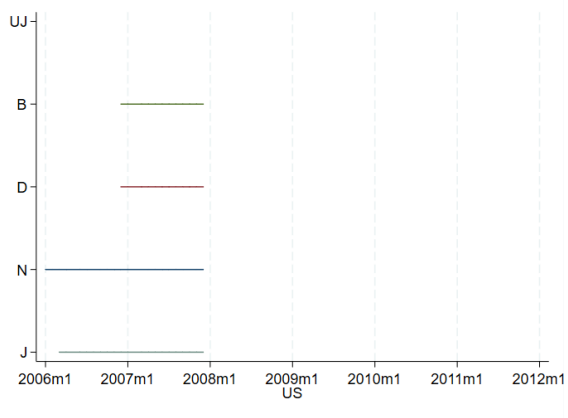
(c) Daejeon



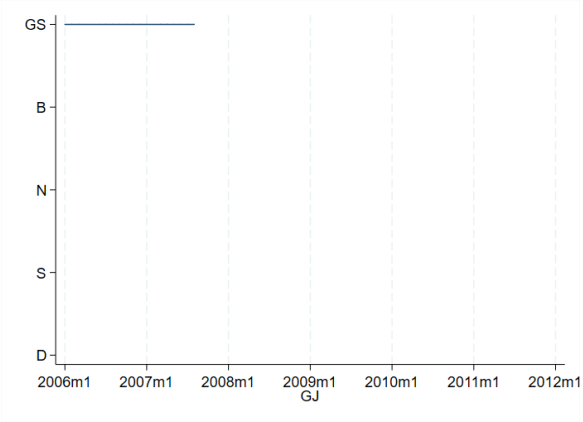
(d) Daegu



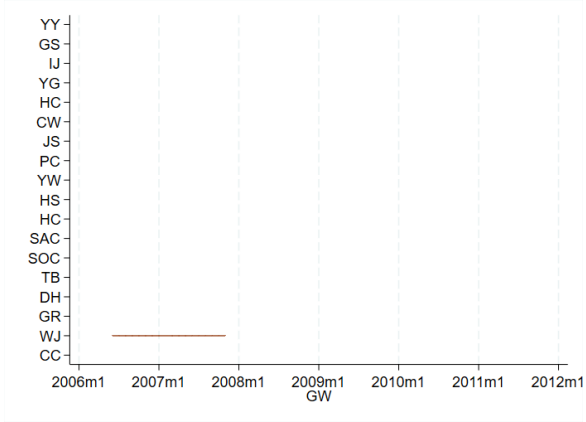
(e) Busan



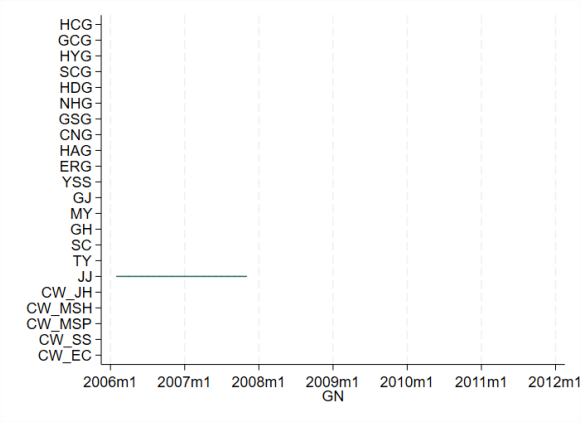
(f) Ulsan



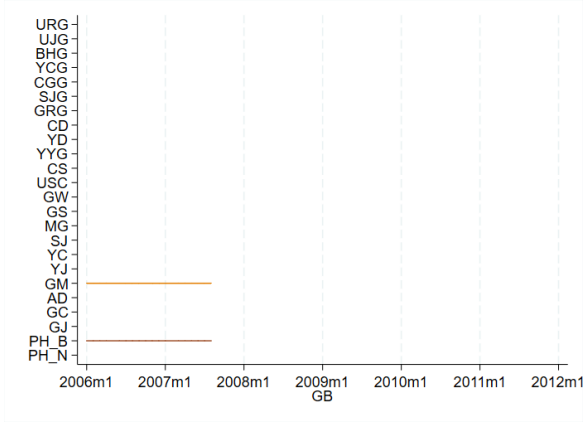
(g) Gwangju



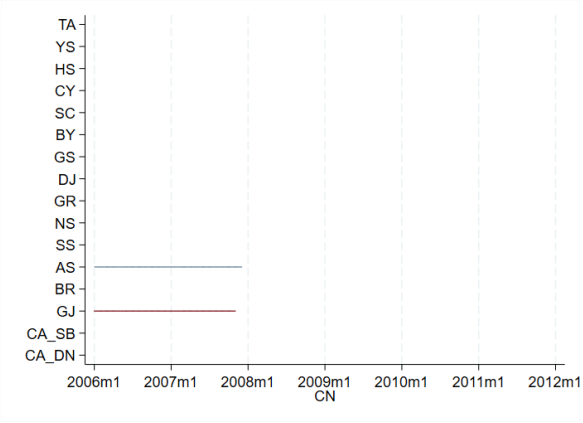
(h) Gangwon-do



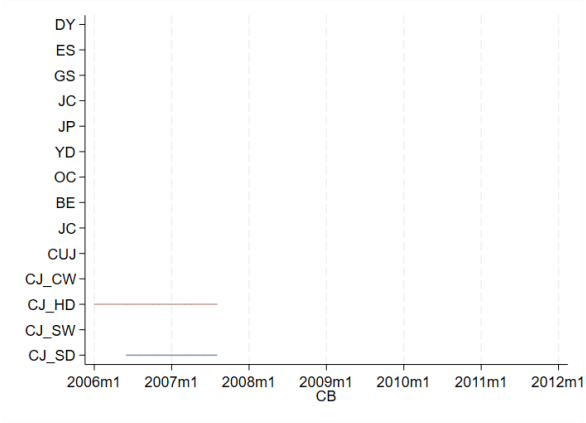
(i) Gyeongsangnam-do



(j) Gyeongsangbuk-do



(k) Chungcheongnam-do



(l) Chungcheongbuk-do

C. Estimate specification 3

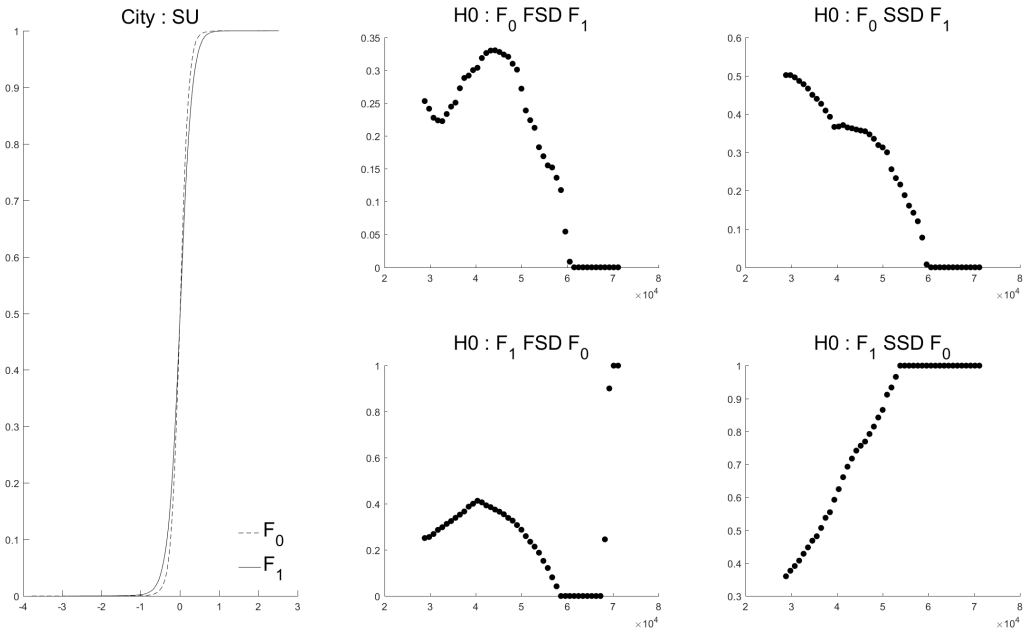
Variable	J	GW	GG	GN	GB	GJ	DG
AGE	j=0	-0.0435***	-0.0308***	-0.0528***	-0.0499***	-0.0543***	-0.0415***
		(-0.0003)	(-0.0001)	(-0.0003)	(-0.0003)	(-0.0003)	(-0.0002)
	j=1	-0.0442***	-0.0026***	-0.0560***	-0.0756***	-0.0791***	-0.0452***
		(-0.0027)	(-0.0001)	(-0.0025)	(-0.0017)	(-0.0008)	(-0.0008)
AGE^2	j=0	0.0007***	0.0005***	0.0008***	0.0007***	0.0009***	0.0007***
		(0)	(0)	(0)	(0)	(0)	(0)
	j=1	0.0015***	0.0000***	0.0014***	0.0027***	0.0028***	0.0012***
		(-0.0001)	(0)	(-0.0001)	(-0.0001)	(0)	(0)
$AREA$	j=0	0.0008***	-0.0012***	-0.0005***	0.0001**	0.0012***	-0.0003***
		(0)	(0)	(0)	(0)	(0)	(0)
	j=1	0.0044***	0.0048***	0.0026***	0.0032***	0.0056***	0.0019***
		(-0.0002)	(0)	(-0.0002)	(-0.0001)	(-0.0001)	(-0.0001)
$FLOOR$	j=0	0.0063***	0.0059***	0.0044***	0.0063***	0.0062***	0.0067***
		(-0.0002)	(0)	(-0.0001)	(-0.0001)	(-0.0001)	(-0.0001)
	j=1	0.0034***	0.0047***	0.0106***	0.0054***	0.0015***	0.0076***
		(-0.0009)	(-0.0001)	(-0.001)	(-0.0006)	(-0.0002)	(-0.0003)
Y	j=0	0.0000***	0.0000***	0.0000***	0.0000***	0.0000***	0.0000***
		(0)	(0)	(0)	(0)	(0)	(0)
	j=1	-0.0000**	0.0000***	0	0	0.0000***	-0.0000***
		(0)	(0)	(0)	(0)	(0)	(0)
CPI	j=0	0.0131***	0.0148***	0.0257***	0.0120***	0.0129***	-0.0034***
		(-0.0005)	(-0.0002)	(-0.0006)	(-0.0006)	(-0.0004)	(-0.0002)
	j=1	0.0931***	0.0111***	-0.026	0.0377***	-0.0307***	0.0094
		(-0.0153)	(-0.0006)	(-0.0171)	(-0.0101)	(-0.0036)	(-0.005)
r	j=0	-0.0215***	-0.0712***	0.0019	0.0164***	-0.0032***	-0.0046***
		(-0.001)	(-0.0003)	(-0.0011)	(-0.0011)	(-0.0008)	(-0.0005)
	j=1	-0.1032**	0.0223***	0.2131***	0.0660**	0.0591***	0.0047
		(-0.0331)	(-0.0034)	(-0.0346)	(-0.0203)	(-0.0067)	(-0.0092)
N	j=0	113157	1308504	110646	112581	88485	319576
	j=1	5440	363334	3881	12612	14256	21324
R^2	j=0	0.5462	0.6856	0.6205	0.5659	0.7643	0.7043
	j=1	0.2143	0.6395	0.2411	0.2239	0.7277	0.4163

Table 7: Regression result

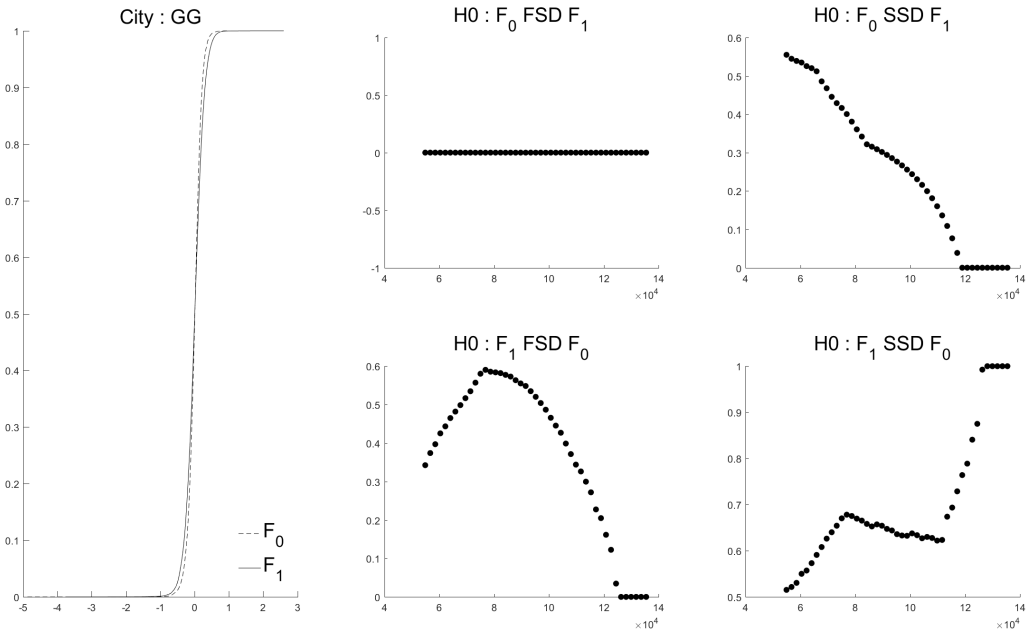
Variable	J	DJ	BS	SU	US	IC	CN	CB
AGE	j=0	-0.0272***	-0.0410***	-0.0294***	-0.0304***	-0.0256***	-0.0429***	-0.0362***
		(-0.0002)	(-0.0003)	(-0.0001)	(-0.0003)	(-0.0002)	(-0.0005)	(-0.0005)
	j=1	-0.0242***	-0.0554***	-0.0008**	-0.0316***	-0.0191***	-0.0890***	-0.0678***
		(-0.0011)	(-0.0051)	(-0.0003)	(-0.0013)	(-0.0004)	(-0.0015)	(-0.002)
AGE^2	j=0	0.0003***	0.0009***	0.0008***	0.0003***	0.0002***	0.0008***	0.0005***
		(0)	(0)	(0)	(0)	(0)	(0)	(0)
	j=1	0.0001**	0.0022***	0.0005***	0.0007***	0.0004***	0.0029***	0.0016***
		(0)	(-0.0002)	(0)	(-0.0001)	(0)	(-0.0001)	(-0.0001)
$AREA$	j=0	0.0019***	0.0012***	-0.0015***	-0.0001*	-0.0005***	0.0048***	0.0030***
		(0)	(0)	(0)	(0)	(0)	(0)	(0)
	j=1	0.0058***	0.0014**	0.0013***	0.0039***	0.0022***	0.0040***	0.0047***
		(-0.0001)	(-0.0004)	(0)	(-0.0001)	(0)	(-0.0001)	(-0.0001)
$FLOOR$	j=0	0.0061***	0.0116***	0.0086***	0.0052***	0.0063***	0.0075***	0.0079***
		(-0.0001)	(-0.0001)	(-0.0001)	(-0.0001)	(-0.0001)	(-0.0002)	(-0.0002)
	j=1	0.0083***	0.0248***	0.0118***	0.0094***	0.0067***	0.0052***	0.0075***
		(-0.0004)	(-0.0023)	(-0.0001)	(-0.0004)	(-0.0002)	(-0.0005)	(-0.0007)
Y	j=0	0.0000***	0.0000***	-0.0000***	0.0000***	-0.0000***	0.0000***	0.0000***
		(0)	(0)	(0)	(0)	(0)	(0)	(0)
	j=1	0.0000***	0	-0.0000***	0.0000***	0.0000***	0.0000***	0
		(0)	(0)	(0)	(0)	(0)	(0)	(0)
CPI	j=0	0.0324***	0.0237***	0.0197***	0.0261***	0.0165***	0.0181***	0.0322***
		(-0.0004)	(-0.0005)	(-0.0002)	(-0.0005)	(-0.0002)	(-0.0007)	(-0.0006)
	j=1	-0.0470***	-0.0124	0.0373***	-0.0625***	0.0388***	-0.0326***	0.0472***
		(-0.0075)	(-0.0779)	(-0.0008)	(-0.0085)	(-0.0009)	(-0.0088)	(-0.01)
r	j=0	0.0043***	-0.0103***	-0.1231***	-0.0025**	-0.1120***	0.0089***	0.0282***
		(-0.0007)	(-0.001)	(-0.0006)	(-0.0009)	(-0.0007)	(-0.0012)	(-0.0012)
	j=1	-0.1675***	-0.0219	0.0577***	0.0242	0.0129*	-0.1769***	-0.0488*
		(-0.0148)	(-0.2772)	(-0.0012)	(-0.0184)	(-0.0063)	(-0.0182)	(-0.0209)
N	j=0	211260	169732	661169	142727	319922	70204	64241
	j=1	19417	621	219152	16015	70724	8031	6274
R^2	j=0	0.5726	0.5994	0.6535	0.6391	0.5872	0.6342	0.6302
	j=1	0.4093	0.3306	0.6116	0.3503	0.4423	0.6373	0.5649

Table 8: Regression result

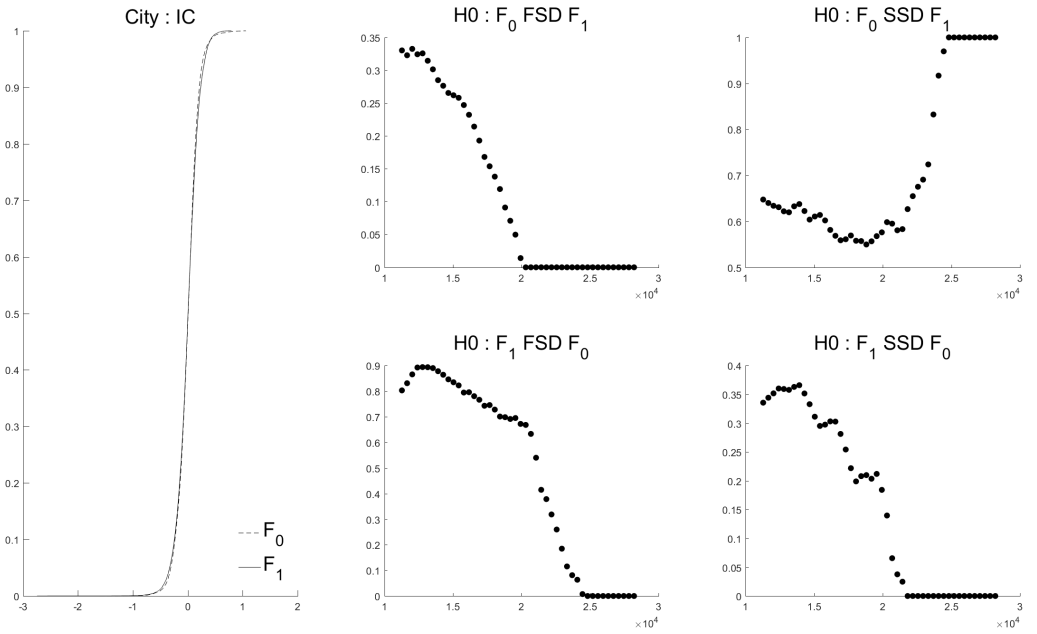
D. ECDFs, and P-values of LMW test



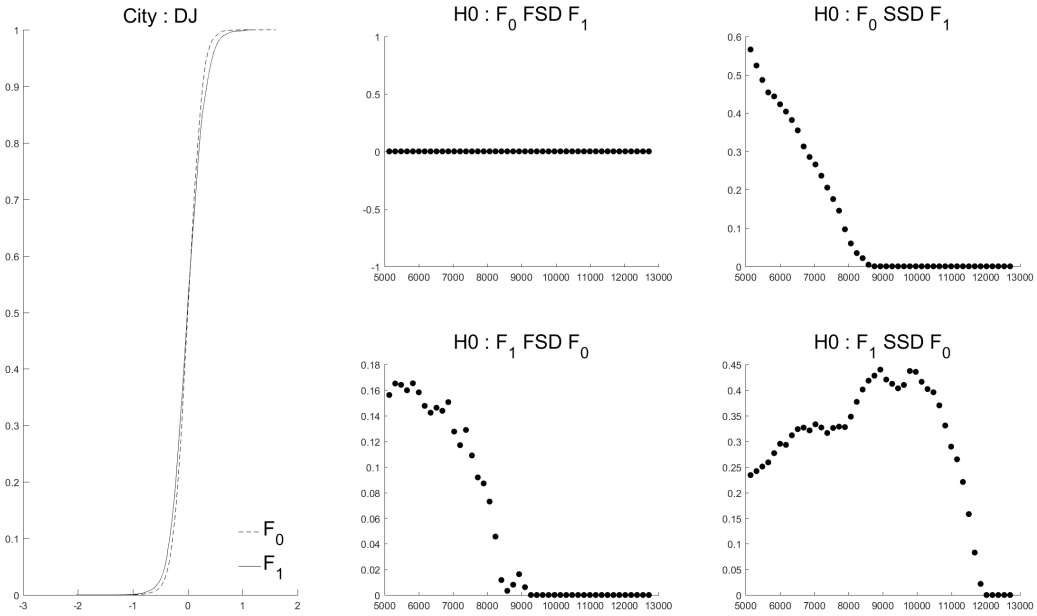
(a) Seoul



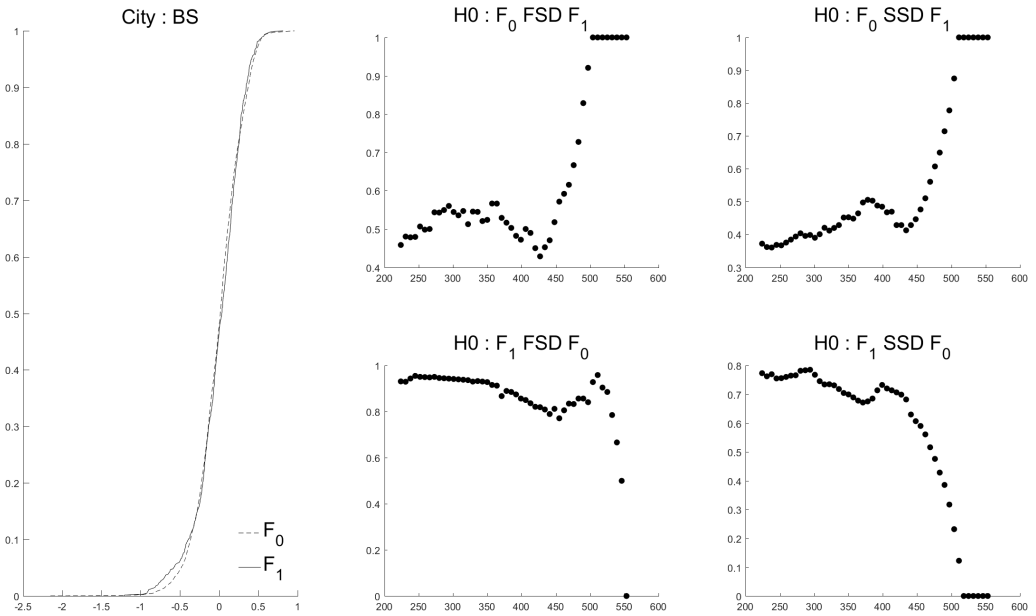
(b) Gyeonggi-do



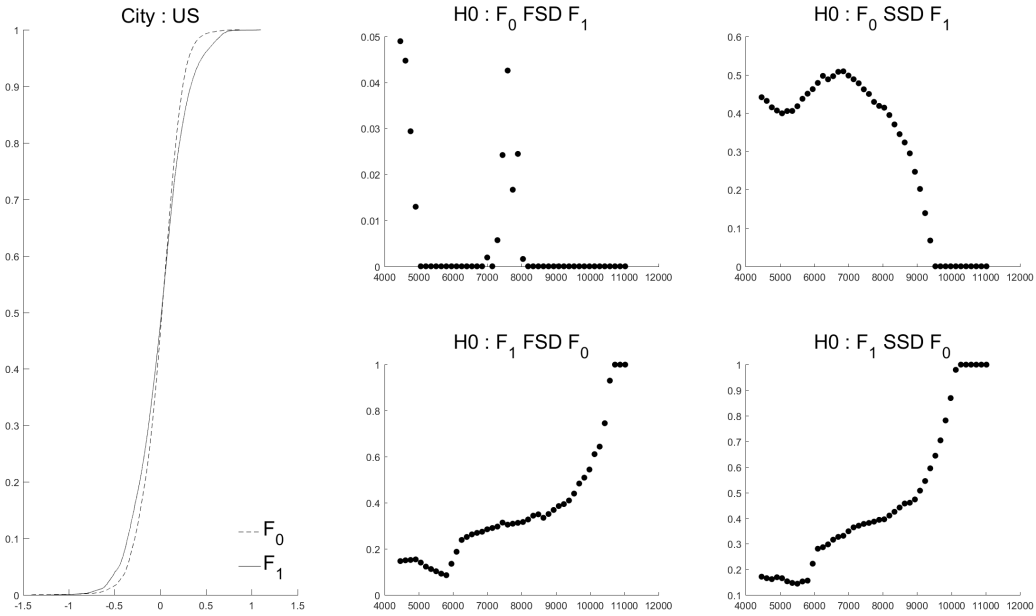
(c) Incheon



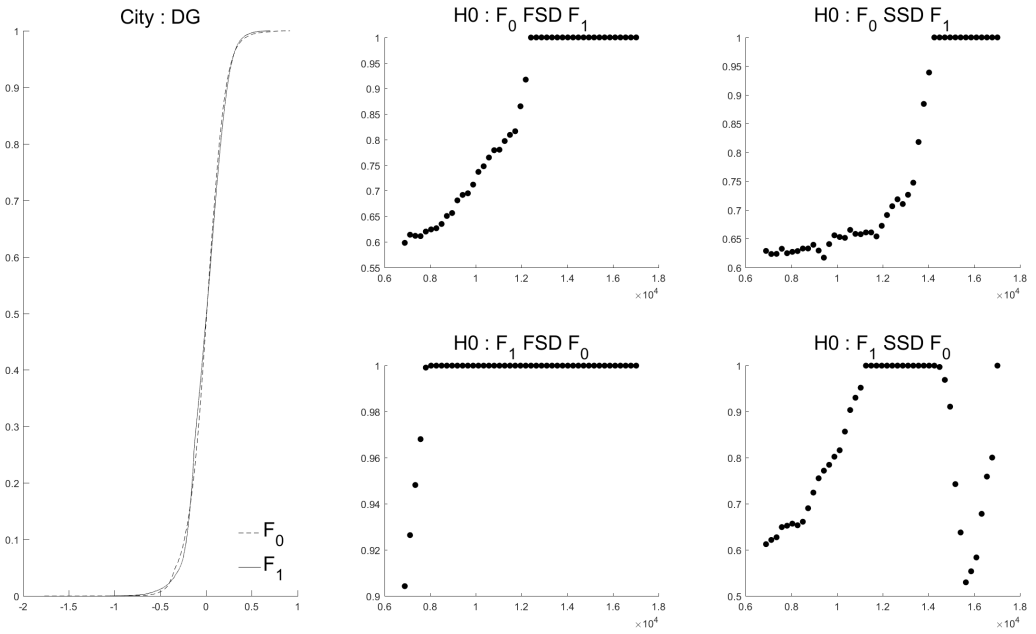
(d) Daejeon



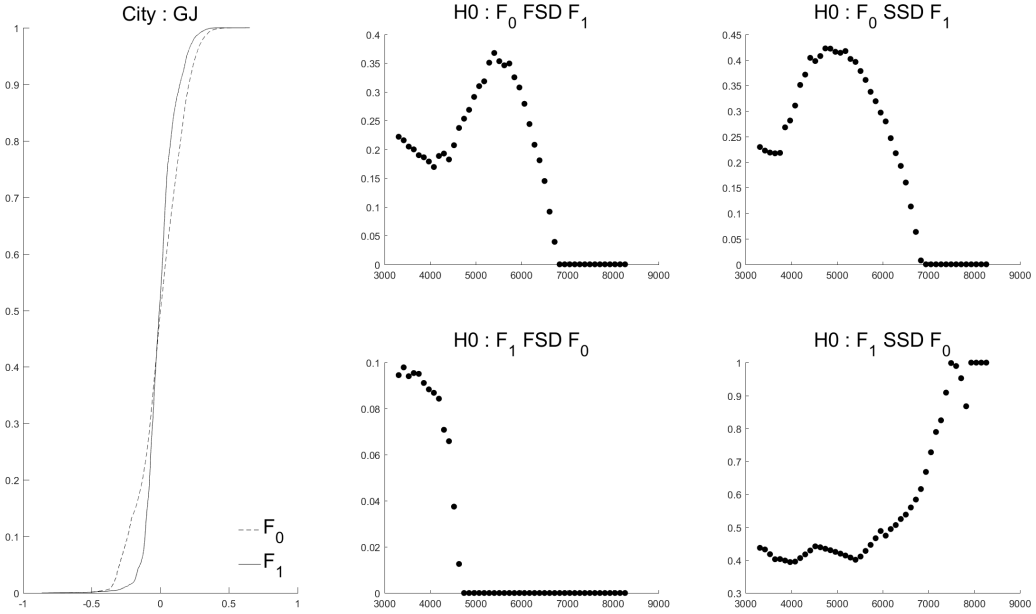
(e) Busan



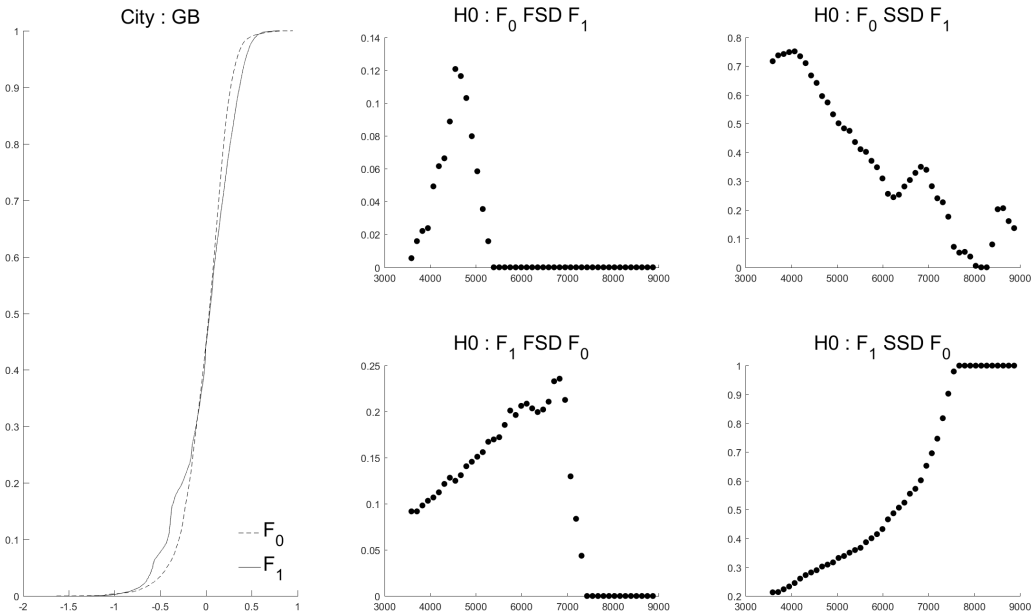
(f) Ulsan



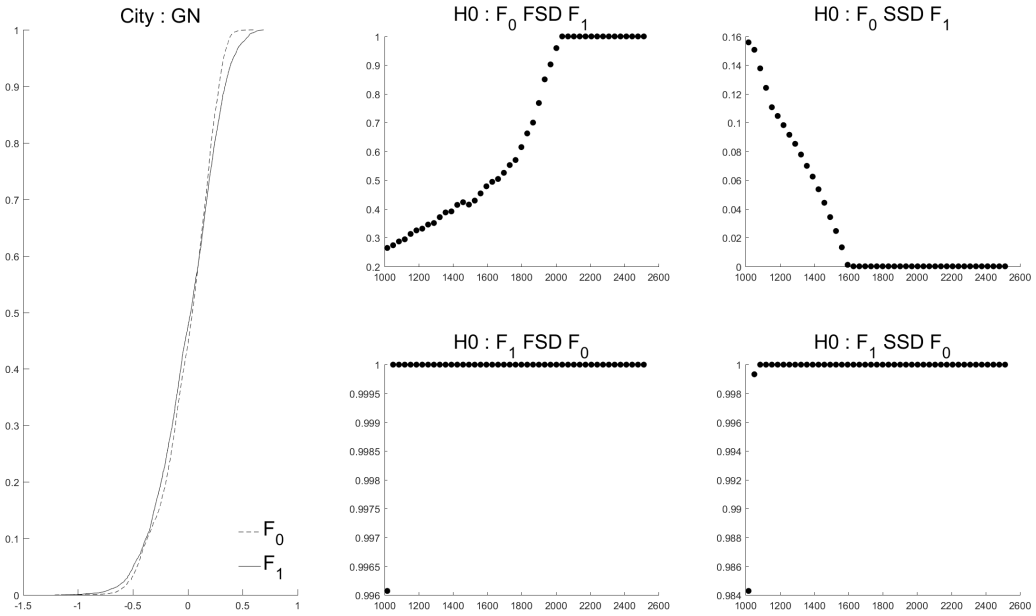
(g) Daegu



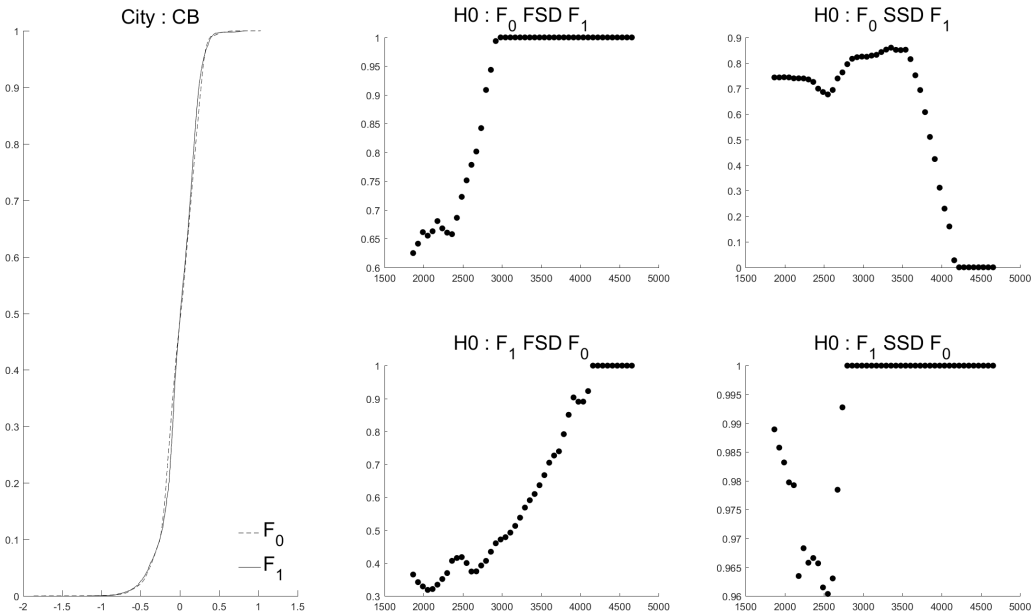
(h) Gwangju



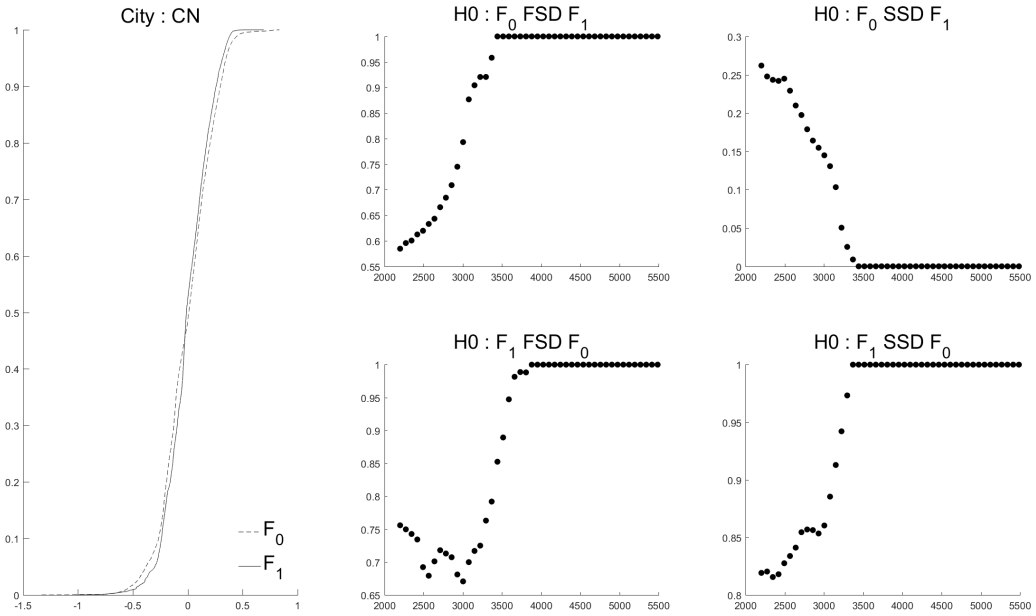
(i) Gyeongsangbuk-do



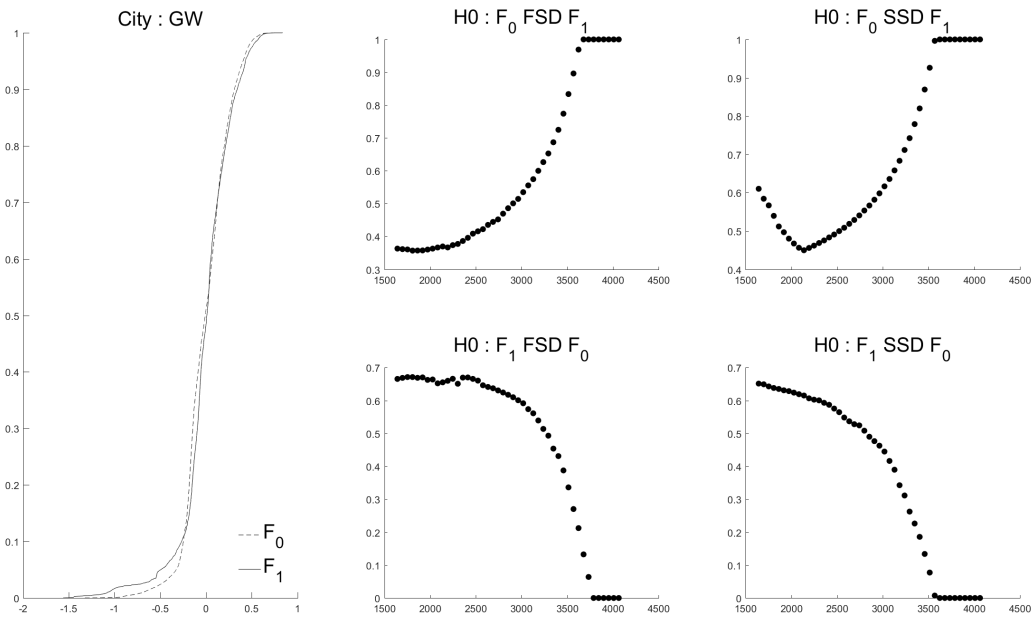
(j) Gyeongsangnam-do



(k) Seoul



(l) Chungcheongbuk-do



(m) Gangwon-do