Essays in Empirical Macroeconomics

실증적 거시경제학에 관한 에세이

Kostiulin Maksim

Advisor: 조성훈 교수님
Co-advisor: 조수진 교수님

최우수논문 자료
2024 년 1월 10일

- **Chapter 1**
- The nonlinear relationship between technological development and income inequality: Evidence from dynamic panel with threshold effect and endogeneity *(Presented at the 19th International Schumpeter Conference, China, 2022)*

- **Chapter 2**
- Relationship between innovation and income inequality under the Technological Kuznets curve hypothesis: Evidence from the ARDL model for South Korea *(Journal of Economic Research (JER), 28(1), 17-44.)*

- **Chapter 3**
- Has the Phillips curve flattened in South Korea? *(with Soojin Jo and Myungkyu Shim, Journal of Market Economy (시장경제연구), 52(2), 38-80.)*

Research questions

- Is there nonlinearity in the innovation-inequality nexus?
- Has the Phillips curve flattened in South Korea?

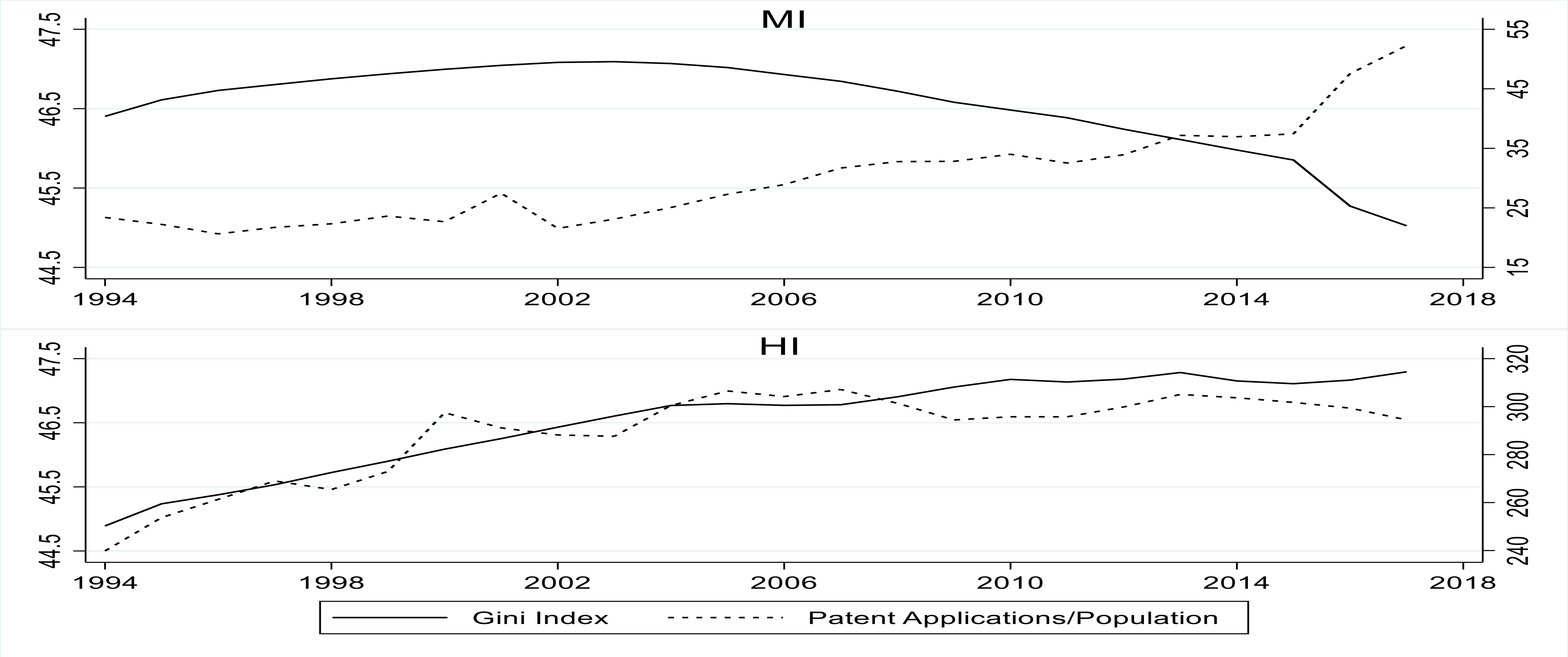
Hypothesis 1 [Confirmed]

- There is a U-shaped curvilinear relationship between innovation and inequality of income (Technological Kuznets Curve, TKC) such that at the early stages of technological development innovation acts as equalizer of income, but at the later stages innovation deepens and starts increasing income inequality within countries [Mark1 – Mark2 Schumpeter’s innovation pattern]

Hypothesis 2 [Confirmed]

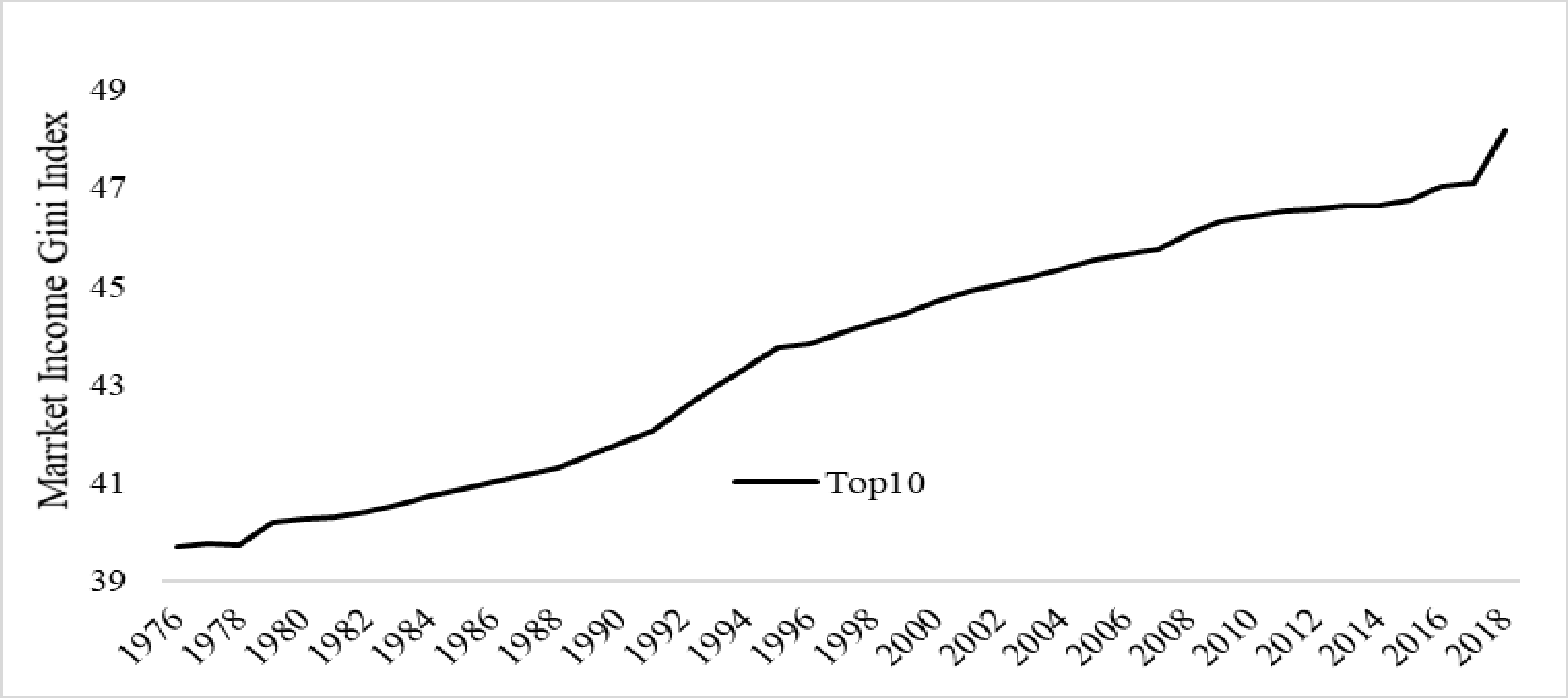
The slope of the Phillips curve is small and was small before the Asian Financial Crisis

Relationship between Gini index (left y-axis) and innovation proxied by patent applications weighted by total population (right y-axis) in high- (HI) and middle-income (MI) countries.



Note: Gini index for market income was retrieved from SWIID (2020), patent applications data was retrieved from WIPO data base for PCT patent applications by resident, then it was divided by total population retrieved from PWT (ver. 10).

Market income inequality of Top 10 Innovative Countries 1976-2018



Source: Standardized World Income Inequality Database (SWIID), 2020; Archive of Bloomberg Innovation Index 2013-2021

Methodology

Following Seo and Shin (2016), the dynamic threshold model is specified as follows:

$$\boldsymbol{INQ_{it} = (\beta_{01} INQ_{i,t-1} + \beta_{11} INN_{it} + \sum_{j=2}^{n} \beta_{j1} X_{jit}) 1\{INN_{it} \le \gamma\} +}$$

$$\boldsymbol{(\beta_{02} INQ_{i,t-1} + \beta_{12} INN_{it} + \sum_{j=2}^{n} \beta_{j2} X_{jit}) 1\{INN_{it} > \gamma\} + \alpha_i + u_{it}}$$

- INQ – Gini index for market income;
- INN – a threshold variable of innovation measured by **relative price of investment goods, patent applications and patent grants weighted by population**;
- γ – a certain threshold value of INN that minimized the GMM function and predicates a switch of regimes;
- X – a set of controls: real **GDP per capita, trade openness, financial development index, inflation, share of population aged 65 and above, private credit as a share of GDP, human capital index.**

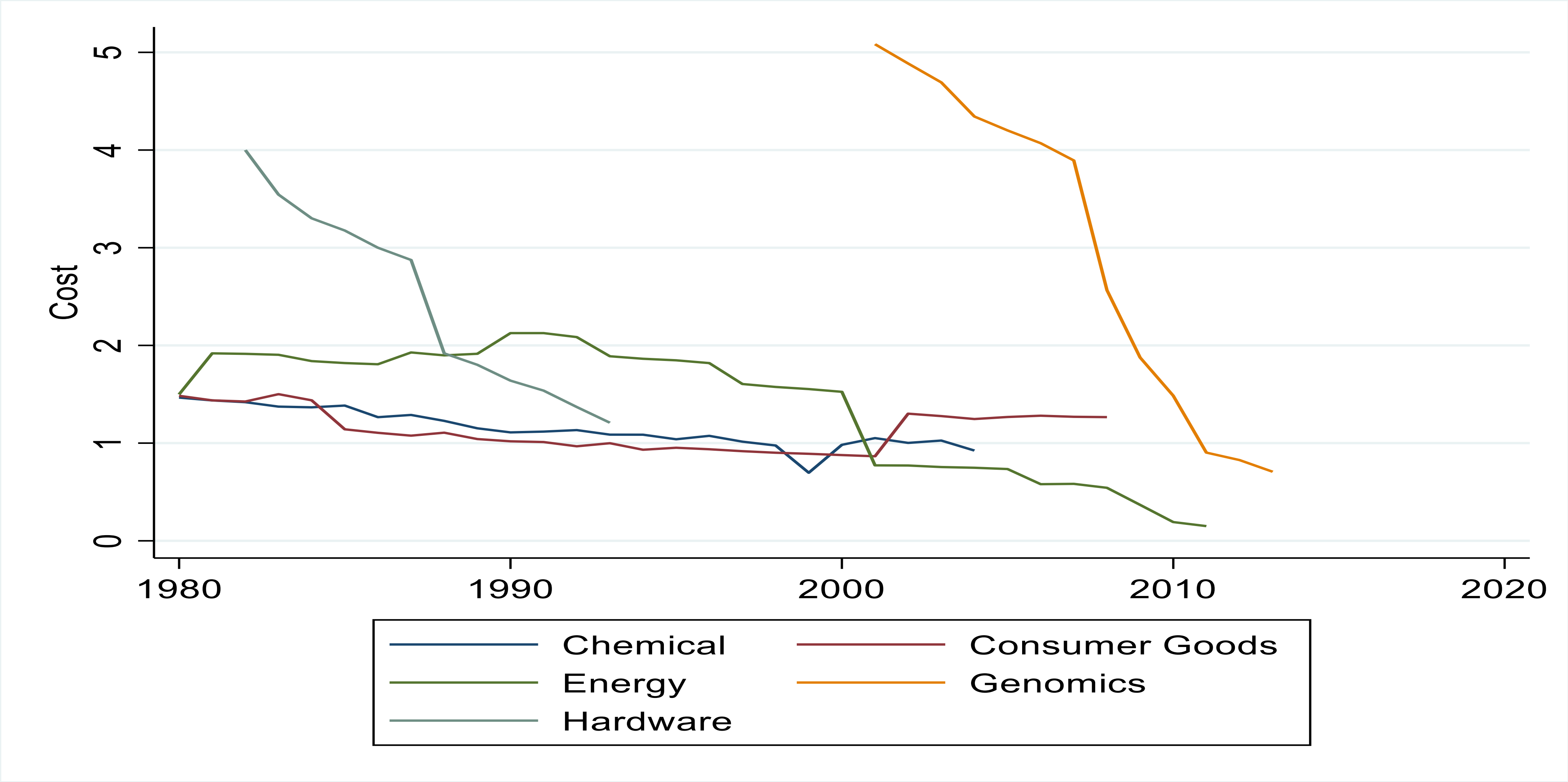
Data

- Period: 1994-2017 divided in 8 three-year periods
- Countries: 72 (39 HIEs, 33 MIEs (19 UMI, 14 LMI))

Variable	Unit of Measurement	Source	Observations
Gini Index for Market Income	0-100 Scale	Standardized World Income Inequality Database, 2020	576
RGDP per capita	US$ chained PPPs (in ths, 2017)	Penn World Table (ver.10)	576
Rel. Price of Investment Goods*	Price Ratio		576
Patent Applications/Population	No. per 1 ml. of population	WIPO data base, PCT, by resident	576
Patent Grants/Population	No. per 1 ml. of population		549
Financial Development Index	0-100 Scale	IMF	576
Domestic Private Credit to GDP	% of GDP	World Bank	573
Trade Openness	% of GDP		575
CPI	Annual %		563
Population 65 and above	% of total population		576
Human Capital Index	-	Penn World Table (ver.10)	560

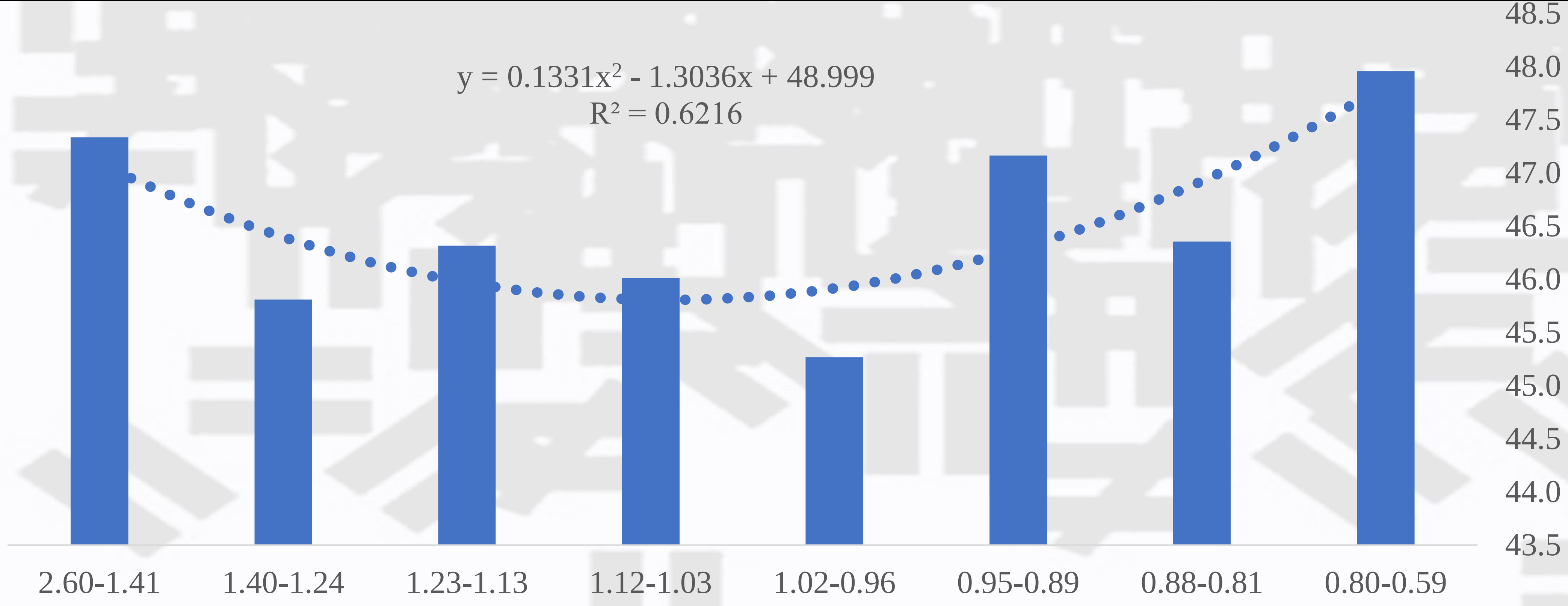
***Relative price of investment goods is a price level of investment goods relative to price level of household consumption in US 2017 prices obtained from Penn World Table (ver. 10)**

Average cost of 66 technologies over 1980-2013: Technological development tends to make technology cheaper decreasing the relative price of investment goods.



Note: Original data was converted into log scale. Based on the dataset from J. Doyne Farmer and François Lafond (2016)

ΔRelative price of investment goods (proxy for tech. innovation) and Gini index



This plot represents the relationship between Gini index (y-axis) and relative price of investment goods (x-axis) for the entire panel with 72 high-income and middle-income countries over 1994-2017. Time period is averaged over 8 three-year periods to smooth fluctuations. Each bin contains equal number of observations (72), and each range of values for relative price of investment goods is plotted against average Gini index for the corresponding range.

Dynamic Panel Model with Endogenous Threshold Variable of Innovations.

	Below Threshold	**Below Threshold**	**Below Threshold**	**Below Threshold**
Lag of Gini Index	0.696***	0.637***	0.691***	0.634***
Rel. Price of Investment Goods	**-4.801*** **	**-5.316*** **	**-5.237*** **	**-2.331*** **
RGDP per capita	-0.0241***	0.0014	-0.0181***	0.0061
Financial Development		0.0222***	0.0119***	-0.0220***
Trade Openness	0.0006	0.0038***	0.0042***	0.0022**
Private Credit/GDP	0.0074***			
HC index		-2.024***		
Aging			-0.0198	
CPI				0.109***
	Above Threshold	**Above Threshold**	**Above Threshold**	**Above Threshold**
Lag of Gini Index	-0.107***	-0.0366*	-0.136***	-0.0035
Rel. Price of Investment Goods	**4.933*** **	**4.132*** **	**4.684*** **	**2.042*** **
RGDP per capita	0.0399***	0.0412**	0.0309***	-0.0176***
Financial Development		-0.0270***	-0.0106**	0.0250***
Trade Openness	0.0011**	0.0071***	-0.00281***	0.0001
Private Credit/GDP	-0.0109***			
HC index		1.970***		
Aging			-0.0479**	
CPI				-0.111***
Threshold value	**0.974*** **	**1.137*** **	**0.984*** **	**0.884*** **
95% Confidence Interval	[0.939 - 1.008]	[1.091 - 1.183]	[0.926 - 1.041]	[0.807 - 0.961]
Bootstrap p-value for Linearity Test	**0.0**	**0.0**	**0.0**	**0.0**
Observations	568	552	568	560

Modeling innovation-inequality relationship in South Korea

Methodology: ARDL-ECM model

For models w/ cointegration, ARDL in ECM representations:

$$\Delta LnINQ_t = a_0 + \sum_{i=1}^{m} a_{i1}\Delta LnINQ_{t-i} + \sum_{i=0}^{m} a_{i2}\Delta LnINN_{t-i} + \sum_{j=3}^{n}\sum_{i=0}^{m} a_{ij}\Delta LnX_{j,t-i} + \lambda ECT_{t-1} + u_t$$

$$\Delta LnINQ_t = a_0 + \sum_{i=1}^{m} a_{i1}\Delta LnINQ_{t-i} + \sum_{i=0}^{m} a_{i2}\Delta LnINN_{t-i} + \sum_{i=0}^{m} a_{i3}\Delta LnINN_{t-i}^2 + \sum_{j=4}^{n}\sum_{i=0}^{m} a_{ij}\Delta LnX_{j,t-i} + \lambda ECT_{t-1} + u_t$$

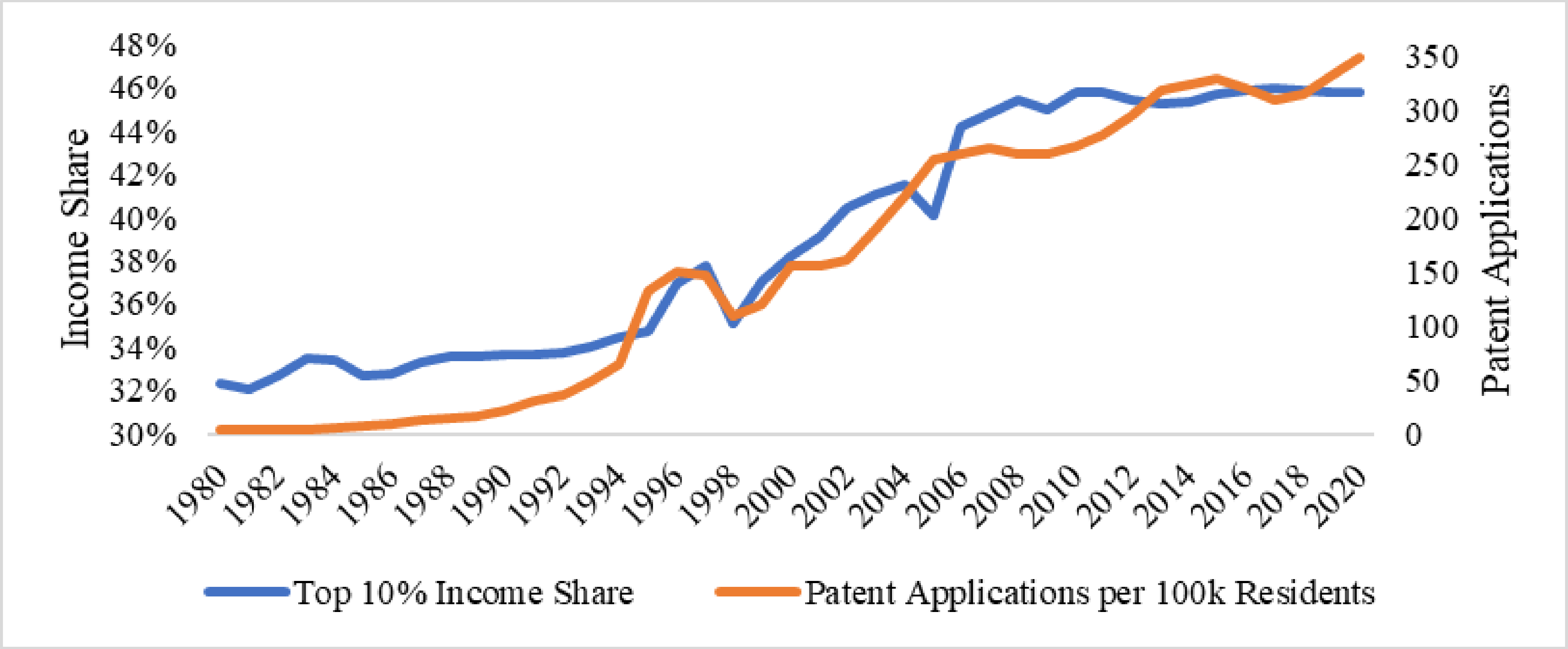
where INQ = [Gini for market income, Income Share of Top 10%]

X= [Financial Development Index, CPI, RGDPc, KOFGI, Domestic credit/GDP]

INN = [Patent Application/Pop, Technological Development Index]

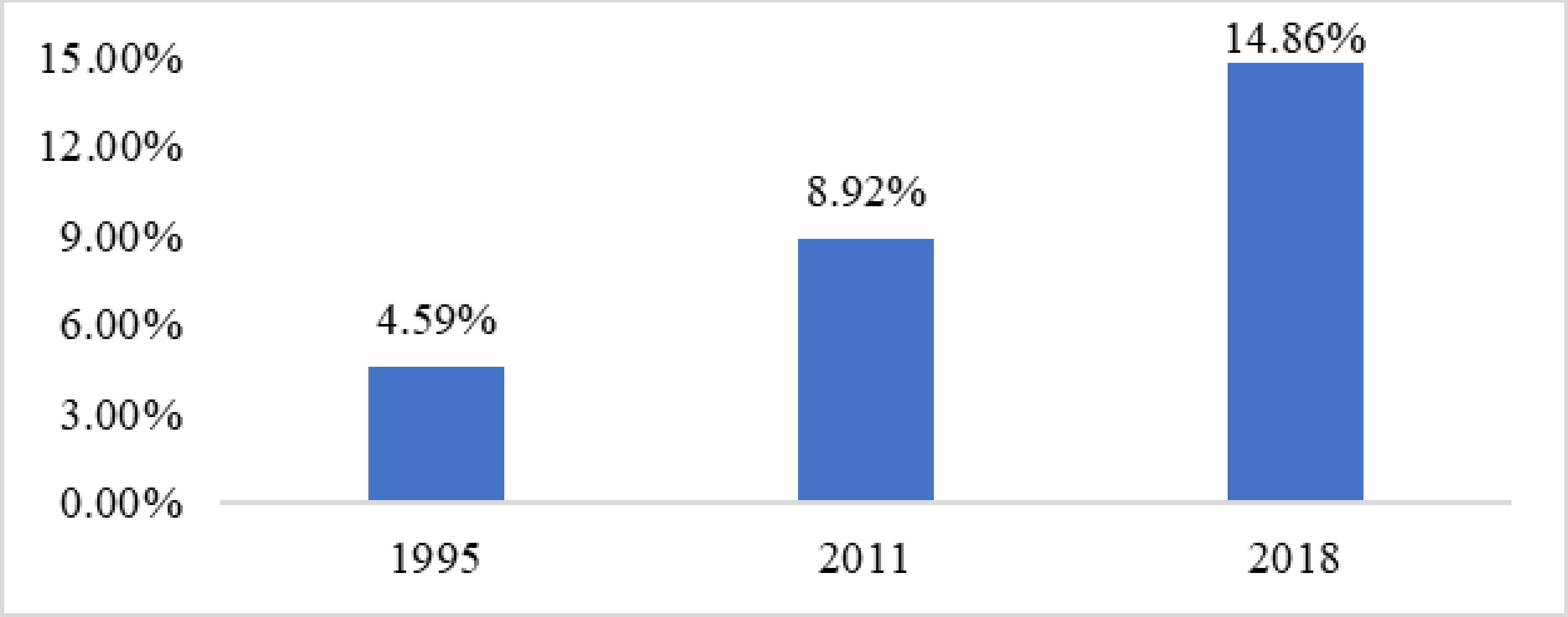
t∈[1986-2020]

Pre-tax national income shares of top 10% of earners and patent applications per 100k of residents in South Korea, 1980-2020



Source: World Inequality Database; WIPO

Share of Samsung's patent filings in total number of international PCT patent filings in South Korea – creative accumulation in large firms



Source: Author's estimates based on WIPO data base

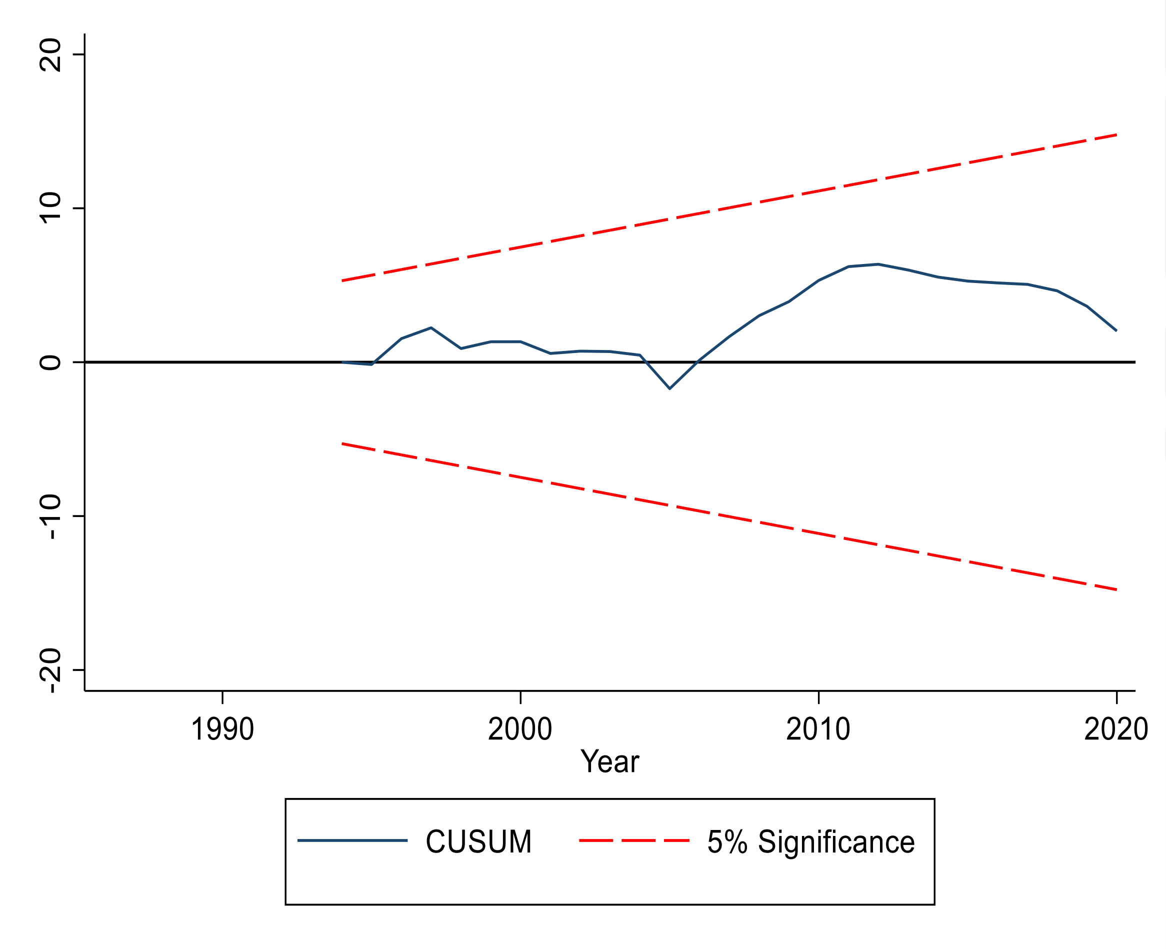
Results of ARDL in ECM form (model 4): negative relationship between tech innovation and income inequality in the short term, and positive one in the long-term – U-shaped pattern.

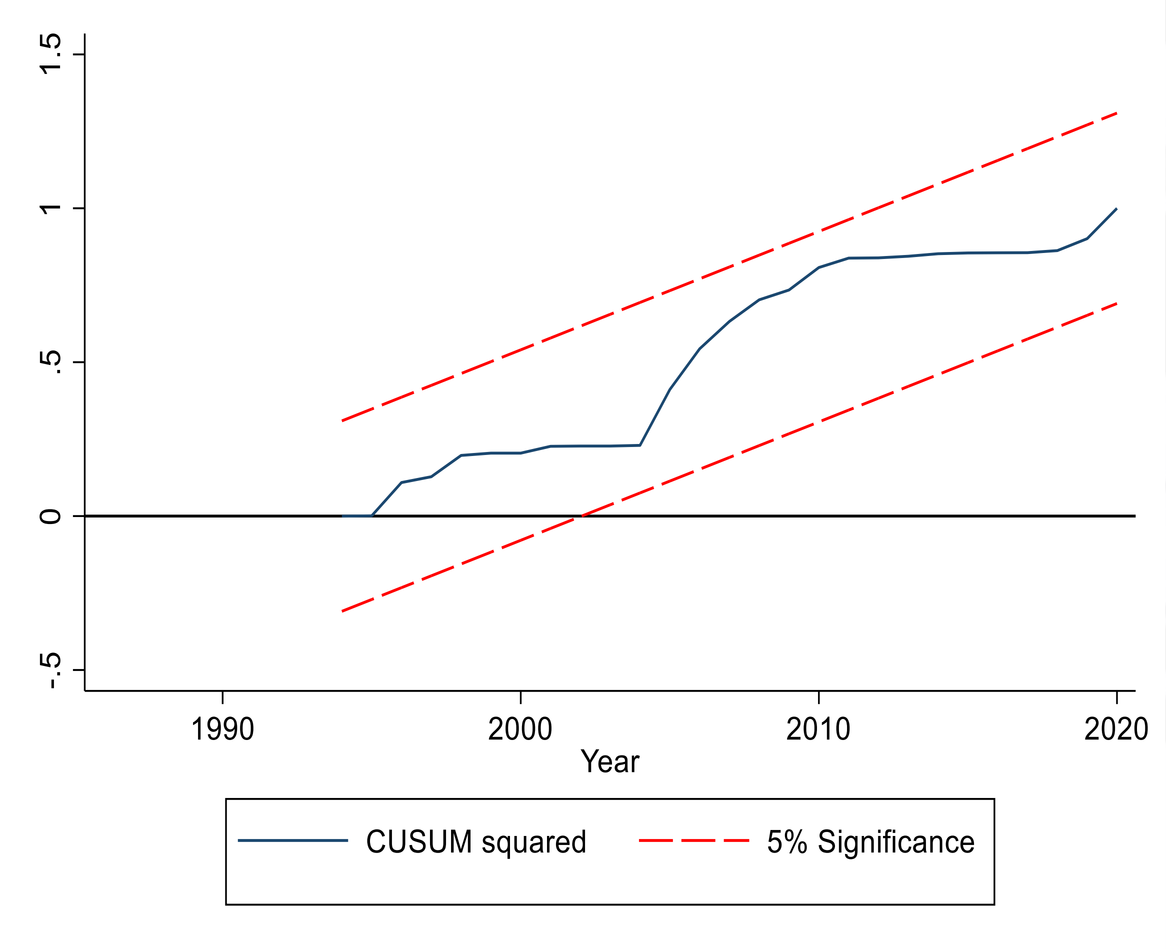
Dep. var.: ΔLTOP10	Variable	Coefficient	St. err.
Adjustment	$LTOP10_{t-1}$	-0.8878***	(0.1731)
SR	$\Delta LTDI_t$	-1.1197***	(0.2909)
	$\Delta LRGDPc_t$	0.6263***	(0.1414)
	$\Delta LRGDPc_{t-1}$	0.2342*	(0.1287)
	$\Delta Ldomcred_t$	-0.1154*	(0.0629)
	Cons	-0.5416	(0.4786)
LR	$LTDI$	0.8292***	(0.2449)
	$LRGDPc$	-0.0865	(0.0909)
	$Ldomcred$	0.1101***	(0.0243)
	$LKOFGI$	0.2168	(0.1368)

F-statistic ARDL (1 1 2 1 0)	F = 7.164*** k=4
R^2	0.7602
Adjusted R^2	0.6621
D.W. d-statistic	2.070996
Breusch–Godfrey LM test for autocor.	Chi2= 0.112 (0.7377)
White's test for heterosc-ty	Chi2=32.00 (0.4167)

Note: The optimal lag lengths of variables were determined based on the Akaike information criterion (AIC); Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

CUSUM and CUSUM square stability tests of model 4





Stability of the model estimates over time within 95% confidence interval

Estimating the Slope of the Regional Phillips curve in Korea

Methodology (Hazell et al. 2022):

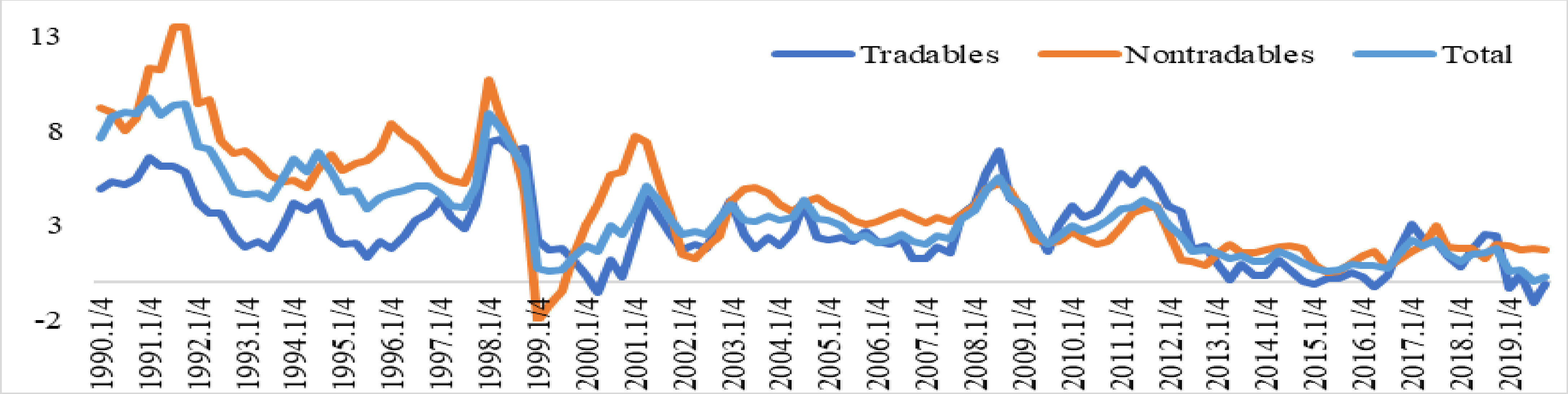
$$\pi_{it}^{N} = \beta E_t \pi_{it+1}^{N} - k\hat{u}_{it} - \lambda \hat{p}_{it}^{N} + v_{it}^{N} \quad (1)$$

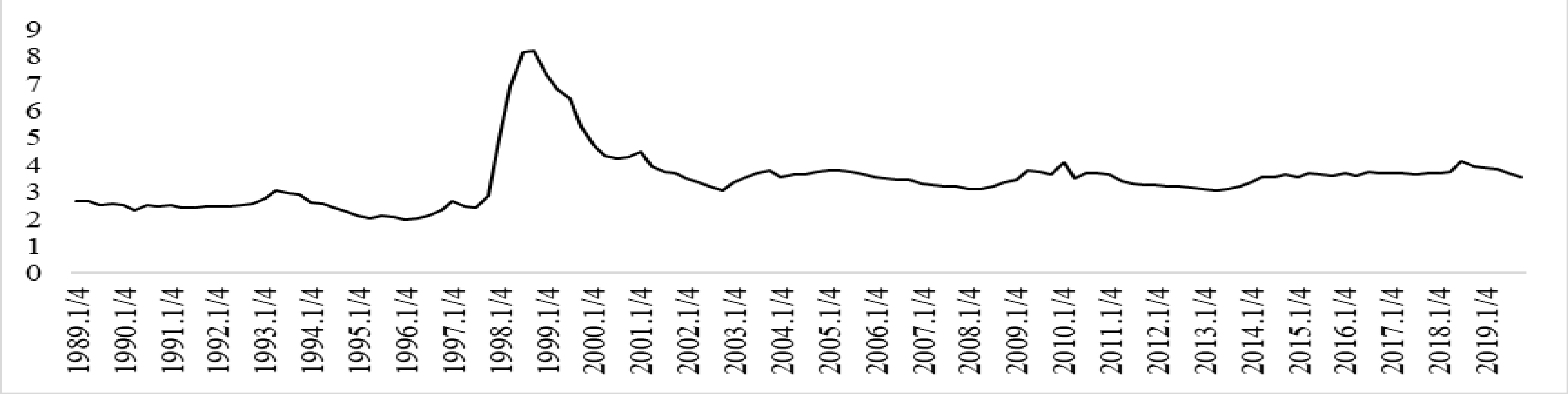
$$\boldsymbol{\pi_{it}^{N} = -k\sum_{j=0}^{T} \beta^{j} u_{i,t+j} - \lambda \sum_{j=0}^{T} \beta^{j}\, \widehat{p}_{it+j}^{N} + \alpha_i + \gamma_t + \widetilde{\omega}_{it}^{N} + \eta_{it}^{N}, \ (2)}$$

$$\boldsymbol{\pi_{it}^{N} = -\psi u_{it-4} - \delta \widehat{p}_{it-4}^{N} + \alpha_i + \gamma_t + \varepsilon_{it} \quad (3)}$$

where $\boldsymbol{\psi} = \frac{\boldsymbol{k}}{\boldsymbol{1-\beta\rho_u}}$, and $\boldsymbol{\delta} = \frac{\boldsymbol{\lambda}}{\boldsymbol{1-\beta\rho_{pN}}}$; ρ_u and ρ_{pN} are AR(1) coefficients for u_{it} and $\hat{p}_{it}^{N}$, respectively

Year-over-year changes in CPI for tradables and non-tradables in South Korea over 1990-2020 and s.a. unemployment rate over 1989-2020.





Full sample estimates of the Phillips curve without housing, 1992-2018.
Once inflation expectations are removed, the slope becomes insignificant in all models.

	(1)	(2)	(3)	(4)
	No fixed effects	No time effects	Lagged unemployment	Tradable demand
κ	- 0.0121*** (0.00229)	- 0.0461 (0.0411)	- 0.0029 (0.00932)	0.0037 (0.0138)
ψ	- 0.3310*** (0.0576)	- 0.5620*** (0.0724)	- 0.0363 (0.0691)	0.9380 (6.5990)
rp	-0.0044 (0.00475)	-0.2780** (0.0942)	-0.0448 (0.0283)	-0.1080* (0.0410)
Fixed Effects	NO	YES	YES	YES
Time Effects	NO	NO	YES	YES
Number of observations	1588	1588	1588	1244

Standard errors clustered by date and region with * $p<0.05$, ** $p<0.01$, *** $p<0.001$

Regional Phillips curve before and after 2000, 2003, and 2005.

The slope of the Regional Phillips curve has been flattening after the year 2000.

Difference in the slope before and after the cutoff-point

	Lagged Unemployment		
	Year>2000	Year>2003	Year>2005
k_before	-0.0350** (0.0091)	-0.0269** (0.0061)	-0.0230*** (0.0047)
ΔIntercept	-2.9527** (0.7664)	-2.1477** (0.5083)	-1.8577*** (0.3818)
ΔSlope	0.0357** (0.0092)	0.0270** (0.0063)	0.0233*** (0.0048)
Test H_0: ΔSlope=0	F(1,15)=15.02 (0.0015)	F(1,15)=18.19 (0.0007)	F(1,15)=23.63 (0.0002)
Test H_0: ΔSlope= ΔIntercept=0	F(2,15)= 7.59 (0.0053)	F(2,15)=9.20 (0.0025)	F(2,15)=12.10 (0.0007)
Region Effects	YES	YES	YES
Time Effects	NO	NO	NO

Standard errors in parentheses: * p<0.05, ** p<0.01, *** p<0.001

Regional Phillips curve before and after 2000, 2003, and 2005.

The slope of the Regional Phillips curve has been flattening after the year 2000.

Difference in the slope before and after the cutoff-point

	Lagged Unemployment		
	Year>2000	Year>2003	Year>2005
Ψ_before	-0.5546*** (0.0473)	-0.5061*** (0.0504)	-0.4870*** (0.0476)
ΔIntercept	-3.9340*** (0.2991)	-3.3867*** (0.3273)	-3.3263*** (0.2986)
ΔSlope	0.6574*** (0.0639)	0.5734*** (0.0831)	0.5301*** (0.0759)
Test H_0: ΔSlope=0	F(1,15)=105.74 (0.0000)	F(1,15)= 44.39 (0.0000)	F(1,15)= 47.14 (0.0000)
Test H_0: ΔSlope= ΔIntercept=0	F(2,15)= 86.63 (0.0000)	F(2,15)= 64.75 (0.0000)	F(2,15)=81.92 (0.0000)
Region Effects	YES	YES	YES
Time Effects	NO	NO	NO

Standard errors in parentheses: * p<0.05, ** p<0.01, *** p<0.001

Contributions to the Literature

1. Empirical support for the TKC hypothesis based on dynamic panel method

1.1. Finding the threshold effects in the innovation-inequality nexus that support the augmented KC and FKC

1.2. Providing additional insight into reasons behind the divergence in the trend of income inequality between HI and MI countries observed for the past 30 years

1.3. Discovering the TKC in South Korea

2. Revisiting the Korean Phillips curve by employing novel methodology that exploits regional variation in employment and price data in Korea to show that the negative slope of the Phillips curve is explained by the long-term inflation expectations

2.1. Estimating inflation for non-tradables in South Korea