

Unintended Pathways: The Impact of High-Speed Rail on Gender Differences in the Local Labor Market

Evidence from South Korea

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NBER SI: Urban Economics (2024)

Gender Gap in the Labor Market

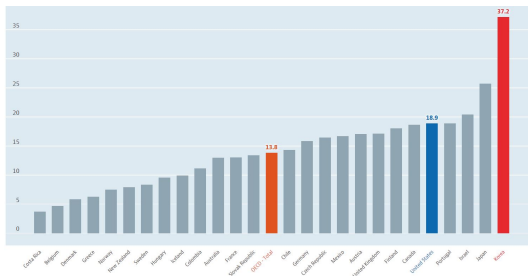


Figure: Gender Earning Gap in OECD Countries

- South Korea shows unprecedented gender gaps in labor market outcomes, despite the narrowed gender education gap.
- Factors contributing to the gender gap:
 - Domestic burden on women leads to higher labor force participation costs for women (Maurer-Fazio et al., 2011).
 - Women tend to seek jobs with more flexible work arrangements and shorter commutes (Goldin and Katz, 2016; Mas and Pallais, 2017; Wiswall and Zafar, 2018).

Impact of Infrastructural and Technological Progress on the Gender Gap in the Labor Market

- Access to energy reduces the domestic burden on women and encourages them to join the labor force (Dinkelman, 2011; Greenwood et al., 2016; Vidart, 2024).
- Robotization unintentionally increases the gender pay gap, as jobs that are male-dominated disproportionately benefit from robots (Aksoy, Özcan, and Philipp, 2021).
- Changes in commuting patterns have differential impacts on men's and women's labor market outcomes (Le Barbanchon, Rathelot, and Roulet, 2021; Harrington and Kahn, 2023; Bütikofer, Løken, and Willén, 2024).

This Paper

Research Question: Do improvements in non-commuter trains (which are supposedly 'gender neutral') have unintended and differing labor market impacts on men and women?

- Massive High-Speed Rail expansion in South Korea beginning in 2004
 - Non-commuter trains (more for business trips, visiting family/friends)
 - Connect the Seoul MSAs to the rest of the country
- Significant gender gap in the labor market: Gender-segmented industry compositions

Empirical Strategy

- District (county)-level outcomes from 2000-2015 (Seoul vs. Non-Seoul)
- Comparing districts near HSR stations with districts further away from HSR stations
 - Select control districts which are closer to historical railroad stations constructed during the Japanese Colonial Era (1890-1945)
- Staggered Difference-in-Differences (CSDID) design (Callaway and Sant'Anna, 2021)

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Preview of Findings

Main Results

- HSR reshapes the economic geography of surrounding areas (Seoul vs. Non-Seoul).
- HSR decreased the gender employment gap in non-Seoul (i.e., less centralized) MSAs.

Suggested Mechanisms for the Decline in Gender Employment Gap

- Increased job opportunities for women.
 - Primarily driven by sectoral reallocations, with significant increases in local service sectors around the stations, which rely more on the movement of people and predominantly employ women.
 - Male-intensive sectors (e.g., transportation, construction, manufacturing) benefit less and decline near stations.
- Improved education and childcare amenities in non-Seoul areas, which might help women join the labor force.

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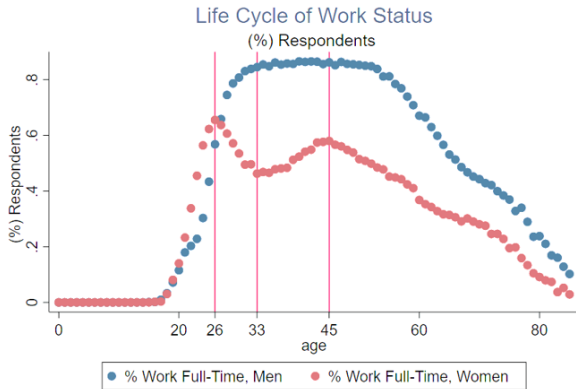
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Literature

- **Impact of transportation infrastructure and its varied effects across different spatial and socio-economic contexts** (Duranton, Morrow, and Turner, 2014; Redding and Turner, 2014; Redding and Turner, 2015; Morten and Oliveira, 2016; Baum-Snow et al., 2017; Donaldson, 2018; Tsivanidis, 2018; Severen, 2018; Zárata, 2022)
 - **Impacts of high-speed rail (inter-city, moving people) on spatial and sectoral reallocation** (Zheng and Kahn, 2013; Qin, 2017; Ahlfeldt and Feddersen, 2018; Charnoz, Lelarge, and Trevien, 2018; Lin, 2017; Heuermann and Schmieder, 2019; Dong, Zheng, and Kahn, 2020; Baek and Park, 2022)
- **Geography of jobs and gender differences in relation to commuting** (Butikofer, Løken, and Willén, 2020; Le Barbanchon, Rathelot, and Roulet, 2021; Velásquez, 2023; Harrington and Kahn, 2023; Liu and Su, 2024; Gu et al., 2024)
- **Impact of technological and infrastructural changes on gender gaps in the labor market** (Dinkelman, 2011; Greenwood et al., 2016; Aksoy, Özcan, and Philipp, 2021; Vidart, 2024)

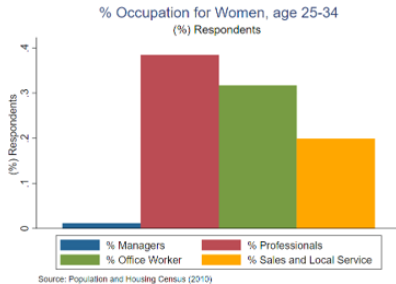
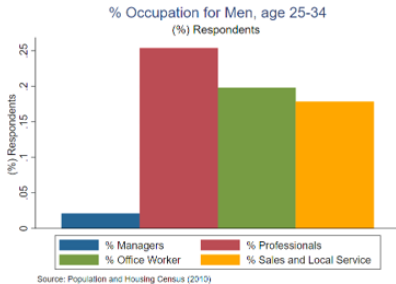
Life Cycle of Work Status by Gender



Source: Population and Housing Census (2010)

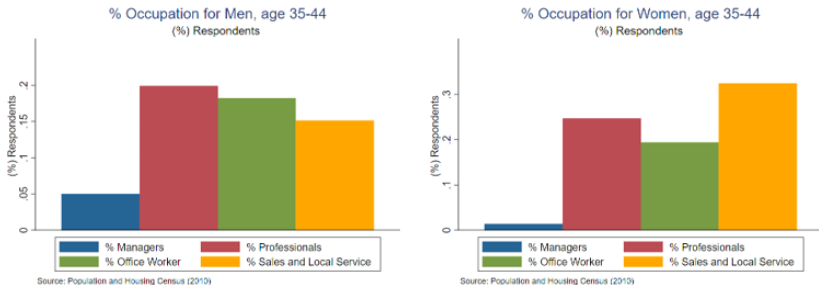
Occupation Choices by Gender (Age 25-35)

Figure: Age Cohort: 25-35



Occupation Choices by Gender (Age 35-45)

Figure: Age Cohort: 35-45



(Married) women tend to work in **sales and local service sectors** with relatively low skill-entry barriers and more flexible work arrangements (e.g, part time jobs, shorter commutes)

Gender Segmented Labor Market

(1) Industry Name	(2) F-to-M Emp. Seoul	(3) Emp. Ratio (2003) Non Seoul	(4) Emp. Share (2003) Seoul	(5) Emp. Share (2003) Non-Seoul
'Male-intensive Sector'				
Transportation and Logistics	0.120	0.111	0.080	0.070
Construction, Utility	0.149	0.134	0.053	0.055
Government	0.297	0.251	0.022	0.031
Wholesales	0.374	0.427	0.094	0.090
Other Services	0.376	0.408	0.032	0.037
Real Estate and Rental Service	0.416	0.413	0.041	0.023
Manufacturing	0.624	0.709	0.239	0.228
Other Retail	0.974	0.973	0.062	0.069
'Female-intensive Sector'				
Lodging	1.117	1.564	0.010	0.013
Food, Bev, Tobacco Retail	1.173	1.386	0.014	0.020
Other Private Education	1.226	1.177	0.057	0.054
General Retail	1.236	1.453	0.029	0.031
Banking, Finance, and Insurance	1.500	1.229	0.049	0.039
Restaurant and Bar	2.157	2.587	0.126	0.140
Medical	2.192	2.059	0.037	0.036
Textiles, Clothing Retail	2.303	2.660	0.019	0.021
Hair Salon and Spa	2.764	2.407	0.017	0.019
Pre and Elementary School	3.825	2.356	0.019	0.024

Notes: Based on Census on Establishment (2003) by Statistics Korea, 3-digit 8th and 9th KSIC industry code.

Geography of South Korea

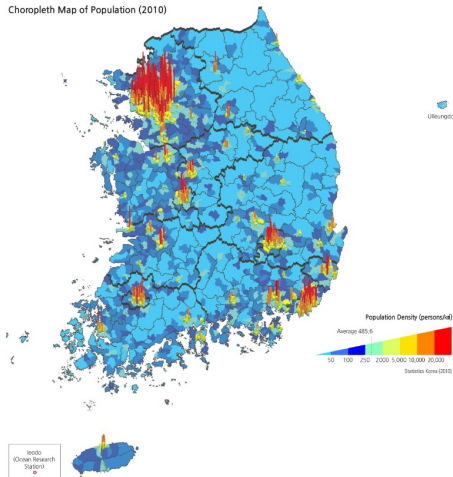
Seoul Metropolitan Area

- South Korea is among the most densely populated countries in the world (World Bank, 2015).
- Strong preference for urban amenities and job opportunities in Seoul.
- Half of the population (25 million) lives in the Seoul MSAs (Seoul, Incheon, Gyeonggi).

Regional Inequality

- Huge development gap between the Seoul region and the rest of the country.
- Heavy congestion and housing affordability issues in Seoul.

Choropleth Map of Population (2010)



Huge development gap (Seoul vs. non-Seoul)



Seoul



Gwangju (5th biggest city)

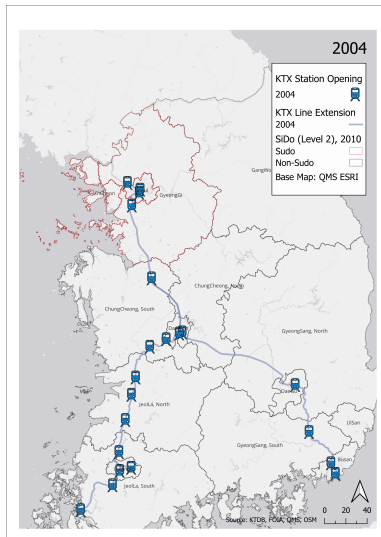
HSR in South Korea

Korean Train eXpress (KTX)

- One of the most popular inter-city transits (car vs. HSR). ◀ Ridership
- Significantly improved connectivity:
 - Seoul – Busan (325 km), 6 hours by car vs. 2 hours by KTX.

Not a Major Commute Mode

- Less than 0.09% of passengers use the train for commuting.
- KTX is used for long-distance trips (avg. 250 km).
- More than 80% of trips are to access amenities, visit distant families, or for business trips.



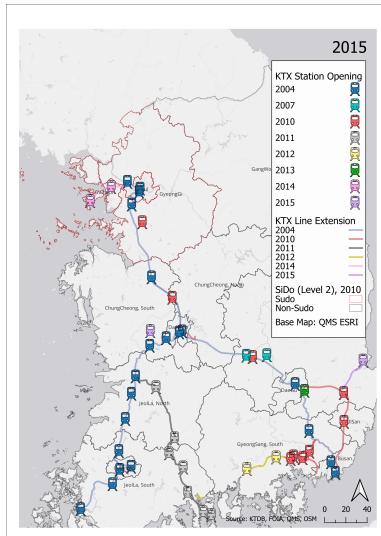
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Data

Census on Establishments

- Administrative survey of all 3.3 million enterprises and establishments in Korea.

Census on Population and Household

- Population and housing census of Korea.

Korea Labor & Income Panel Study (KLIPS)

- Labor panel survey of sample individuals and households

Internal Migration Statistics

- Migration flow data of households

Korean Transport DataBase (KTDB)

- Historical and current transportation network

Staggered Difference-in-differences

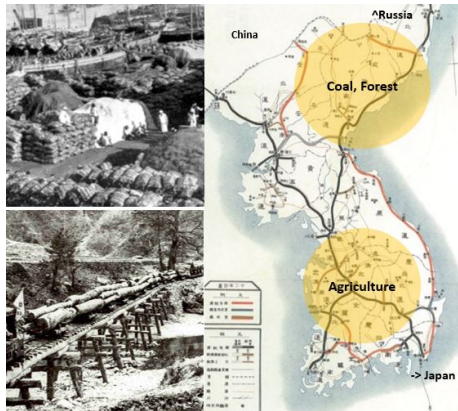
In a district i at year t (sample period: 2000-2015)

$$Y_{it} = \alpha_i + \gamma_t + \sum_l \beta_l \cdot \mathbb{1}\{t - E_i = l\} + \epsilon_{it} \quad (1)$$

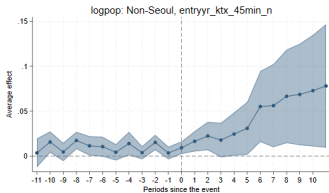
- Y_{it} : log population, employment, gender gap in labor market outcomes, etc.
- $\mathbb{1} = 1$ if a district i at year t is within 30min (Seoul) or 45min (non-Seoul) from HSR stations with no traffic driving time. ◀ Driving
- E_i : year of the first HSR station opening in district i .
- α_i : District-fixed effect
- γ_t : Year-fixed effect
- Standard errors are clustered at the district level
- Preferred Estimator: Callaway and Sant'Anna (2021)
 - Heterogeneous treatment effects in Diff-in-Diff (DiD) with variation in treatment timing and multiple periods (Staggered treatments)

Identification Strategy and Selection of Control Group

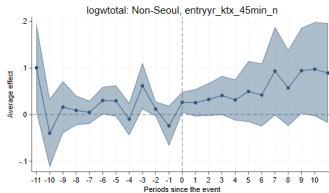
- Control groups: districts located within 50, 100 km of old railroad stations constructed during the Japanese Colonial Era (1890-1945)
 - Railways to transport resources from Korea to Japan (agricultural good, coal, forest) or to serve Japanese-Russian War (Baum-Snow, 2007; Baum-Snow and Ferreira, 2014; Duranton, Morrow, and Turner, 2014; Garcia-López, Holl, and Viladecans-Marsal, 2015)
- Identifying assumption: treated and control districts share similar characteristics in terms of economic and gender dynamics.



Impact on Population and Employment (Non-Seoul)

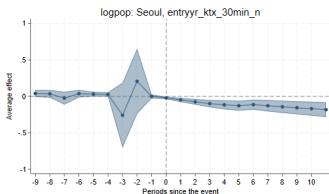


(c) Y: log(population)

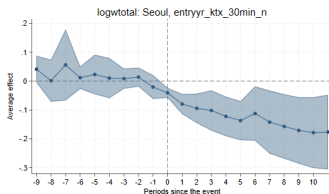


(d) Y: log(employment)

Impact on Population and Employment (Seoul)



(e) Y: log(population)



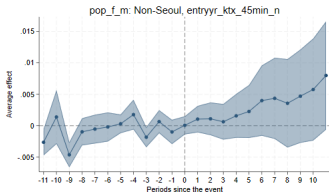
(f) Y: log(employment)

Average Treatment Effect: Population, Employment

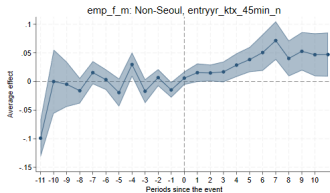
	(1)	(2)	(3)	(4)
	Seoul		Non-Seoul	
	Log(Population)	Log(Employment)	Log(Population)	Log(Employment)
<i>Treat</i>	-0.114*** (0.029)	-0.125*** (0.038)	0.04** (0.016)	0.054* (0.027)
<i>District FE</i>	✓	✓	✓	✓
<i>Year FE</i>	✓	✓	✓	✓
Obs	1,168	1,168	2,141	2,141

Notes: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. The coefficients are Average Treatment effect for Treated (ATT) using (Callaway and Sant'Anna, 2021) estimator, with 'never-treated' and 'not-yet-treated' districts as control groups. *Treat* = 1 if districts are in 30min (45min) from any HSR station for Seoul (non-Seoul) areas. Seoul is defined as districts within the Seoul metropolitan area of Incheon, Seoul, or Gyeonggi provinces. Non-Seoul encompasses all other districts except a few islands. Standard errors are in parentheses, clustered at the district level.

Impact on Female-to-Male Ratio (Non-Seoul)

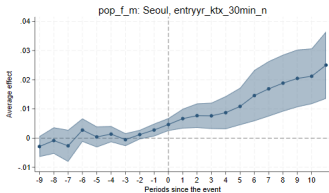


(g) Population Ratio

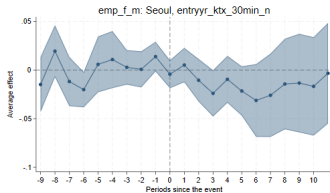


(h) Employment Ratio

Impact on Female-to-Male Ratio (Seoul)



(i) Population Ratio



(j) Employment Ratio

Average Treatment Effect: Gender Differences

	(1)	(2)	(3)	(4)
	Seoul (F-to-M Ratio)		Non-Seoul (F-to-M Ratio)	
	Population	Employment	Population	Employment
<i>Treat</i>	0.013*** (0.003)	-0.015 (0.015)	0.003 (0.002)	0.034*** (0.01)
<i>Mean (2003)</i>	0.986	0.744	1	0.791
<i>District FE</i>	✓	✓	✓	✓
<i>Year FE</i>	✓	✓	✓	✓
Observations	1,168	1,168	2,141	2,141

Notes: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. The coefficients are Average Treatment effect for Treated (ATT) using (Callaway and Sant'Anna, 2021) estimator, with 'never-treated' and 'not-yet-treated' districts as control groups. $Treat = 1$ if districts are in 30min (45min) from any HSR station for Seoul (non-Seoul) areas. Seoul is defined as districts within the Seoul metropolitan area of Incheon, Seoul, or Gyeonggi provinces. Non-Seoul encompasses all other districts except a few islands. Standard errors are in parentheses, clustered at the district level.

Mechanism. Impact on Gender Gap in Labor Market

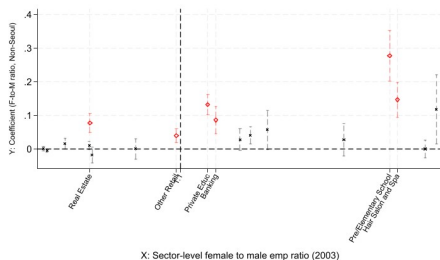
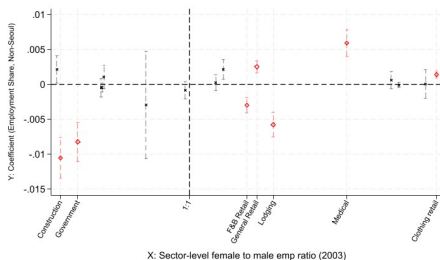
1. Increased Job Opportunities for Women

- Effect on Reallocation of Industries around HSR Stations
 - Decline in male-intensive sectors (e.g., manufacturing, construction)
 - Increase in female-intensive sectors (e.g., local service sectors: retail, health care, insurance, restaurants)
 - More women are hired in already female-intensive sectors.
 - Effects are more pronounced in Non-Seoul (serves mostly local residents' demand, with shorter commutes for women) vs than Seoul (beyond local foot traffic).

2. Improvement in Endogenous Amenities

- Education and childcare sectors, which help women reduce their childcare burden, improved in non-Seoul MSAs.

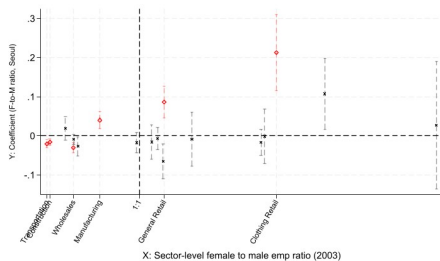
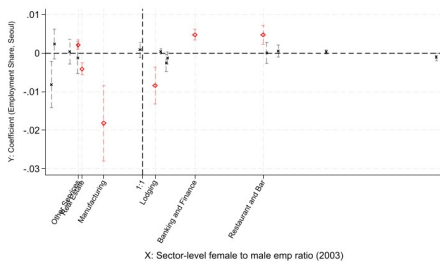
Mechanism 1. Employment Effects by Sectors: Non-Seoul



- Y: coefficients (employment share of industry k in districts j)
- X: industry-level female-to-male gender ratio

- Y: coefficients (F-to-M gender share)
- X: industry-level female-to-male gender ratio

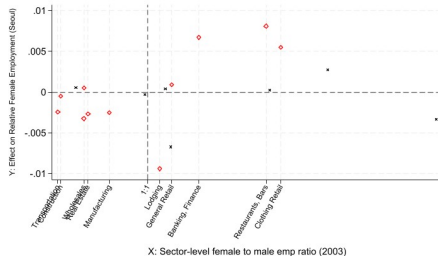
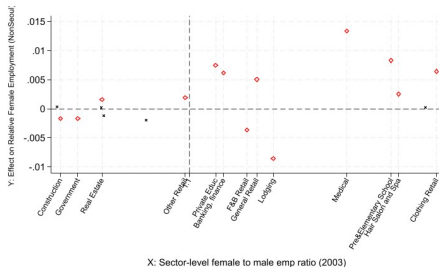
Mechanism 1. Employment Effects by Sectors: Seoul



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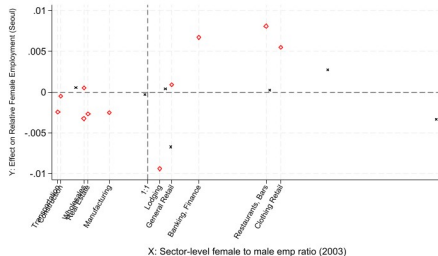
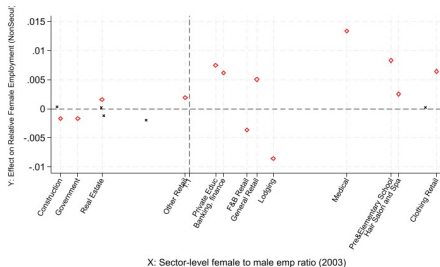
Mechanism 1. Total Relative Job Opportunities for female



- Total Effect for industry $k = \Delta EmpShr_k \Delta GenderShr_k$
- $TotalEffect_k = \alpha + \beta^{NonSeoul} Femaleshr_k + \epsilon_k$
 - Non-Seoul $\beta^{NonSeoul} = 0.003^*(0.001)$
- Total Relative Job Opportunities for female (Non-Seoul)=
 $\sum_k \Delta EmpShr_k \Delta GenderShr_k = +0.042(3.88\%)$

- Total Effect for industry $k = \Delta EmpShr_k \Delta GenderShr_k$
- $TotalEffect_k = \alpha + \beta^{Seoul} Femaleshr_k + \epsilon_k$
 - Seoul: $\beta^{Seoul} = 0.001(0.001)$
- Total Relative Job Opportunities for female (Seoul) =
 $\sum_k \Delta EmpShr_k \Delta GenderShr_k = -0.003(-0.33\%)$

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Mechanism 2. Impact on Education and Childcare Amenities

	(1)	(2)	(3)	(4)
	Y: Number of Employment per (10,000) Residing Women			
Industry	Pre&Elem. Sch	Private Educ	Pre&Elem. Sch	Private Educ
Region	Seoul	Seoul	Non-Seoul	Non-Seoul
<i>Treat</i>	-15.001*** (4.195)	-14.99 (4.573)	3.857 (3.768)	14.327** (5.860)
<i>District FE</i>	✓	✓	✓	✓
<i>Year FE</i>	✓	✓	✓	✓
<i>Mean (2003)</i>	98.06	288.58	124.02	211.92
Observations	1,166	1,166	2,144	2,144

Notes: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. The coefficients are Average Treatment effect for Treated (ATT) using (Callaway and Sant'Anna, 2021) estimator, with 'never-treated' and 'not-yet-treated' districts as control groups. *Treat* = 1 if districts are in 30min (45min) from any HSR station for Seoul (non-Seoul) areas. Seoul is defined as districts within the Seoul metropolitan area of Incheon, Seoul, or Gyeonggi provinces. Non-Seoul encompasses all other districts except a few islands. Standard errors are in parentheses, clustered at the district level.

Educ N.firm

Conclusion

- This paper documents how HSR in South Korea reshaped the economic geography of affected areas (Seoul vs. non-Seoul).
- HSR increased employment opportunities for women through sectoral reallocation around HSR stations and the provision of childcare, especially in non-Seoul areas.
- Limitations and Future Work:
 - Investigating how women and men choose residential vs. work locations differently should be considered.
 - This paper does not consider the quality of jobs (e.g., occupations, wage, part-time vs. full-time employment) mainly due to data limitations.
 - The reduced gender gap does not indicate that gender inequality is ultimately improved, as the effects are driven by the fact that women are disproportionately working in the local service sector.



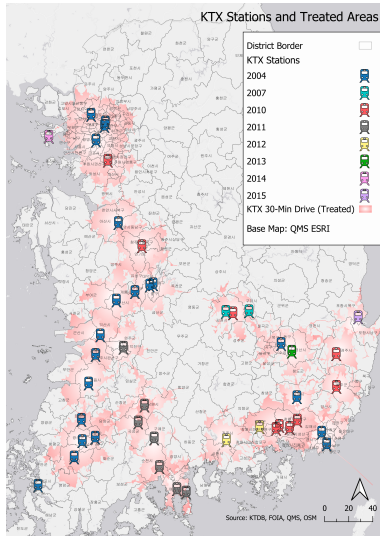
Thank You!

Question to: Eunjee Kwon
kwonee@ucmail.uc.edu

Treatment Identification: Travel Time (Minutes)

HSR reduces travel time

- Comparison travel time: District to district **driving**
- HSR travel time
 - District centroid to HSR station **driving** + **transfer** + HSR **train trip** + **transfer** + HSR station to district **driving**
- Today's results: **Treated** if a district to HSR station is less than 30 minutes driving
- Planned update: $Treat_{ij} = 1$ or ω , if $TravelT_{ij}^{HSR} < TravelT_{ij}^{Car}$ for district i and j (or sum across 236 destinations as continuous dose)



Travel Time: Geospatial OD Network Analysis

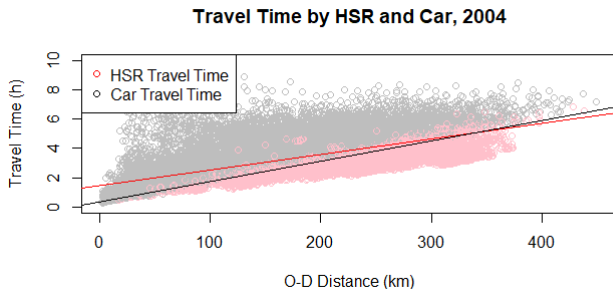
Data: KTDB GIS and Network DB (Government FOIA)

- Station location, rail lines extension, average train speed by line, (station opening date)

Analysis Packages: QGIS built-in network packages

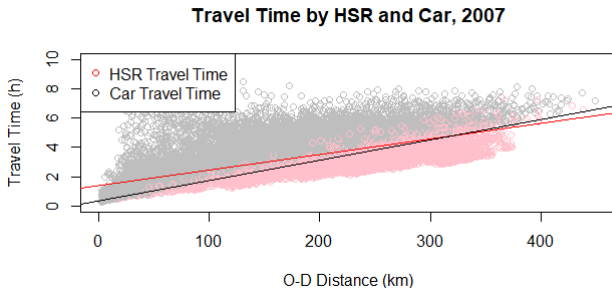
- The driving time is measured with open source traffic information
- The HSR travel time required more comprehensive analysis with our own data
- While rail line and speed data are simple, KTDB road data is massive and speed cannot be simplified. Also, KTDB geo-coordinates are often stray.
- Limitation: Time-invariant driving time (available API sources do not offer (long) historical variations)

Travel Time: Geospatial OD Network Analysis

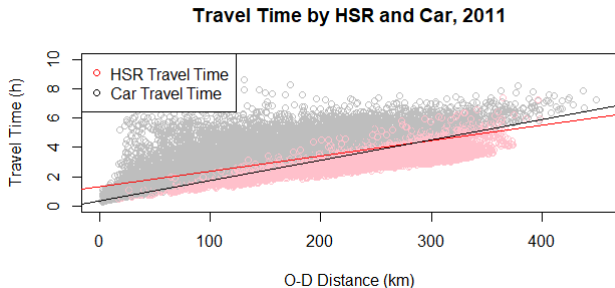




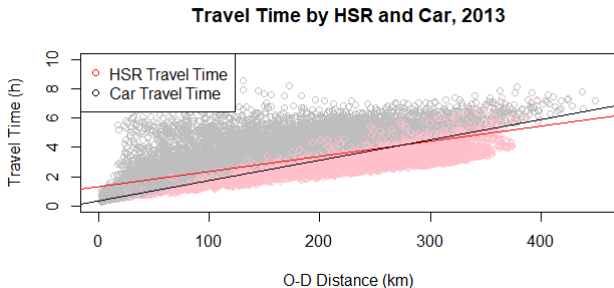
Travel Time: Geospatial OD Network Analysis



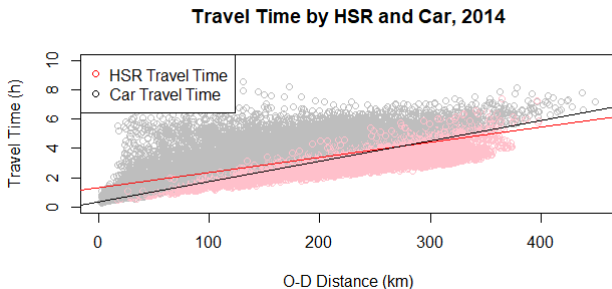
Travel Time: Geospatial OD Network Analysis



Travel Time: Geospatial OD Network Analysis

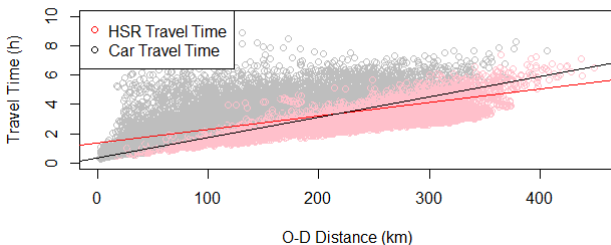


Travel Time: Geospatial OD Network Analysis



Travel Time: Geospatial OD Network Analysis

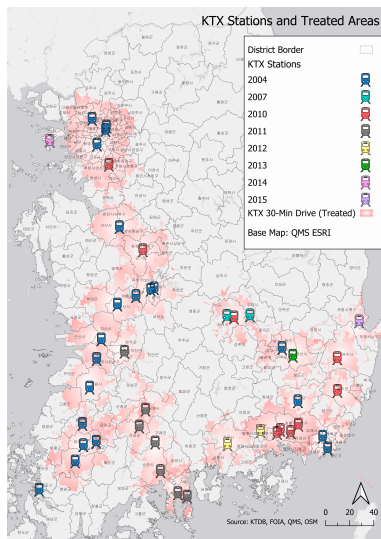
Travel Time by HSR and Car, 2015



Treatment Identification: Travel Time (Minutes)

HSR reduces travel time

- Comparison travel time: District to district **driving**
- HSR travel time
 - District centroid to HSR station **driving** + **transfer** + HSR **train trip** + **transfer** + HSR station to district **driving**
- Today's results: **Treated** if a district to HSR station is less than 30 minutes driving
- Planned update: $Treat_{ij} = 1$ **or** ω , if $TravelT_{ij}^{HSR} < TravelT_{ij}^{Car}$ for district i and j (or sum across 236 destinations as continuous dose)



District-Level Two-Way Fixed Effect Model

In a district i of a province s at year t (sample period: 2000-2015)

$$\log(y_{ist}) = \alpha + \beta_c \text{Seoul}_i \text{Treat}_{it} + \beta_{nc} \text{NonSeoul}_i \text{Treat}_{it} + \delta_i + \text{year}_t + \theta_{st} + \epsilon_{ist} \quad (2)$$

■ Outcome

- y_{it} : outcome variables of interest (e.g., gender gap in labor market outcomes etc)

■ Heterogeneous Treatment

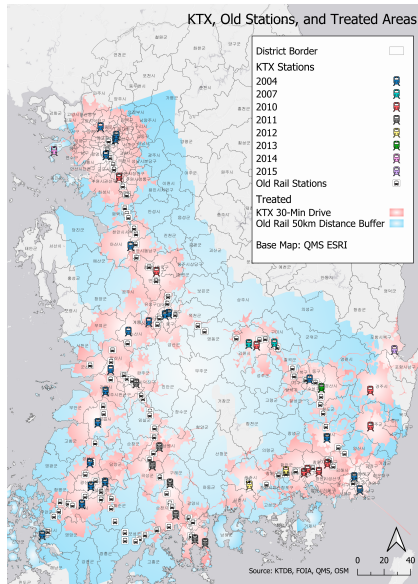
- $\text{Treat}_{it} = 1$: if district i 's population-weighted centroid is located in 15km from any HSR stations at year t Centroid
- (Non) $\text{Seoul}_i = 1$: if district i is located in (Non-)Seoul metropolitan area

■ Fixed Effects

- δ_i : district-fixed effect
- year_t : year-fixed effect
- θ_{st} : province-by-year fixed effect

■ Standard errors are clustered at the district-level

Historical Route and HSR Network



Robustness Checks

■ Sub-sample analysis

- Without large cities
- Without districts located close to North Korean border
- Without districts designated as a special district by the government

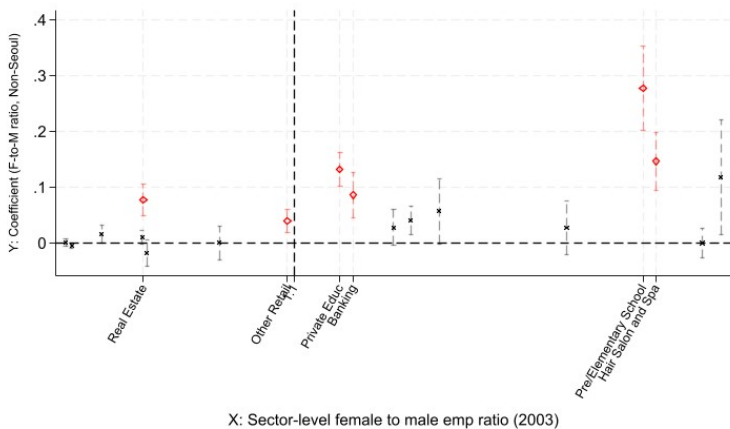
Back

Mechanism 2 (2). The Impact on Education and Childcare Amenities

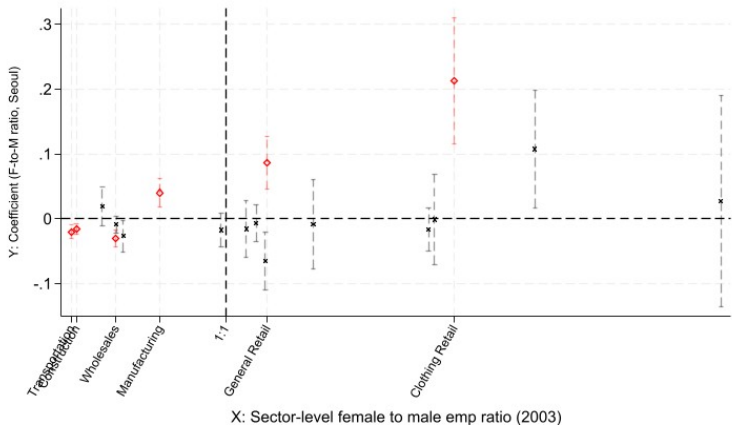
	(1)	(2)	(3)	(4)
	Y: Number of Establishment per Resident			
	Pre&Elem. Sch Seoul	Private Educ Seoul	Pre&Elem. Sch Non-Seoul	Private Educ Non-Seoul
Treat	0.043 (0.266)	-0.004 (1.102)	0.192 (0.156)	1.687** (0.718)
<i>District FE</i>	✓	✓	✓	✓
<i>Year FE</i>	✓	✓	✓	✓
<i>Mean (2003)</i>	98.06	288.58	124.02	211.92
Observations	1,166	1,166	2,144	2,144

[Back](#)

Mechanism 1 (2). Gender Share Effects by Sectors: Non-Seoul



Mechanism 1 (4). Gender Share Effects by Sectors: Seoul

[◀ Back](#)

Mechanism 2. Endogeneous Amenities

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	F&B	FIN	School	Private Educ	Gen Retail	Food, Bev Retail	Clothing	Med	Beauty
Panel A. Seoul									
ATT	-1.406 (3.622)	1.337*** (0.366)	0.043 (0.266)	-0.004 (1.102)	2.559*** (0.676)	0.488 (0.669)	0.257 (2.466)	0.999** (0.289)	0.486 (0.550)
Panel B. Non-Seoul									
ATT	- 5.369*** (1.739)	0.708** (0.325)	0.192 (0.156)	1.687** (0.718)	2.984*** (0.543)	-0.763 (1.125)	2.896*** (1.042)	0.101 (0.214)	0.965** (0.388)

- Endogenous amenities (defined as the number of establishments per population following Diamond (2016)) increased with HSR.