Unintended Pathways: The Impact of High-Speed Rail on Gender Differences in the Local Labor Market - Evidence from South Korea*

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Abstract

This paper examines the role of High-Speed Rail (HSR) in reducing the gender gap in labor market outcomes in South Korea. The country's notable gender disparity, coupled with the extensive HSR network starting from 2004 that connects Seoul metropolitan areas with non-Seoul regions, presents a distinctive setting for this study. Using a staggered difference-in-differences method and an instrumental variable strategy based on historical railroads from the Japanese colonial era, we evaluate HSR's impact from 2000 to 2015. The empirical analysis demonstrates that the gender employment gap in labor markets of regions connected by HSR has diminished following the rail expansion. We provide empirical evidence that this decline is mainly due to the heightened labor demand in local service industries, a sector where women are disproportionately more likely to be hired than men. Additionally, improved local amenities, particularly childcare services, have facilitated women's labor force participation. Finally, we observe a tendency among the female population to move closer to areas with HSR access, more so than the male population. Our results highlight how infrastructure projects like HSR can inadvertently benefit certain demographics by reshaping local labor market and urban structures.

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1 Introduction

The gender gap in the labor market narrows with economic development, yet disparities remain salient even in developed countries like the U.S., Japan, and South Korea ((Blau and Kahn, 2017)). South Korea, in particular, is known as one of the countries with the highest levels of gender inequality among the developed world, exhibiting a 37.2% wage gap and a 22.2 percentage points difference in labor force participation rates between men and women (Figure A1), which is unprecedented given the narrowed education gap between genders. The costs associated with labor force participation for women are generally higher, primarily due to the substantial burden of childcare (Maurer-Fazio et al. (2011)) and home production responsibilities (Greenwood, Seshadri, and Yorukoglu (2005)). Consequently, women tend to work fewer hours, seek jobs with more flexible arrangements, and choose different industries and occupations than men (Goldin and Katz (2016)).

Previous literature has shown that infrastructural and technological progress can improve the gender gap in labor market outcomes. For example, access to energy, such as electrification, in household sectors reduces the domestic burden on women (Dinkelman, 2011; Greenwood et al., 2016; Vidart, 2020) and helps decrease the gender gap in the labor market by encouraging them to join the labor force. On the other hand, robotization unintentionally increases the gender pay gap, as jobs that are male-dominant disproportionately benefit from robots, ultimately increasing gender disparities in the labor market (Aksoy, Berkay, and Philip (2019)). These findings imply that technological progress could potentially affect men and women differently in the labor market, given the distinct labor market constraints they face and the different industries and occupations they choose.

Extensive literature has documented that transport infrastructure that reduces travel costs for people changes overall spatial distribution and local labor market landscapes, however, there is limited evidence regarding its effects on reshaping gender disparities. This study extends the literature by investigating whether improvements in non-commuter trains could have 'unintentionally' different labor market impacts on men and women. We investigate the case of South Korea's High-Speed Rail (HSR[1]), which serves as inter-city transit and not

[1]High-Speed Rail (HSR) is a fast-speed intercity railway mainly used for passenger carriage. Invented in

primarily used as a commuter train in the South Korean context, facilitates most trips for visiting relatives and family, leisure and business, or enjoying services in other cities. Given the substantial government spending involved in such infrastructure investment[2], understanding its heterogeneous impacts across different demographic groups is necessary. Despite the fast-growing literature on the impact of HSR[3], there is only limited evidence of its impact on gender disparities in labor market outcomes. This study aims to fill this gap.

The construction of HSR in South Korea provides a distinct setting to explore its unintended impacts on gender disparities in the labor market. As an advanced economy still grappling with labor market gender disparities, including different labor participation rates, wages, and occupational choices, South Korea offers an ideal testing bed to study whether transportation infrastructure can have gender-biased effects. In particular, it shows a noticeable segregation in industry employment post-marriage, where women predominantly occupy roles in local service sectors, which generally provide flexible work arrangement with no particular work experience. Additionally, the country's socioeconomic and population concentration in the Seoul metropolitan area, which includes Seoul, Incheon, and Gyeonggi provinces, adds meaningful external validity to our findings. The estimation results in this paper could be especially relevant for similarly urbanized and concentrated economies looking to understand the broader implications of such infrastructure projects.

The potential of HSR to reshape labor dynamics extends across both demand and supply spectrums. On one hand, HSR might catalyze local gender-specific labor demand by favoring sectors reliant on the mobility of individuals over goods. If women are overrepresented in these sectors, HSR could inadvertently elevate their labor demand. Conversely, the sup-

1964, the railway is expanding worldwide from advanced economies as first adopters. Although there is no international standard, a rail system with an average speed beyond 120 miles or 200 kilometers per hour is considered as HSR. Most newly built systems have speeds above 140 miles or 300 kilometers per hour.

[2]For example, the HSR in California, which links Los Angeles–San Francisco–Las Vegas, is estimated to cost $7 billion. The total cost to construct HSR in South Korea, linking Seoul to Busan and several other major cities, is $15 billion (2015).

[3]The literature finds that HSR enhances interaction among scientists living in different cities (Dong, Zheng, and Kahn (2020)) and enhances the spatial agglomeration of cities (Zheng and Kahn (2013); see Qin (2017) for Chinese cases; for German examples, see Ahlfeldt and Feddersen (2018)). HSR also affects the location decisions of firms (Charnoz, Lelarge, and Trevien (2018) for French firms) and has heterogeneous impacts across industries (Lin (2017)). Furthermore, HSR expansion can affect workers' decisions on where to live and where to work. For example, in Germany, workers prefer jobs in smaller cities while residing in larger towns (Heuermann and Schmieder (2019)).

ply side may witness shifts as HSR alters economic distributions and enhances amenities, potentially easing women's entry into the workforce by alleviating childcare burdens. This paper explores these dynamics within the framework of South Korea's unique socio-economic landscape.

To navigate the causal linkage between HSR and the gender gap in local labor outcomes, we primarily employ a staggered Difference-in-Differences (DID) design (Callaway and Sant'Anna, 2021). However, the strategic placement of HSR and the local labor market can be endogenous because workforce presence can facilitate regional development and the demand for transport infrastructure, and transport infrastructure can again bring more workers and populations. Therefore, we provide alternative empirical strategy exploiting the historical presence of Japanese-era railroad stations constructed before 1920 as an instrumental variable for the HSR (Duranton, Morrow, and Turner, 2014; Morten and Oliveira, 2016; Garcia-López, Holl, and Viladecans-Marsal, 2015; Tsivanidis, 2018) and show consistent estimates. Leveraging historical railways presupposes that existing infrastructure minimizes HSR rail route and station construction costs due to topological well setup and that the colonial-period stations, over a century old and followed by the Korean War, damaged most impacts the old rails made at the time and no longer directly affect regional economic development.

The estimation results indicate that the South Korean HSR played a significant role in diminishing gender gaps in employment and wages, with discernible effects observed both within and beyond the Seoul metropolitan area. These empirical findings validate that the expansion of HSR has positively impacted sectors characterized by higher female employment, such as retail and education while exerting negative effects on male-dominated, such as manufacturing. Moreover, the evidence suggests that HSR contributes to mitigating gender-specific barriers to labor participation, particularly by improving local amenities such as childcare facilities in less centralized areas. In terms of population dynamics, the expansion of HSR led to a reduction in population in districts near HSR stations compared to non-nearby districts within the Seoul metropolitan region. Conversely, districts outside the Seoul metropolitan area with access to HSR experienced population increases relative to districts

distant from HSR stations.

The empirical findings emphasize HSR's unexpected role in guiding local economies towards greater female inclusion in labor markets. Sectors with higher female employment, particularly local service sectors, inherently rely more on the movement of people than goods. Our population estimates indicate that HSR has enhanced faster and more efficient people mobility, disproportionately benefiting these sectors. Consequently, it has indirectly facilitated environments where women's employment opportunities have expanded.

The study aligns with and expands upon existing literature on the impact of inter-city transportation infrastructure and its varied effects across different spatial and socio-economic contexts (Duranton, Morrow, and Turner, 2014; Redding and Turner, 2014; Morten and Oliveira, 2016; Baum-Snow et al., 2017; Donaldson, 2018; Tsivanidis, 2018; Severen, 2018). It delves into the crucial, yet less examined aspect of cost of moving people, offering insights into how transportation infrastructure can influence labor market outcomes beyond the traditional focus on commuting costs. By integrating perspectives from urban economics and transportation literature on gender differences in location choices and commuting decisions (Rosenthal and Strange, 2012; Black, Kolesnikova, and Taylor, 2014; Chauvin, 2017; Kawabata and Abe, 2018; Farré, Jofre-Monseny, and Torrecillas, 2020; Le Barbanchon, Rathelot, and Roulet, 2020; Liu and Su, 2020), this research highlights the change-generating potential of HSR in reducing gender disparities through labor demand and supply mechanisms that extend beyond mere commuting.

Additionally, our study contributes to the discussion on gender disparities and economic structures by investigating the unintended effects of HSR advancements on gendered labor market dynamics. It extends the existing literature on the differential impacts of structural changes on male and female labor market outcomes, previously explored through the lens of technological shocks from both supply (Greenwood et al., 2016; Vidart, 2020) and demand (Aksoy, Berkay, and Philip, 2019) perspectives. With the case of South Korean HSR, this research uncovers how additional transport modality mitigate gender disparities even when not targeting the improvement in commuting. Our results demonstrate that HSR bolsters labor demand in sectors with higher female employment, (akin to the mechanisms observed

in the Bartik shock (Bartik, 1991)), while also facilitating women's labor supply by improving local amenities, especially in education and childcare. This dual focus on demand and supply sides enriches the understanding of transportation technological advancements' implications on gendered labor dynamics, a dimension that bridges transportation economics with gender-focused urban economic analysis in a novel way.

The rest of this paper is structured as follows. Section 2 provides contextual and infrastructure policy information, including the South Korean economic geography, gender gaps, and the expansion of HSR. Next, Sections 3 and 4 respectively detail the data and empirical strategies employed in this study. The estimation results are summarized in Section 5, and Section 6 empirically estimates and discusses some of the driving mechanisms behind these effects. Lastly, Section 7 concludes the paper.

2 Background

2.1 Gender Gap in Labor Market

Among OECD countries, South Korea stands out as one of the most gender unequal countries in terms of labor market outcomes. Figure A1, Panel (a) shows that female full-time employees, on average, earn 37.2% less than their male counterparts, an unprecedented level relative to any other country. Panel (b) reveals that women's labor force participation rates are 22.2 percentage points lower than men's. The existing gender disparities are astonishing because South Korea is one of the most educated countries with thin gender gap in educational attainment.

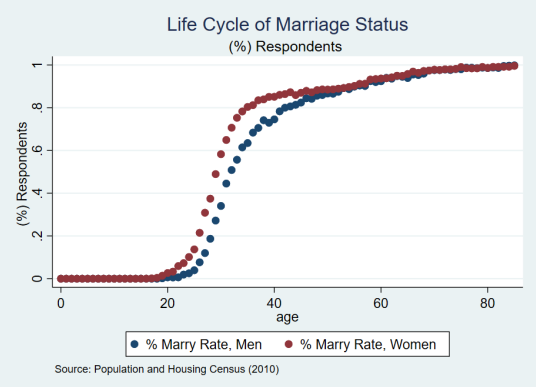
The disparity may result from other socioeconomic factors, such as heavier female domestic work expectation and childcare, discrimination, or social norms. Figure A2 presents the gender differences in time use over the years (Korea Income and Labor Panel Survey, 2000-2015). Female employment increased slightly, but the gender gap has not narrowed as much. Around 80% of men reported that they are 'working full-time' whereas only 40-50% of women responded likewise. Another 40-50% of women reported 'doing domestic work' as their main time use. Another 10% of women paralleled domestic work and part-time labor.

Domestic burdens do not appear to be a significant concern for men, with less than 5% of men reporting domestic work as their primary activity.

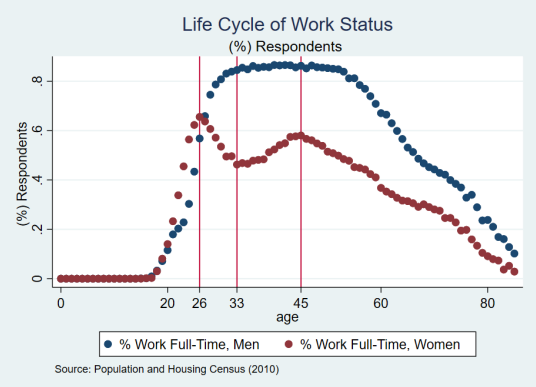
Marriage and Work Status Exploring the reasons for differing labor market decisions of women and men in South Korea is particularly intriguing, given the shrinking education gap between genders. Figure 1 illustrates the life cycle patterns of male and female marriage and work status. Initially, men and women exhibit similar labor force participation rates until their mid-twenties. However, a divergence occurs in their mid-twenties as women start to get married and have children, leading many to exit the labor market. Although some women re-enter the workforce in their mid-thirties, the numbers do not recover nor catch up to those of their male counterparts.

Figure 1: Life Cycle of Work and Marriage Status

(a) Married (%)



(b) Labor Force Participation (%)

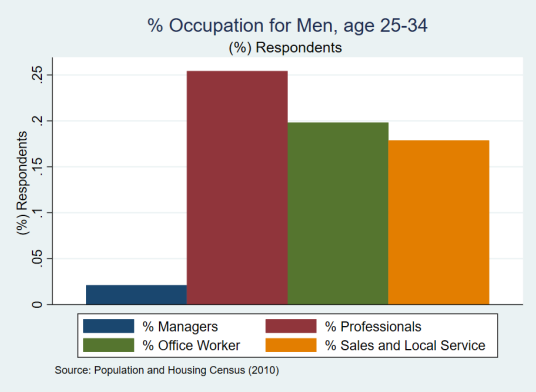


Notes: The graph plots the life cycle of men (blue dots) and women (red dots) with respect to marriage (Panel (a)) and labor force participation decisions (Panel (b)). Each dot represents the percentage of the birth cohort married and working, based on the Population and Housing Census (2010). "Married" in Panel (a) includes those ever married (including divorced or widowed), and labor force participation includes all types of work, including full-time and part-time jobs.

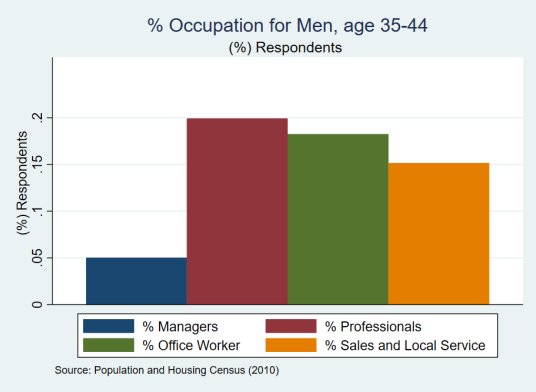
Furthermore, upon re-entering the labor market after marriage, women often find themselves in different positions compared to when they exit the market. Figure 2 displays the occupational composition of each age group for men and women before their exit from the market (ages 25-34) and upon re-entry (ages 35-44). In the earlier stages of their lives (ages

Figure 2: Occupation Composition for Gender and Age Groups

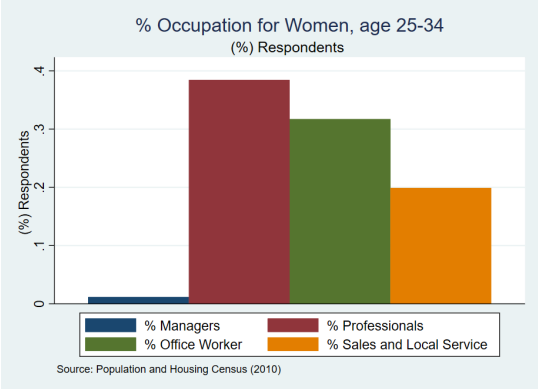
(a) Men (age 25-34)



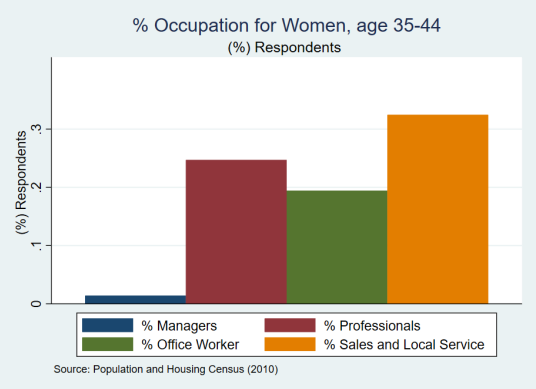
(b) Men (age 35-44)



(c) Women (age 25-34)



(d) Women (age 35-44)



Notes: The graph plots each gender and birth cohort's occupational compositions, based on the Population and Housing Census (2010). Each bar represents the share of gender-birth cohorts working in managerial positions (blue bar), white-collar professions (red bar), office workers (green bar), and the local service sector (orange bar). The sample includes workers in all kinds of jobs, including full-time and part-time positions.

25-34), men and women share a similar distribution across occupations, typically holding white-collar jobs such as managers, professionals, or office workers. However, upon their return to the workforce between the ages of 35-45, a notable shift occurs for women, with a significant increase in employment within sales and local services as illustrated in Figure 2, (b) and (d). This pattern is not observed among men, whose occupational distribution remains relatively unchanged. The occupational shift indicates a pronounced tendency for post-marriage women to experience career-disconnection or pursue flexible work arrangements.

Indeed, this phenomenon is not exclusive to South Korea. Research by Goldin (2016) suggests that the gender gap in the pharmacy sector in the United States has diminished over time (Goldin and Katz, 2016). This sector has witnessed a reduction in the pay penalty for part-time work and has adapted to better accommodate women's demands for flexible working hours. This example underscores a broader trend where job flexibility can profoundly influence gender disparities in labor market outcomes.

The divergent labor market trajectories of men and women, especially as influenced by marriage and working status, underscore the complex interplay between social norms and economic opportunities. This dynamic is further complicated and shaped by the economic geography of South Korea, a country that has experienced rapid urbanization and concentration of economic activities. The next section elaborates on how South Korea's urbanization and the strategic development of HSR network play pivotal roles in shaping labor market opportunities and, by extension, gender disparities within these markets. Understanding the geographical distribution of population and economic activities provides crucial context for analyzing the potential of the HSR to influence labor market outcomes across different regions, offering insights into whether and how infrastructure development can mitigate gender gaps in employment.

2.2 Economic Concentration and the Expansion of KTX

Home to 51 million people, South Korea is renowned not only for its rapid economic growth but also for its high urbanization rate and significant geographical concentration of eco-

nomic activities. The urbanization rate stood at 81.7% in 2018, similar to that of developed countries like the United States, Canada, and France. Half of the South Korean population resides in the Seoul metropolitan areas.[4] The population of Seoul proper was estimated at 10.29 million in 2016; however, the sprawling metropolitan area is significantly larger, encompassing 25.6 million people which is slightly more than the half of 51 million total population.

High-Speed Rail (HSR) Expansion The Korea Train eXpress (KTX), South Korea's high-speed rail (HSR) system, has constantly been evolving since its first introduction in 2004. The initial KTX planning was made in the 1980s to reduce regional economic disparities and to alleviate acute urbanization problems near Seoul including unaffordable housing and traffic congestion. The bullet train not only connected major cities such as Seoul and Busan but also brought many satellite smaller towns back then into the system improving their connectivity.

Figure 3 and Table A1 depict major expansion phases of the KTX system. The system continuously evolved with major segment expansion in 2004, 2010, and 2012.[5] In April 2004, KTX began its first operation in twenty-one stations along the Gyeongbu line, connecting Seoul to the southeastern region, and the Honam line, connecting Seoul to the southwestern part of South Korea. Between November and December 2010, nine more stations in the Gyeongbu and Gyeongui lines opened extending the service from Daegu to Busan. In October 2011, seven more stations in the Jeonla line began operation. By 2012, KTX covered 22% of the total territory and served 56% of the total South Korean population (KOSIS).

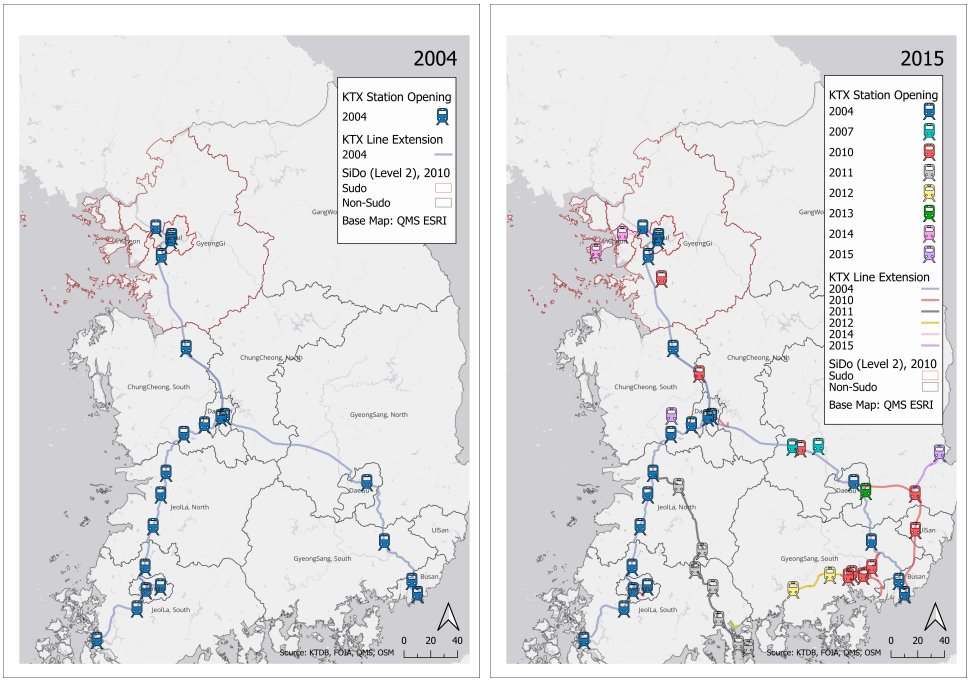
KTX enabled a same-day round-trip between Seoul and Busan, and Seoul and Gwangju, the mega-cities near three out of four vertices of South Korean territory. A one-way trip from Seoul to Busan takes six hours by car or traditional rail corridor but only takes two

[4]With a population density of 16,425 per square kilometer, Seoul, the capital of South Korea, ranks second in population density among urban areas with more than 5 million inhabitants. Seoul metropolitan areas indicate the country's capital and surrounding areas encompassing Gyeonggi and Incheon provinces. Given South Korea's average population density of 528 persons per square kilometer, the Seoul metropolitan areas are disproportionately large.

[5]There were other major expansions in later years, but our data points ended in 2015. The present information is from the Korea Railroad Corporation (KORAIL), upon the authors' information release request through the Korea Ministry of Interior and Safety (MOIS).

Figure 3: KTX Network Expansion

(a) 2004 (b) 2015



Notes: aaaaaa

to three hours via KTX. It is a passenger train with more than 80% of KTX passengers using the service to visit friends or relatives or for business trips. Initially, fewer than 1% of passengers used KTX for daily commutes due to the high ticket price.[6] The scoping out of metropolitan regions and the expansion of the KTX routes increase commuting use, but is still not a major purpose of travel.

As illustrated in Figure A3 Panel (a), KTX ridership has increased significantly since its inception. KTX accounted for 3.7% of interregional ridership (buses, cars, KTX, or non-KTX trains) in 2004 and reached 10% by 2015[7], while ridership on other modes of transportation (except for domestic flights) has decreased over time. Considering the total passenger-kilometers in Figure A3 Panel (b), the increase for KTX is even more significant. Total passenger-kilometers for KTX surpassed those of non-KTX trains by 2006, contributing to the overall increase in total passenger-kilometers from 2011. Combining Figures A3 (a) and (b), in 2015, the average travel distance per ticket was 15,000,000,000 passenger-kilometers / 60,000,000 tickets = 250 km, which far exceeds the average commute distance in South Korea.

KTX primarily competes with intercity buses and existing train networks but not with domestic flights. Domestic flights, excluding flights to Jeju Island, are not considered significant interregional transit options due to airports located distant from city centers, rendering domestic flights a less efficient mode of travel. Indeed, ridership on domestic flights (excluding flights to Jeju Island) remained stagnant during the sample period from 2000 to 2015, while ridership for non-KTX trains or intercity buses significantly decreased over the same period. This shift in transportation preferences underscores the transformative role of the KTX in South Korea's interregional connectivity and sets the stage for examining its broader socio-economic impacts. Among these, the potential influence of HSR expansion on labor market dynamics, particularly in terms of gender inequality, warrants closer examination.

[6] A one-way train ticket from Seoul to Busan costs around $40. With the average household net-adjusted disposable income per capita at USD 19,372 per year in 2015 (USD 1,614.33 per month), train tickets were prohibitively expensive for daily commutes.

[7] Korea Transport DataBase (KTDB), Korea Transport Institute (KOTI).

3 Data

This section outlines the data and its processing for analyses in this paper. To compile a geocoded 16-year (2000-2016) panel dataset at the district level, we harmonized the Census on Establishments, the Population and Housing Census, and the Internal Migration Statistics (IMS). [8] The microdata for the Census on Establishments and the Population and Housing Census were obtained through a subscription to the Micro Data Integrated System (MDIS), operated by Statistics Korea (KOSTAT). In this study, regions are delineated at the district level. In 2010, South Korea was divided into 228 districts across 15 provinces[9]. By amalgamating the aforementioned datasets, we created a (nearly) balanced panel dataset at the district level, encompassing 228 districts, for the period from 2000 to 2015 (t=16).

The administrative datasets were integrated into Origin-Destination (OD) travel time matrices by travel modes. To construct the travel time, we utilized Network and Geographical Information System Databases at the Korea Transport DataBase (KTDB) of the Korea Transport Institute (KOTI) and requested additional information from the Korea Railroad Corporation (KORAIL). For the instrumental variables, we employed historical railroad data from the KTDB. The below section details each dataset and variable construction methods.

Census on Establishments The Census on Establishments is an annual population survey that provides business information on all 3.3 million enterprises and establishments in South Korea. Beginning in 1994, the employer administrative data offers each establishment's business information, such as its' 5-digit industry code, number of employees, and geographic information. This detailed information makes it possible to construct a panel data of job creation[10] and job destruction[11] attached to the detailed geographic and establishment information. In our paper, we used information on the number of employees and the

[8] The three administrative data are collected by Statistics Korea and managed in the Micro Data Integrated System (MDIS) restricted to subscribers.

[9] Given our focus on railroad transportation, districts on Jeju Island and Ulleng Island were excluded from this study.

[10] The number of jobs created each year due to either firms' entrance or expansion of employment of incumbents.

[11] The number of jobs that disappeared each year due to either exit of firms or declines in employment of surviving firms.

number of establishments at the district level across different industries or establishments of different sizes.

Population and Housing Census The Population and Housing Census is an administrative survey that collects population, residential, and mobility information on all 50 million Koreans and foreign residents in South Korea every five years. The survey includes information on demographics (age, gender, education level), socio-economic status (job status), as well as residential location, job location, commuting patterns, and the residential location of the respondent five years before the survey.

This study uses 4 waves (2000, 2005, 2010, 2015) of the Census data, which contain a 2% random sample from the population survey. The key information we used in this paper includes current residential location, residential location 5 years prior, commute location, commuting mode, and other socio-demographic characteristics such as education level, gender, and marriage.

Korean Labor and Income Panel Study, KLIPS Korean Labor & Income Panel Study (KLIPS) is a longitudinal survey of the labor market and income activities of households and individuals residing in Korean urban areas. The first Wave of the KLIPS was launched by the Korea Labor Institute (KLI) in 1998, and the survey is conducted annually. Around 5,000 households and 15,000 individuals are surveyed every year. As our administrative data does not offer wage information during our analysis periods, we employed KLIPS to construct the wage variable. KLIPS offers rich information on sample individuals including their work, housing, and socioeconomic status. Among them, the information we used is each worker's monthly wage, gender, education, age, and cross-sectional and longitudinal built-in person weights. Due to the small sample and large volume of district-year strata in our analyses, the district-level wage construction is undergoing several robustness checks. The final results will be added in future updates.

Korea Transport DataBase, KTDB KTDB is a comprehensive transport database operated by the Korea Transport Institute (KOTI). The primary objective of KTDB is to

deliver geospatial data such as the OD travel and network information as a public social capital. However, it also offers a broader set of transport data and statistics.

Among the available information, we employed GIS DB and Network DB to construct travel time variables. GIS DB contains geographic and attribute information on transport objects including roads, public transit, railways, stations, and other transport facilities. Network data contains more comprehensive information enabling demand forecast or transit service simulation.

In our analysis, we employed the geographic layers of KTX stations and rail segments. Also, we extracted the average speed of each train running different rail routes to average the speed by route. The earliest available year for the GIS DB in the World Geodetic System (WGS) is 2009, which contains transport information in 2008. Despite most years offering quality data, a couple of years fail to align station and rail line objects when running the OD travel analysis. For example, the newly opened Dong-hae line and Pohang station do not produce travel time estimates. Therefore, we primarily used the years 2009 to 2015 data to build the data for previous years and supplemented some years with 2016 and 2017 data. The network data is available from the year 2006, but the train speed information is missing from 2006 to 2009. We used the 2005 speed data for the year 2004 analysis and calculated 2006 to 2009 speeds with 2005 and 2010 speed differences and inferred yearly growth rates.

Figure A4 shows the yearly change in the KTX and driving travel times. The red line indicating the KTX travel time becomes dominant over the black line indicating the car travel time for shorter distance OD district pairs over time.

The summary statistics for key variables used in our analysis is in Table A2.

4 Empirical Strategy

Does the construction of HSR influence gender disparities in labor market outcomes, such as wages and employment levels? Additionally, does the construction of HSR lead to a redistribution of population and employment from core to non-core areas, or does it result in a greater concentration of economic activities in core areas? This section connects the

questions into testable empirical designs.

4.1 Staggered Difference-in-Differences (DID) Design

First, we exploit the Difference-in-Differences (DID) research design to study the impact of the HSR expansion on outcome variables. The HSR station installments have a 'staggered' nature as they roll out over the years. The DID literature discusses potential identification problems when treatment timing varies across units and periods, and it suggests a number of solutions (**baker2022much**; Borusyak, Jaravel, and Spiess, 2022; Sun and Abraham, 2021). To address the potential identification issues, we adopt the estimator proposed by Callaway and Sant'Anna (2021).

With the new methods, we estimate dynamic effects of HSR across different duration after interventions. For a district i at time t, our main specification is as follows.

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

where Y_{it} represents the logged outcome of interest in district i at year t, $\mathbb{1}$ is an indicator function for a district i being defined as 'treated'. In our main analysis, we define treated districts as districts within 30 minutes of driving time from any HSR stations, and E_i is the year of the first HSR station opening in district i during the sample period, thus l constitutes the duration after the initial intervention. District fixed effects (α_i) and year fixed effects (γ_t) are included in the regression, with standard errors clustered at the district level. β coefficients can be interpreted as the change in the outcome of interest following the construction of a KTX station in a district, relative to the control group. The map of the treated districts is in Figure A5.

To identify the heterogeneous impacts between core and non-core areas, in our main regression, we separate the districts located in core versus non-core areas. Core areas are defined as districts located in the Seoul metropolitan areas (Seoul, Gyeonggi, and Incheon provinces), and non-core areas are districts in the rest of the provinces.

4.2 Instrumental Variables (IV) Approach

Non-random Assignment of HSR Stations Studying the causal effects of transportation infrastructure requires careful inspection due to selection issues; the decision on transportation facility installment is a place-based policy. The central inference problem here is that transportation is not randomly assigned but determined by observed or unobserved location characteristics and the outlook on expected benefits (Redding and Turner, 2014).

Although the government announced the location of KTX stations fourteen years before the actual opening (Baek and Park, 2015), endogeneity concerns remain. For example, districts that expect to gain the most are likely to have lobbied strongly. The location of the stations, therefore, can be non-random. Besides, other unobserved factors might have affected the timing and sequence of station openings. Therefore, we employ an Instrumental Variables (IV) estimation strategy for our robustness check methods.

Old Railroad Stations in Japanese Colonial Era as IVs Existing literature addresses the endogeneity issue in transportation infrastructure by employing railroad planning map (Baum-Snow, 2007; Duranton, Morrow, and Turner, 2014), historical railroads (Garcia-López, Holl, and Viladecans-Marsal, 2015; Morten and Oliveira, 2016; Tsivanidis, 2018), or topological traits (Faber, 2014) as IVs. The planning or topological features do not directly affect employment or population except through the actual railroad constructions. In this study, the historical railroad stations, constructed during Japanese colonial era, were used as the IVs for the HSR stations.

In 1894, Japan commenced railroad construction in the Korean territory as part of their "modernization process." The first railroad network in Korea, Gyeongin-line, was opened in 1899. Since then, the the railroad expanded over the years. From 1904–1906, the Gyeongbu-line and the Gyeongui-line were added to transport military logistics to China and Russia. In 1910, the Honam-lines were added to carry natural resources and agricultural products from South Korea to Japan.

The existing station and corridor sites might offer a more cost-effective foundation for new high-speed rail (HSR) construction, which satisfies the relevance condition of IV($Pr(D =$

$1|Z = 0) \neq Pr(D = 1|Z = 1))$. Empirically, our first-stage F-statistics is above 130. The high F-statistics, probes that the relevance condition of the IV is satisfied (Stock and Yogo, 2002). In addition, the visual mapping of the overlapping treatment regions is in Figure A6.

At the same time, the old railroads eroded and damaged passing decades of time and the Korean War are less likely to have direct impacts on contemporary employment and population, especially the gender gap (exclusion restriction, $E(\epsilon|Z = 1) = E(\epsilon|Z = 0)$). When in operation, the old railways mainly carried military logistics and resources. Many station locations were near resource extraction sites or military factories than agglomerated town centers for centuries. Empirically, the district fixed effects (f_i) in our regression design control for the initial level difference in population, employment, and gender gaps across districts. Further robustness check results, employing statistical methods devised in previous literature, will be added in later updates.

IV estimation Since our instrumental variables (Z_j) are time-invariant, we calculated a long-difference between the initial year (2000) and the final year (2015). Based on this calculation, we conducted the following empirical estimation.

$$\Delta log(y_i) = \beta \Delta Treat_i + \delta \Delta X_i + \Delta \eta_s + \Delta \epsilon_j \tag{2}$$

Here, $Treat_i$ of whether a districted is within 30 minutes driving distance from the KTX stations is instrumented by $Z_i = 1$ indicating if a railroad station was built in district i or not during the Japanese colonial era. Consequently, $treat_i * post_t * D_j^k$ is instrumented by $Z_i * D_i^k$, for $k \in \{core, non - core\}$.

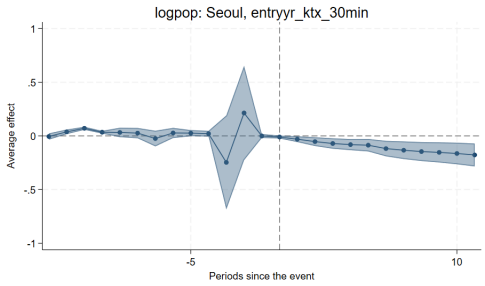
5 Results

5.1 KTX and the Changes in Local Employment and Population

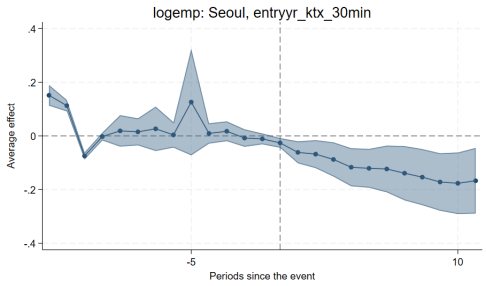
DID Estimates Figure 4 and Table 1 illustrate the impact of HSR on the relative population and employment changes for treated districts. Note that there barely is a pre-trend in the results of Figure 4. The spatial redistribution of population and labor activity diverges

Figure 4: Impact of HSR on Local Population and Employment, DID Estimates

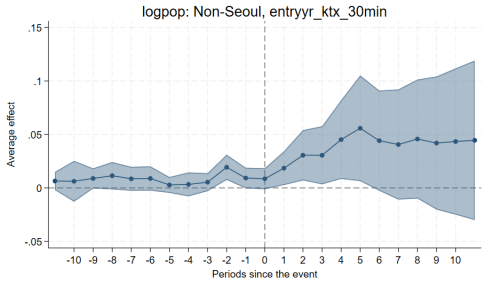
(a) Seoul (log Population)



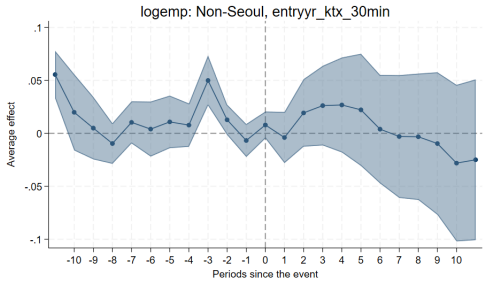
(b) Seoul (log Employment)



(c) Non-Seoul (log Population)



(d) Non-Seoul (log Employment)



Notes: The graphs are event study plots for Average Treatment effect for Treated (ATT), using (Callaway and Sant'Anna, 2021) estimator with 'never-treated' and 'not-yet-treated' districts as control groups. The dependent variable for Panel (a) and (c) is log population and for Panel (b) and (d) is log employment. Panel (a) and (b) depict the estimates from the Seoul metropolitan area sample, which includes Incheon, Seoul, and Gyeonggi provinces. Panel (c) and (d) illustrate the estimates from the non-Seoul area, including all districts other than the Seoul metropolitan and a few districts in island. Standard errors are clustered at the district level.

Table 1: Impact of HSR on Local Population and Employment (Difference-in-Difference Estimator)

	(1)	(2)	(3)	(4)	(5)	(6)
	Log(Population)			Log(Employment)		
	Overall	Seoul	Non-Seoul	Overall	Seoul	Non-Seoul
Treat (ktx< 30min)	0.024*	-0.101***	0.037*	-0.02	-0.117***	0.002
	(0.013)	(0.032)	(0.020)	(0.022)	(0.039)	(0.023)
District FE	✓	✓	✓	✓	✓	✓
Year FE	✓	✓	✓	✓	✓	✓
Observations	3,712	3,712	3,712	3,712	3,712	3,712

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. The dependent variable for columns (1)-(3) is log population and for columns (4)-(6) is log employment. 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.

for treated and control districts due to the installment of the stations. Seoul experienced a consistent decline in population and employment. The population in non-Seoul constantly increased, but employment first increased and then declined.

Table 1 synthesizes the event study estimates into one-shot pre and post-ATT results. The results indicate that proximity to high-speed rail (HSR) stations induces a 3.7% increase in population among districts in non-core areas. However, the impact on employment in these districts, while positive, is not statistically significant. This could be due to the direction of the change shifting from positive to negative over time. In the Seoul Metropolitan area, proximity to HSR stations induces a substantial decrease in population and employment, at 10.1% and 11.7% respectively. These findings suggest that HSR does play a role in redistributing economic activities, moving populations from core to non-core areas.

IV Estimates Table 2 summarizes the IV estimates, employing old railroad stations as IVs. Overall, the signs of estimates are robust with two to three times greater coefficient magnitudes and greater statistical significance. The Seoul area experienced a decline in population and employment. Conversely, the non-Seoul area benefits from the opening of

Table 2: Impact of HSR on Local Population and Employment (Instrumental Variable Approach)

	(1)	(2)	(3)	(4)
	Log Population		Log Employment	
	Seoul	Non-Seoul	Seoul	Non-Seoul
Treat (KTX< 30min)	-0.261**	0.132***	-0.114	0.093*
	(0.116)	(0.048)	(0.109)	(0.055)
1st stage F-stat	163.91	164.96	163.91	164.96
Observations	73	159	73	159

Notes: *** p<0.01, ** p<0.05, * p<0.1. The coefficients are the Instrumental Variable estimates from Section 4.2. The dependent variable for columns (1) and (2) is log population and for columns (3) and (4) is log employment. 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.

HSR stations with the increases in population and job opportunities.[12]

5.2 KTX and the Gender Gap in Employment and Population

DID Estimates Figure 5 and Table 3 reveal the impact of HSR on the female-to-male population and employment ratios in Seoul and non-Seoul areas. The staggered DID results in Figure 5 show the absence of a pre-trend suggesting that the observed changes are attributed to the HSR station installments. In the Seoul area, relative female representation in the population constantly increased in the treated districts. The female representation in employment slightly decreased and then slightly increased. Notably, the relative female representation in both population and employment increased in the non-Seoul, treated districts where the KTX stations were newly installed.

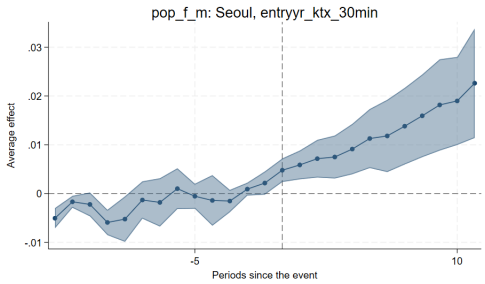
Table 3 presents the one-shot ATT estimates on the gender gap. Columns (1)–(3) show that proximity to an HSR station is associated with a 3% increase (i.e. 1.2 percentage points) in the female-to-male population ratio in the Seoul areas and a 1.1% (i.e. 0.005 percentage points) increase in non-Seoul areas. The impact on the female-to-male employment ratio is more pronounced in non-Seoul areas with an 8% increase (Column (6)). The impact on the

[12]Land prices in non-core areas increased by 5.8% whereas the prices in core areas remained unchanged.

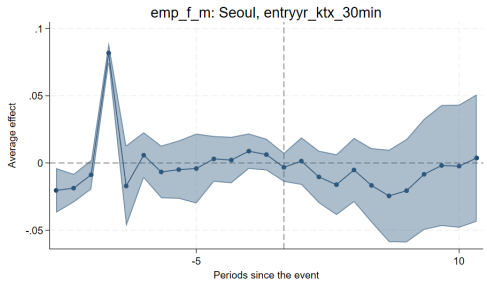
female-to-male employment ratio in the Seoul area is close to zero and not statistically or economically significant (Column (5)).

Figure 5: Impact of HSR on Population and Employment Gender Ratio, DID Estimates

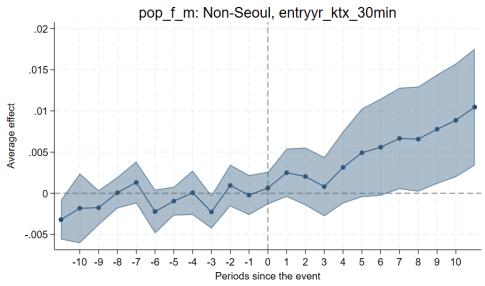
(a) Seoul (Female-to-Male Pop Ratio)



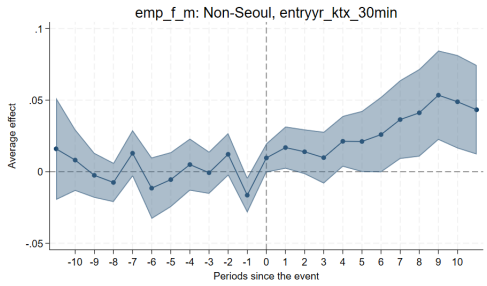
(b) Seoul (Female-to-Male Emp Ratio))



(c) Non-Seoul (Female-to-Male Pop Ratio)



(d) Non-Seoul (Female-to-Male Emp Ratio)



Notes: The graphs are event study plots for Average Treatment effect for Treated (ATT), using (Callaway and Sant'Anna, 2021) estimator with 'never-treated' and 'not-yet-treated' districts as control groups. The dependent variable for Panel (a) and (c) is the female-to-male population ratio, and for Panel (b) and (d) is the female-to-male employment ratio. Panel (a) and (b) depict the estimates from the Seoul metropolitan area sample, which includes Incheon, Seoul, and Gyeonggi provinces. Panel (c) and (d) illustrate The estimates from the non-Seoul area, including all districts other than the Seoul metropolitan and a few island districts. Standard errors are clustered at the district level.

IV Estimates Table 4 presents the IV estimates on population and employment gender gaps. The results are robust to the DID estimates with greater magnitudes, perhaps due to the long-differences.

Table 3: Impact of HSR on Population and Employment Gender Ratio, DID Estimates

	(1)	(2)	(3)	(4)	(5)	(6)
	Female-to-Male Pop Ratio			Female-to-Male Emp Ratio		
	Overall	Seoul	Non-Seoul	Overall	Seoul	Non-Seoul
Treat (KTX< 30min)	0.001***	0.012***	0.005**	0.024***	0.001	0.034**
	(0.000)	(0.003)	(0.002)	(0.001)	(0.015)	(0.01)
District FE	✓	✓	✓	✓	✓	✓
Year FE	✓	✓	✓	✓	✓	✓
Pre-treatment (2003) Mean	0.996	0.986	1	0.704	0.699	0.706
Observations	3,712	3,712	3,712	3,712	3,712	3,712

Notes: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. 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. The dependent variable for columns (1)-(3) is the female-to-male population ratio and for columns (4)-(6) is the female-to-male employment ratio. 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.

Table 4: Impact of HSR on Population and Employment Gender Ratio, IV Estimates

	(1)	(2)	(3)	(4)
	Female-to-male Pop Ratio		Female-to-male Emp Ratio	
	Seoul	Non-Seoul	Seoul	Non-Seoul
Treat (KTX< 30min)	0.027***	0.019***	0.020	0.047**
	(0.009)	(0.006)	(0.030)	(0.020)
Pre-treatment (2003) Mean	0.986	1	0.699	0.706
1st stage F-stat	163.91	164.96	163.91	164.96
Observations	73	159	73	159

Notes: *** p<0.01, ** p<0.05, * p<0.1. The coefficients are the IV estimates from Section 4.2. The dependent variable for columns (1) and (2) is the female-to-male population ratio and for columns (3) and (4) is the female-to-male employment ratio. 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.

6 Mechanism

To summarize our main findings, the HSR expansion in South Korea led to a reduction in both population and employment in the affected districts within the Seoul areas while increasing the population in districts outside Seoul. Additionally, the treated districts in the Seoul area saw improvements in the population gender gap, and the non-Seoul areas experienced a better female representation in both population and employment. Among findings, the gender employment gap improvement is notable as the HSR is non-commute purpose transit. What factors contribute to these unintended improvements in the gender gap?

6.1 Labor Demand Channel

From the labor demand perspective, new train stations could have induced local agglomeration and regional development where female-intensive sectors such as local services can prosper. Whereas, male-intensive sectors such as manufacturing could have been pushed away due to increasing land prices. In this section, we empirically examined if the HSR stations affect employment differently for male and female-intensive sectors.[13]

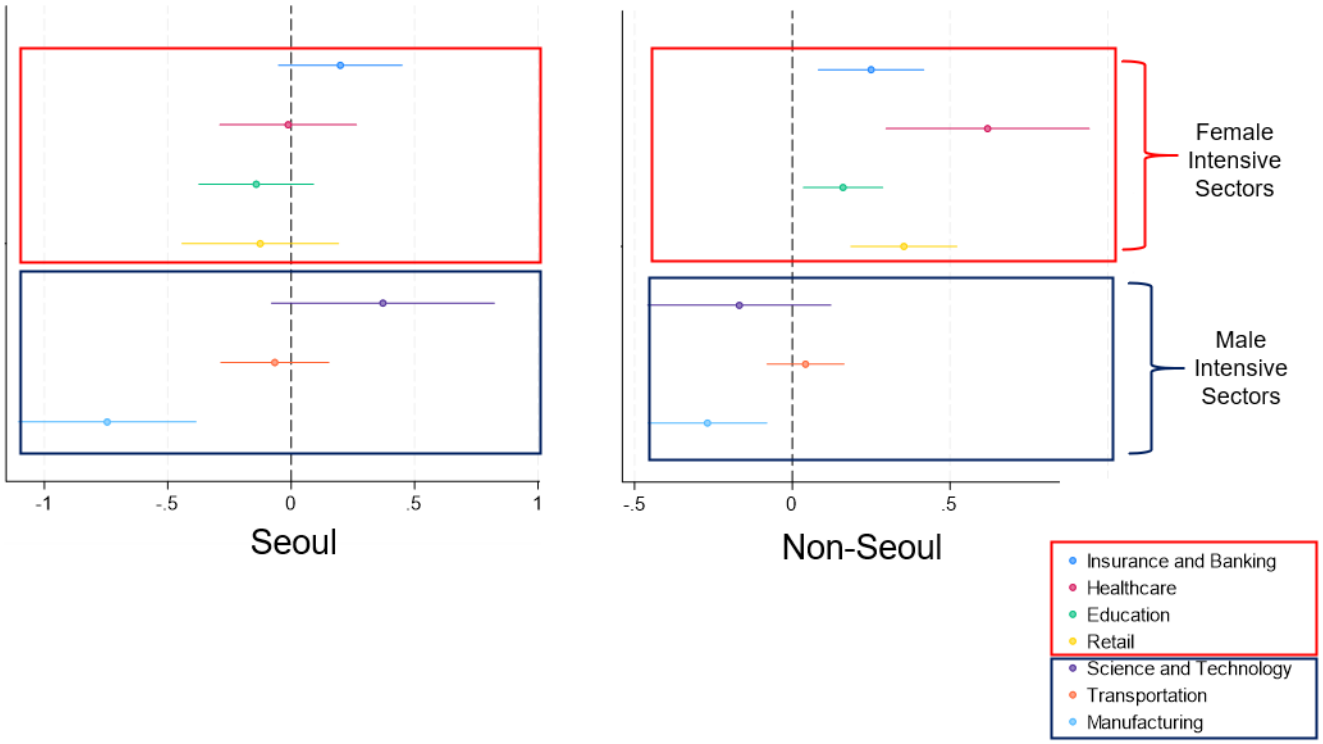
Figure 6 shows the IV estimation results. Interestingly, male-intensive sectors, in general, showed employment declines in both Seoul and non-Seoul areas. Meanwhile, female-intensive sectors showed an employment decline in Seoul but a steep increase in non-Seoul areas. The impacts of the non-commute transport on the gender gap improvements The HSR stations favored female-intensive sectors in non-core regions while disfavoring male-intensive sectors overall.

6.2 Labor Supply Channel

From the labor supply perspective, new amenities around the train stations could have eased childcare and domestic labor burdens of females allowing them to participate in labor

[13]The most male-intensive sector is transportation, with a ten-to-one male-to-female gender ratio, whereas the most female-intensive sectors are the lodging and restaurant industries with a male-to-female ratio of 0.5.

Figure 6: The Employment Effects of HSR by Sector, IV Estimates



Notes: aa

Table 5: The Impact of HSR on Endogeneous Amenities, IV Estimates

	(1)	(2)	(3)	(4)	(5)	(6)
	Retail Est. per Pop		Educ. Est. per Pop		Healthcare Est. per Pop	
	Seoul	Non-Seoul	Seoul	Non-Seoul	Seoul	Non-Seoul
Treat	0.188***	0.071**	0.241***	0.169***	0.338***	0.117**
	(0.049)	(0.029)	(0.084)	(0.056)	(0.098)	(0.046)
1st stage F-stat	163.91	164.96	163.91	164.96	163.91	164.96
Observations	73	159	73	159	73	159

Notes: *** p<0.01, ** p<0.05, * p<0.1. The coefficients are the second stage regression results of IV estimation. The dependent variable for columns (1) and (2) is the log of the number of retail establishments per capita (population), for columns (3) and (4) is the log of the number of education service establishments per capita, and for columns (5) and (6) is the log of the number of healthcare service establishments per capita. 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.

activities outside their home fences. To empirically test the argument, we estimated the impacts of HSR on the local amenity level. Following the definition from Diamond (2016), local amenity level is quantified as the number of establishments per resident in certain service industries (Diamond, 2016).

Table 5 shows the estimation results. After the installments of HSR stations, the number of establishments in retail, medical services, and education services per resident increased in both core and non-core areas. The results indirectly suggest that the childcare and domestic burdens for women decreased with the HSR development, lowering the labor force participation costs for women.

7 Conclusion

This study investigates the impact of High-Speed Rail (HSR) on the redistribution of economic activities and gender disparities in population and labor market outcomes. Employing a staggered Difference-in-Differences (DID) approach as the primary analytical method and using the construction of old railroads during the Japanese colonial era as Instrumental Variables (IV) for robustness checks, we demonstrate that HSR construction in South Korea prompted shifts in population and employment from Seoul (core) to the rest of the country (non-core) areas. Women, in particular, benefit disproportionately from HSR expansion with the increasing labor demand from the local service sector, a field where women are predominantly employed. Furthermore, the rise in endogenous local amenities due to HSR potentially eased female childcare and domestic burdens, promoting the labor supply.

Through our research, we contribute to the existing literature on transportation infrastructure and gender disparities in labor market outcomes, an area that has been relatively under-explored. Our findings advance the discussion by examining how advanced transportation technologies affect both the demand and supply sides of the gender-segmented labor market. This study underscores the importance of understanding the varied impacts of infrastructure investments across different demographic groups, especially in the context of significant spending on transportation infrastructure.

Despite the contributions to literature, this study has several limitations and areas for future work. Immediate tasks include securing consistent wage data to make inferences on the changes in labor returns, and expanding the scope of causal estimations to include population migration and land prices. More broadly, the study does not fully explore the overall welfare impacts on men and women, nor does it directly test how HSR affects women's economic opportunities. Consequently, the conclusions about reductions in women's labor force participation costs remain somewhat speculative. Future research could delve deeper into these issues, providing more definitive evidence and broader implications from a more comprehensive general equilibrium perspective.

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A Appendix: Data Appendix

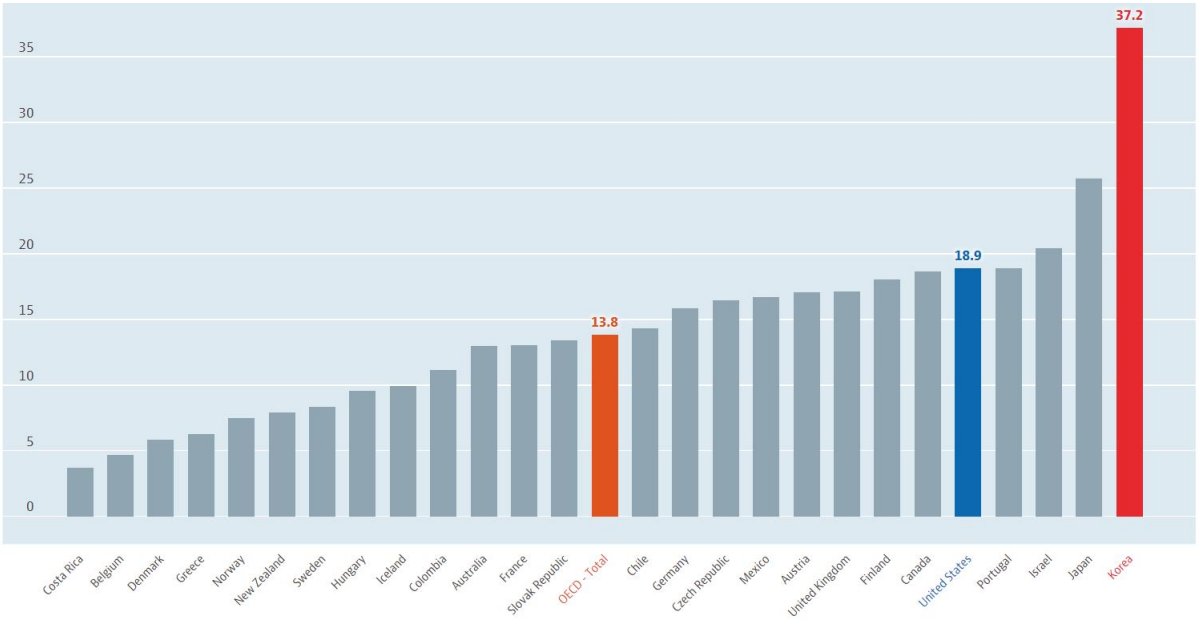
Internal Migration Statistics (IMS) IMS is an administrative dataset of residential migration for establishing population policies. The data records households moving from zip code to zip code. This enables tracking all the zipcode migrants in South Korea. The information is collected at the household level with demographic information (gender and age) of all household members moving together. With the IMS, we track district-to-district migrations flow each year.

Aggregating 88,248,353 year-household observations into annual OD county pair data, we construct 849,600 OD-year migration flow data. We focus on the number of migrants, the number of female and male migrants, and the number of migrants across different age groups to observe heterogeneous migration patterns across different demographics. The migration analysis results are in progress and will be added in later updates.

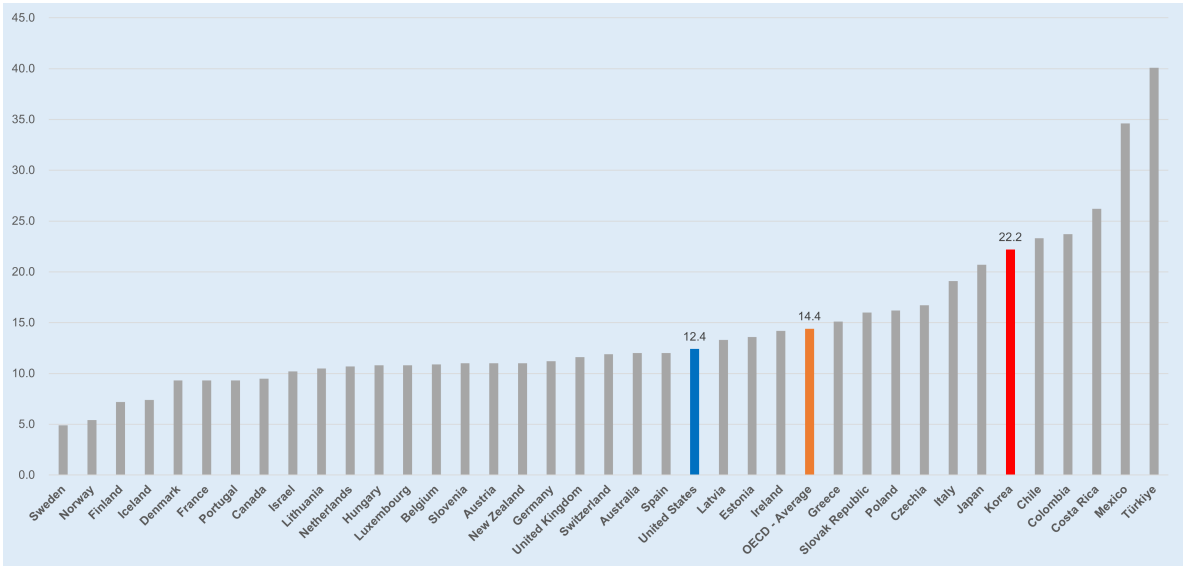
B Appendix: Auxiliary Figures and Tables

Figure A1: Cross-Country Gender Gap in the Labor Market

(a) Gender Wage Gap (Percentage Points)



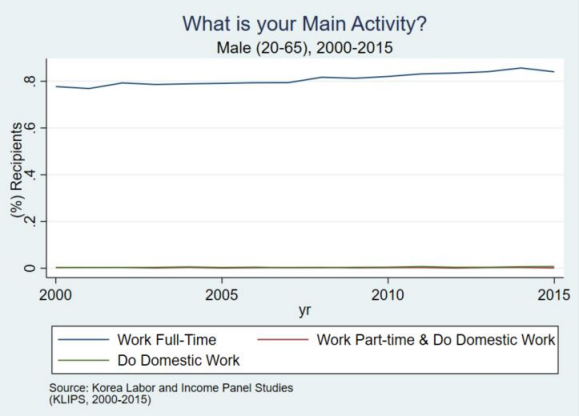
(b) Labor Force Participation Gap (Percentage Points)



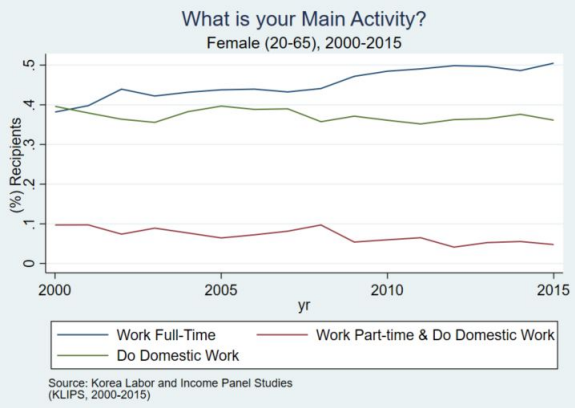
Notes: The gender wage gap in panel (a) is the difference between the median earnings of females and males. Here, the workers only include full-time employees and self-employed individuals. The labor force participation gap in panel (b) is the difference in the labor participation rate of males and females in paid work, including full-time workers. Source: OECD (2020).

Figure A2: Gender Differences in Time Use across Years

(a) Men



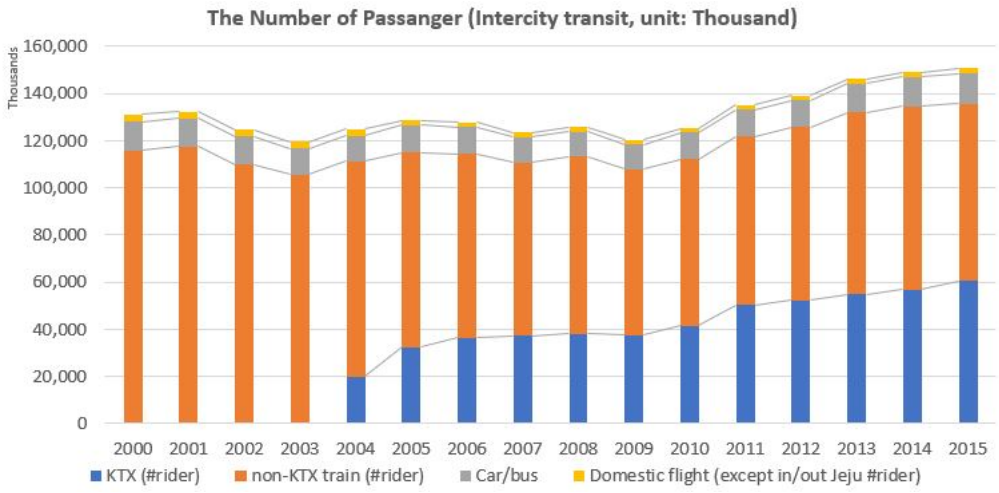
(b) Women



Notes: The graphs show the annual share of survey answers to the question, 'What is your main activity last month?' from the Korea Labor and Income Panel Studies (KLIPS), for men (Panel (a)) and women (Panel (b)). The answer options are: worked full time (blue bar), worked part time (red bar), and did domestic work (green bar). 'Other' is omitted from the graph.

Figure A3: Annual Ridership across Different Transportation Modes

(a) Passenger Volume

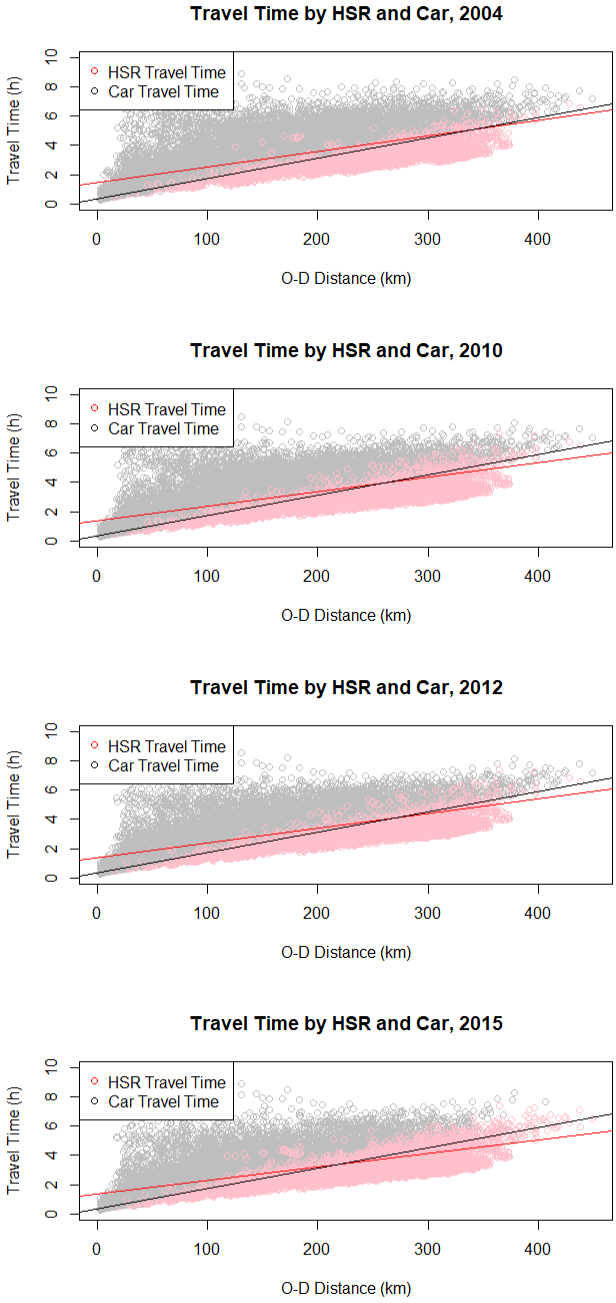


(b) Total Passenger Travel Distance (KM)



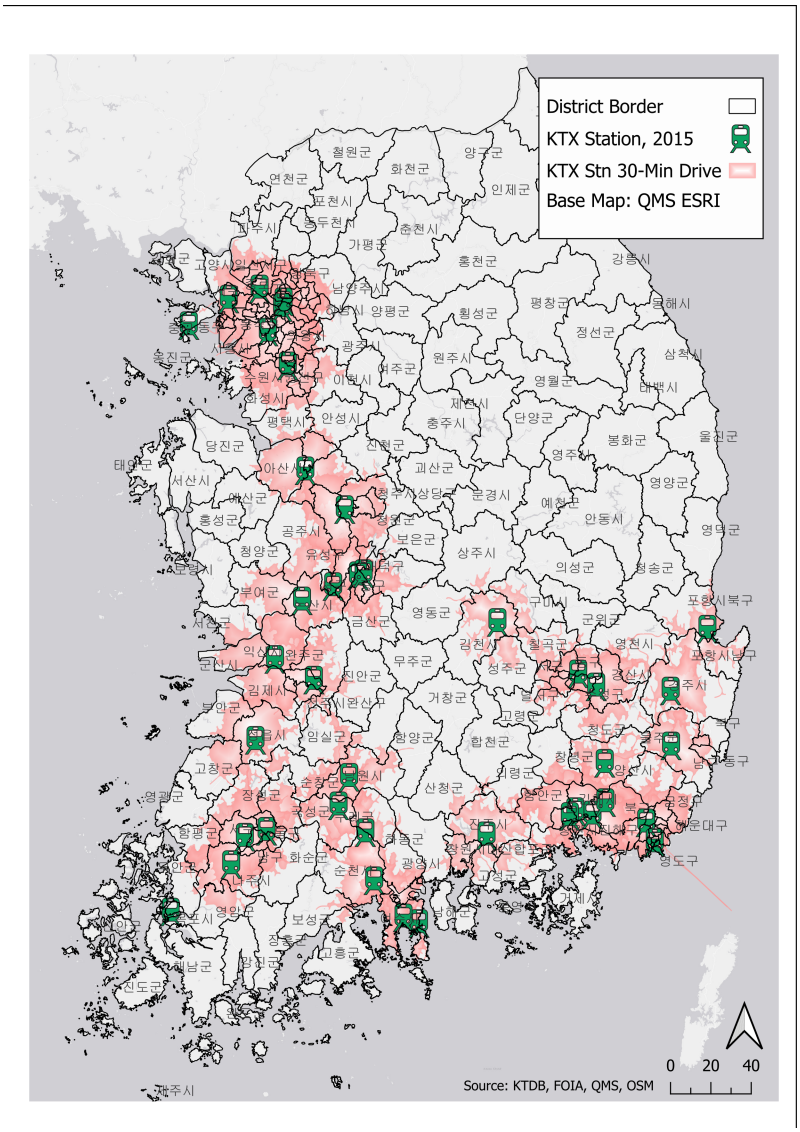
Notes: Source: Korea Transportation DataBase (KTDB).

Figure A4: District to District Travel Time by KTX and Car



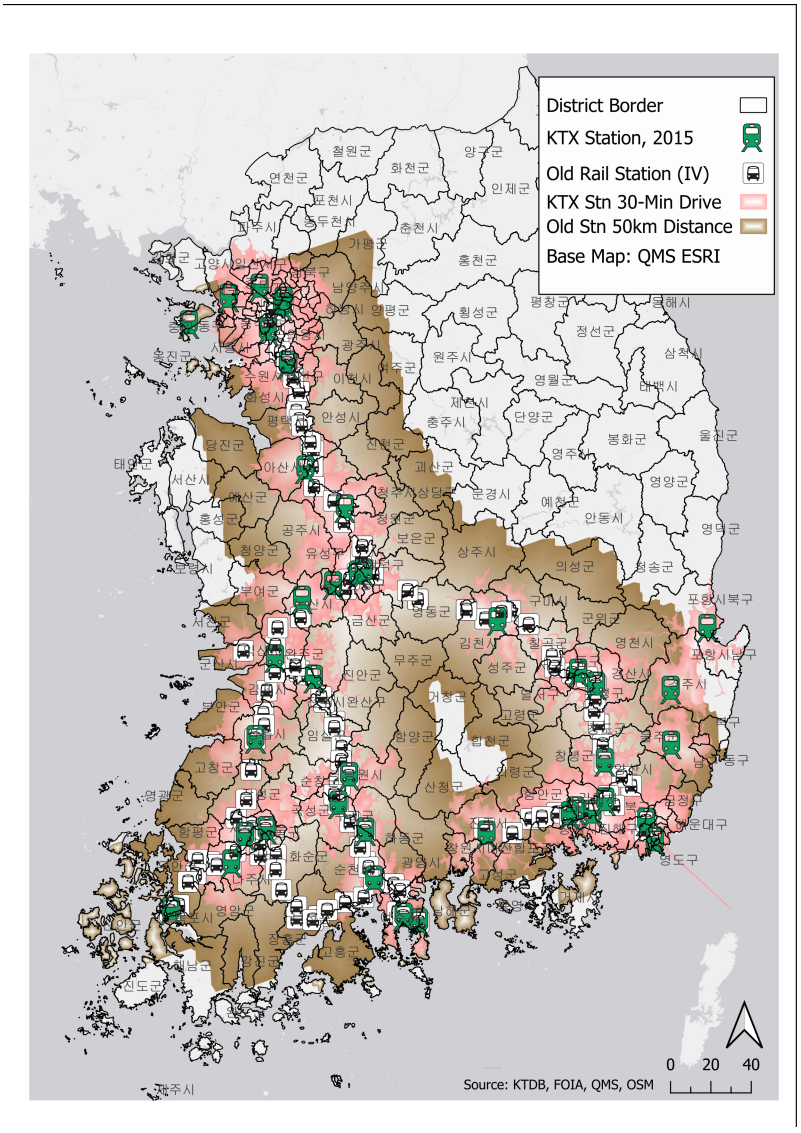
Notes: The red line represents travel time by KTX whereas the black line represents travel time by car. The X-axis denotes the geographic distance between OD districts. Grey dots indicate OD pairs where driving time is faster than HSR travel time, while pink dots indicate OD pairs where HSR travel time is faster. There is an increasing trend in OD pairs where HSR travel time dominates, especially over shorter distances. Source: KTDB.

Figure A5: KTX and Treated Areas



Notes: A district is treated if its centroid is within 30 minutes from the closest KTX station by car.
Source: KTDB.

Figure A6: IV First Stage Visualization: Overlap of KTX Treated Districts with Old Railroad Bufferss



Notes: The map depicts the treated districts and together marking 50km buffer (brown shades) from old railroad stations. We excluded the old rail routes and stations which are significantly distant from the KTX rail routes, such as the ones in the northeastern regions.
Source: KTDB.

Table A1: History of the KTX Station Expansion

Date	Line	From/To	Project Type	Station
2004 (+21)	Gyeongbu	Seoul/Daegu*	New line	Seoul, Hangshin, Gwangmeng, Cheonan-Asan, Daejeon, Dong-Daegu
		Daegu/Busan**	New line	Gupo, Milyang, Busan
	Honam**	Daejeon/Mokpo	New line	Yongsan, Seo-Daejeon, Gyeryong, Nonsan, Iksan, Gimje, Jeongeup, Jangsung, Gwangju, Gwangju-songjeong, Naju, Mokpo
2007 (+2)	Gyeongbu	Daegu/Busan	Add-station	Gumi, Gimcheon
2010 (+9, -2)	Gyeongbu*	Seoul/Daegu	Add-station	Suwon, Osong
		Daegu/Busan	Add/Close-station	Shin-Gyeongju, Ulsan, Gumi-Gimcheon, (Gumi), (Gimcheon)
			Improve speed	Busan
	Gyeongjeon**	Milyang/Masan	New line	Jinyoung, Changwon-Joongang, Changwon, Masan
2011 (+7)	Jeonla**	Ilsan/Yeosu	New line	Jeonju, Namwon, Guryegu, Sooncheon, Yeocheon, Yeosu-expo, Goksung
2012 (+2)	Gyeongjeon**	Masan/Jingu	Add-station	Haman, Jinju
2013 (+1)	Gyeongbu	Daegu/Busan	Add-station	Gyeongsan
2014 (+2)	Int'l Airport*	Incheon Airport/Seoul	New line	Gumam, Incheon International Airport
2015 (+1, -3)	Donghae*	Busan/Pohang	New line	Pohang
	Multi lines	-	Add/Close-station	Gongju, (Gimje), (Jangsung), (Haman)

Notes: *High Speed Railroad is defined to be maximum speed greater than $305km/h$. **Electrified conventional railway directly connected with HSR ($V_{max} < 180km/h$). Source: KORAIL.

Table A2: Summary Statistics

Variable	(1) Mean	(2) Std Dev	(3) Min	(4) Median	(5) Max
log(Employment)	10.639	1.065	7.954	10.789	13.475
log(Establishment)	9.154	0.939	6.811	9.253	11.206
Sex ratio (Employment)	1.460	0.364	0.764	1.383	4.044
Sex ratio (Population)	1.006	0.041	0.898	1.005	1.308
log(Landprice)	87.267	9.316	46.527	90.003	105.563
log(Wage, female)	-0.399	0.254	-2.377	-0.382	0.538
log(Wage, male)	0.038	0.240	-1.664	0.038	1.184
log(Wage, male)- log(Wage, female)	0.437	0.240	-0.596	0.434	2.201
log(Employment): Transportation	7.613	1.286	4.477	7.767	10.815
log(Employment): Construction	7.720	1.095	5.182	7.637	11.136
log(Employment): Public Admin	7.578	0.719	5.011	7.540	10.325
log(Employment): Manufacturing	8.817	1.403	4.382	8.802	12.440
log(Employment): Retail Store	7.024	0.932	4.407	7.064	9.616
log(Employment): Education	8.067	1.078	5.357	8.137	11.140
log(Employment): Medical Service	7.217	1.240	4.060	7.286	10.386
log(Employment): Restaurant	8.545	0.967	6.174	8.684	11.107
Establishment per population: Retail	0.003	0.002	0.001	0.003	0.011
Establishment per population: Education	0.003	0.001	0.001	0.002	0.012
Establishment per population: Medical Service	0.001	0.001	0.000	0.001	0.005
Establishment per population: Restaurant	0.016	0.008	0.005	0.014	0.059
Education Workers Per Kids ($age < 14$)	9.417	2.482	14.295	87.968	16.707

Notes: The analysis unit is district by year. Source: Census on Establishments, Population and Housing Census, IMS, KLIPS.