

Exploring the Interaction between Transportation Infrastructure and Population Dynamics

: A Systematic Literature Review*

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Abstract

This study systematically reviews 28 peer-reviewed journal articles to examine the interaction between transportation infrastructure and population dynamics. The findings reveal that the effects of transportation infrastructure provision vary by type and regional context, falling into two dominant patterns: the Win-Win effect, where transportation infrastructure development stimulates population growth across all affected areas, and the Win-Lose effect, where it fosters population growth in some areas while causing declines in others. Both road and rail infrastructure exhibit these patterns. Roads generally promote population growth, especially in small and remote cities; local roads often show the Win-Win effect, whereas highways enhance accessibility but also induce suburbanization and population dispersion, reflecting the Win-Lose effect. Rail demonstrates the Win-Win effect in less developed regions but fosters suburbanization and gentrification in urbanized areas. High-speed rail often amplifies the siphon effect, facilitating population outflows to major cities with an inverted U-shaped distance effect, representing Win-Lose dynamics. By contrast, airports and seaports consistently exhibit the Win-Win effect, serving as regional growth poles that enhance connectivity and support long-term development. Some studies also identify a bidirectional causal relationship, where population growth drives transportation infrastructure expansion, although mismatches between infrastructure supply and demographic demand are also noted. These findings underscore the need for regionally tailored long-term transportation infrastructure strategies that integrate demographic and economic indicators to more precisely evaluate their impacts.

Keywords Transportation Infrastructure, Population Change, Systematic Literature review, Urban Spatial Structure, Regional Disparity

I. Introduction

Transportation infrastructure has traditionally been regarded as a fundamental driver of national and regional economic growth, serving as a strategic policy instrument to enhance interregional connectivity and promote spatial development (Aschauer, 1990; Munnell, 1992; Rietveld and

Bruinsma, 1998; Banister and Berechman, 2000). Investments in transportation infrastructure, including highways and railways, have long been closely associated with improved accessibility, expanded economic opportunities, and increased residential attractiveness (Rietveld and Bruinsma, 1998; Banister and Berechman, 2000; Vickerman, 2015). These improvements are, in turn, expected to ultimately

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stimulate population inflows and promote urban expansion (García-López, 2012; Baum-Snow, 2007).

However, recent global demographic and spatial trends, such as population decline and widening regional disparities, raise fundamental questions about the continued validity of these assumptions. Empirical evidence increasingly reveals that the impacts of transportation infrastructure are neither uniform nor universally positive, but instead vary considerably depending on regional socioeconomic conditions and spatial characteristics (Boarnet, 1998; Chandra and Thompson, 2000; Banister and Berechman, 2001; Baum-Snow, 2007; Vickerman, 2015; Baum-Snow et al., 2017). In other words, while transportation infrastructure may enhance economic activities and residential conditions in certain regions, thereby inducing population growth, it can simultaneously cause population outflows and regional decline in neighboring areas, potentially leading to increased uneven development and regional disparities.

This dual nature of transportation infrastructure investments, serving as a catalyst for growth in some regions while accelerating decline in others, has emerged as a central concern in the field of urban and regional planning. Such uneven outcomes can be effectively explained by Myrdal's (1957) concept of the backwash effect and Hirschman's (1958) theory of polarization, and have more recently been referred to as the straw effect (Ono and Asano, 2005; Jo and Woo, 2014; Kim and Han, 2016). In Japan, for instance, the expansion of the Shinkansen network has contributed to mitigating population decline in certain cities, yet it has also been criticized for intensifying marginalization and disparities in areas excluded from its benefits (Reggiani and Ortiz-Moya, 2022). In China, the development of the high-speed rail network has been found to further aggravate population loss in shrinking cities, thereby exacerbating spatial imbalances between growing and shrinking cities (Deng et al., 2019). Similarly, in South Korea, although the initial introduction of the Korea Train eXpress (KTX) was expected to yield benefits through improved accessibility, empirical studies have shown that it contributed to stagnation in small and medium-sized cities and to population outflows from non-beneficiary areas, thereby widening of interregional disparities over time (Jung and Lee, 2011; Jo and Woo, 2014).

These cases demonstrate that transportation infrastructure does not function solely as a driver of regional growth

but can also serve as a structural factor contributing to regional decline under certain conditions. Accordingly, this study aims not merely to challenge the conventional assumption that transportation infrastructure investment inevitably leads to population inflows and regional growth, but to systematically examine the conditions under which its effects may be either positive or negative. In particular, this study seeks to explore the mechanisms and contexts behind the 'Win-Win effect,' in which transportation infrastructure induces population growth across all affected areas, and the 'Win-Lose effect,' in which transportation infrastructure development fosters population growth in some areas while causing population decline in others.

For this study, a systematic literature review was conducted, focusing on empirical studies retrieved from major international academic databases that examine the interaction between transportation infrastructure and population dynamics. The reviewed studies are classified into two main types. Type 1 includes research that analyzes the effects of transportation infrastructure on population change, which can be further subdivided into studies identifying Win-Win and Win-Lose effects. Type 2 consists of studies that examine how population change influences the provision and expansion of transportation infrastructure. This classification aims to clarify the conditions and directions of the relationship between transportation infrastructure and population change, and to derive relevant policy implications.

The structure of this paper is as follows. Chapter II outlines the research methods and analytical procedures of the systematic literature review. Chapter III provides a descriptive overview of the reviewed journal articles, including their temporal and regional distribution and methodological characteristics. Chapter IV synthesizes the main findings by causal type and systematically analyzes the interaction between transportation infrastructure and population dynamics. Finally, Chapter V summarizes the key results and discusses policy implications derived from the analysis.

II. Research Methodology

This study adopts a systematic literature review approach, which aims to comprehensively collect and analyze existing studies on a specific topic to derive synthesized conclusions. Unlike a narrative review, which relies on the subjective

judgment of researchers, this method follows a rigorous and transparent selection process to ensure the objectivity and reproducibility of research findings (Petticrew and Roberts, 2008; McAlister et al., 1999). Given these methodological advantages, this approach has gained increasing prominence in recent urban studies (Kim and Yang, 2023; Seomun and Song, 2023; Oh and Jung, 2024). To enhance methodological rigor, this review followed the PRISMA 2020 (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines, an updated evidence-based framework that improves reporting quality through a 27-item checklist and a four-phase flow diagram covering identification, screening, eligibility, and inclusion (Page et al., 2021). The entire review process was documented using the PRISMA flow diagram to ensure transparency and replicability.

A comprehensive literature search was conducted in two major academic databases, Web of Science and Scopus, using the keywords “transportation infrastructure” and “population change” with the AND operator to identify studies containing both terms. To ensure topic relevance and search precision, the final search string was refined through an iterative pre-testing process. This search resulted in a total of 1,817 records, including 771 from Web of Science and 1,046 from Scopus.

The selection process followed the PRISMA 2020 guidelines (see <Figure 1>). In the identification phase, 812 records were excluded due to duplication, language restrictions, or classification as non-academic sources such as conference

proceedings and other forms of grey literature. Only English-language and peer-reviewed journal articles were retained, leaving 1,005 records for screening. In the screening phase, titles were reviewed first, leading to the exclusion of 906 records unrelated to transportation, population, or urban and regional planning, including those in fields such as environmental science, public health, energy systems, or disaster management. The remaining records were then reviewed by abstract, and 53 were excluded for not addressing both transportation infrastructure and population change. In the eligibility phase, full-texts of 46 articles were assessed. Of these, 3 could not be retrieved. Among the 43 accessible articles, 4 were excluded for employing virtual, theoretical, or predictive modeling approaches, and 11 were excluded for lacking empirical analysis evaluating effectiveness. As a result, only studies employing empirical research designs were retained for the final synthesis, yielding a total of 28 journal articles. This systematic and transparent selection process ensures that the reviewed literature provides robust empirical evidence on the relationship between transportation infrastructure and population dynamics.

III. Descriptive Analysis Results

<Figure 2> illustrates the temporal and regional distribution of the 28 journal articles. The number of publications steadily increased over time, with one article (3.6%) published in the early 1990s, two (7.1%) in the mid-2000s, six (21.4%) in the early 2010s, eight (28.6%) in the late 2010s, and eleven (39.3%) in the early 2020s. Earlier studies predominantly focused on North America and Europe, but from the 2010s onward, the geographic scope expanded to include Asia. By the early 2020s, Asia, particularly China, emerged as

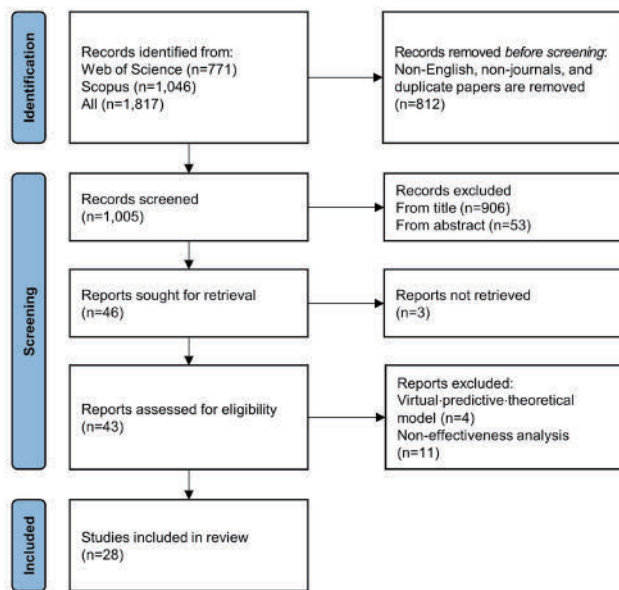


Figure 1. PRISMA flow diagram of the systematic literature review

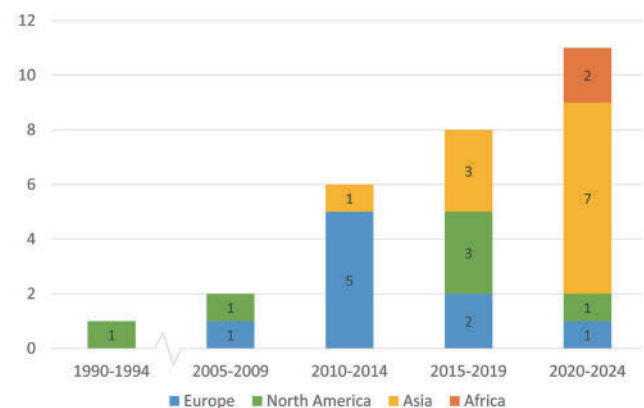


Figure 2. Temporal and regional distribution of journal articles

the primary focus of scholarly attention. During this period, studies on Africa also began to appear, indicating a growing

academic interest in non-Western contexts.

(Table 1) presents a descriptive overview of the reviewed

Table 1. Descriptive overview of the reviewed journal articles

Spatial scope	Continent	Country	Author (Year)	Region	Time	Methodology	Keywords	Citations (Web of science)	
North America	U.S.		Voss & Chi (2006)	Wisconsin	1960s-1990s	OLS, SEM, SLM, Logistic OLS	Public infrastructure; Nonmetropolitan communities; Productivity, Growth	29	
			Iacono & Levinson (2016)	Minnesota	1988-2007	PCSE, Granger causality	Highways; Economic development; Employment; Panel data; Minnesota; Population	2	
Europe	England		Levinson (2008)	London	1871-2001	Spatial OLS	Transport; Land use; London underground; London railways; Network growth; Induced demand; Induced supply; Panel data; Cross-section time series	112	
	Spain		García-López (2010)	Barcelona Metropolitan Region	1991-2005	LWR	Population suburbanization; Urban spatial structure; Subcenters; Polycentrism; Dispersed model; Accessibility city	67	
			García-López (2012)	Barcelona Metropolitan Region	1991-2006	OLS, IV, 2SLS	Urban spatial structure; Suburbanization; Transportation infrastructure	105	
	Finland		Makkonen et al. (2013)	Pargas	2009	GIS, Correlation	Accessibility; Archipelago; Finland; Ferry; Rural population; Transportation	22	
	Iceland		Bjarnason (2021)	Tröllaskagi Peninsula	1991-2020	Comparison	Tunnels; demography; coastal communities; Iceland	7	
Single-region	Saudi Arabia		Aljoufie et al. (2013)	Jeddah City	1964-2007	GIS, Comparison	Urban growth; Transportation; Spatial-temporal analysis; Indicators; Remote Sensing; GIS	114	
			Aljoufie (2021)	Jeddah City	2007-2014	Correlation, Paired t-test, Comparison	Population density; Temporal impact indicators; Transportation; Statistical analysis; Urban sustainability; Jeddah	15	
	Iran		Forouhar (2022)	Tehran	2006-2016	DID	Rail transportation; Neighborhood change; Transit-oriented development; Tehran	15	
	Asia	Indonesia		Yudhistira et al. (2019)	Jakarta Metropolitan Area	2000-2010	OLS, IV, 2SLS	The Jakarta metropolitan area; Transportation infrastructure; Suburbanization; Population density; Night light	18
		Taiwan		Lin & Chung (2017)	Taipei	1996-2013	OLS, GLS	Metro; Gentrification; Panel data analysis	38
				Loo et al. (2017)	Hong Kong	1993-2013	Natural experiment, Comparison	Greenfield sites; Infill sites; rail-based transit-oriented development; Socio-economic change; Land use; Travel behavior	43
		China		He et al. (2024)	Guangdong	2010-2020	Decoupling model, Exploratory spatial data analysis (ESDA)	Transportation land; Population; Decoupling relationship; Spatial heterogeneity; Guangdong Province	3

(Continue on next page)

Spatial scope	Continent	Country	Author (Year)	Region	Time	Methodology	Keywords	Citations (Web of science)	
Single-region	Africa	Nigeria	Faiyetole & Adewumi (2024)	Akure	1999-2018	ANOVA, OLS	Land use land cover; Urban growth; Built-up area; Stock of roads; Road network; Road density	0	
			Goetz (1992)	50 metropolitan areas	1950-1987	Correlation, OLS	-	80	
Multi-region	North America	U.S.	Wood et al. (2016)	50 metropolitan areas	2000-2010	GIS, Comparison	Transport policy; Travel; Impacts	42	
			Kasu & Chi (2018)	3,109 counties	1970-2010	OLS, SEM, SLM	Transportation infrastructures; Railroads; Highways; Airports; Population change; Employment change; Spatial regression	7	
		Sheard (2021)	179 Core-Based Statistical Areas	1991-2018	OLS, 2SLS	Airport; Network; Transportation infrastructure; Urban growth	6		
		Portugal	Ribeiro et al. (2010)	86 municipalities	1991-2001	SAR	Road infrastructure; Daily accessibility; Population; Purchasing power; Education levels; Spatially autoregressive models	41	
		Germany	Breidenbach & Mitze (2016)	413 districts	1991-2008	OLS, IV	Efficiency; Amenities; Location; Growth	6	
	Europe	Spain	Coronado et al. (2019)	34 cities	1992-2017	Comparison	High-speed rail; Long-term effects; Urban systems; Small cities; Impacts; Growth; Integration	17	
		Netherlands	Meijers et al. (2012)	102 towns and villages	2003-2008	OLS	Distributive effects; Cohesion; Transport infrastructure; Accessibility; Centre-periphery	58	
		Asia	China	Li et al. (2020)	40 cities	2001-2017	Synthetic control method (SCM)	High-speed rail; Synthetic control methods; Economic effect disparity	34
				Han et al. (2023)	1,838 county-level cities	2003-2018	DID	Transportation infrastructure; High-speed railway; County; Population agglomeration	17
				Li & Chen (2023)	277 prefecture-level cities	2006-2018	DID, 2SLS	Transportation infrastructure; Urban shrinkage; Multi-dimensional; Factor outflow; Difference-in-difference model	14
Africa	Sub-Saharan Africa	Jedwab & Storeygard (2022)	39 countries	1960-2010	DID, Event study, Propensity score matching (PSM)	Housing vacancy rate; High-speed railway; Smart meter data; Urban-rural differences; Siphoning effect; Impacts; Integration	6		
					OLS, IV	Trade; Growth; Roads; Infrastructure; Urbanization; Highway; Costs; Railroads; Impacts	26		

journal articles, including their spatial scope, geographic focus, temporal coverage, methodology, keywords, and citation counts. Spatial scope is classified based on whether

the analysis is confined to a single subnational administrative unit (e.g., state, province, or region) or extends across multiple subnational administrative units or national terri-

tories. This classification reflects the different scales used to examine the relationship between transportation infrastructure and population change, ranging from localized effects to broader regional dynamics. The studies also differ in their units of analysis, with some focusing on individual cities such as London, Barcelona, or Jeddah, and others on larger administrative units such as provinces, prefectures, or metropolitan regions. Most studies employ longitudinal data spanning 10 to 30 years, with some extending beyond five decades, underscoring a structural and cumulative understanding of transport-population dynamics rather than short-term fluctuations. A wide range of quantitative methods is applied, including ordinary least squares (OLS), spatial regression models (spatial OLS, spatial error model, spatial lag model), instrumental variable techniques (IV, 2SLS), panel data models (PCSE, GLS), and the difference-in-differences (DID) methods. These methodological approaches reflect increasing efforts to address spatial dependence, endogeneity, and causal inference. Citation counts based on Web of Science indicate varying levels of scholarly impact, from highly cited foundational works to more recent contributions reflecting emerging trends.

The keywords listed in each article were compiled and analyzed to trace the thematic evolution of the field. These author-assigned keywords reflect how researchers framed the core concepts of their studies. For this review, a keyword co-occurrence network analysis was conducted using the VOSviewer, based on keywords that appeared at least twice across the selected articles. (Figure 3) presents the results of this analysis, where each node represents a keyword and links indicate co-occurrence relationships. The color gradient represents the average publication year in which each keyword appeared, ranging from blue (early 2010s) to yellow (up to 2024). While the dataset extends back to the 1990s, the most prominent keywords cluster between the early 2010s and early 2020s, enabling a temporal interpretation of evolving research priorities.

Across all periods, core keywords such as ‘transportation’, ‘infrastructure’, ‘population’, ‘growth’, and ‘impacts’ have consistently occupied central positions in the network, confirming their foundational role in shaping scholarly discourse. In the early 2010s, studies frequently focused on urban spatial structures and decentralization, as evidenced by keywords such as ‘cities’, ‘sub-center’, ‘expansion’,

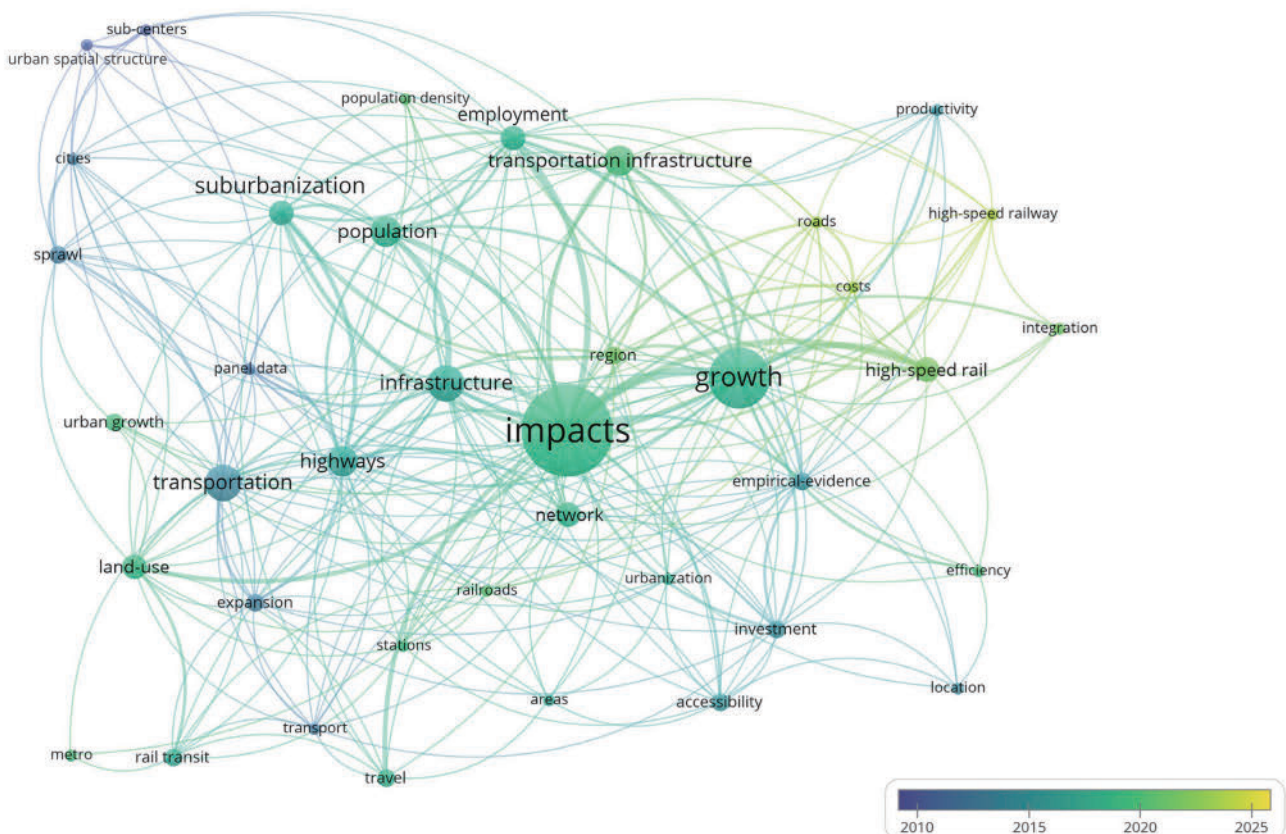


Figure 3. Temporal co-occurrence network of keywords in journal articles

‘sprawl’, and ‘suburbanization’. In the mid-to-late 2010s, attention shifted toward urban expansion and land-use change, with keywords such as ‘metro’, ‘rail transit’, ‘highways’, ‘transportation’, ‘infrastructure’, ‘urban growth’, and ‘land use’ becoming more prominent. Around 2020 and beyond, newer studies increasingly addressed high-speed transportation networks and their broader regional effects, with keywords such as ‘high-speed rail(way)’, ‘region’, ‘integration’, ‘costs’, ‘productivity’, ‘efficiency’, and ‘accessibility’ gaining visibility. These reflect a shift toward policy-oriented research that examines regional integration, economic spillover effects, and accessibility, while also addressing spatial inequalities and regional disparities. This thematic evolution suggests a broadening of the research perspective, from localized urban structure to macro-scale policy implications.

Lastly, a review of citation counts based on Web of Science data identified several key studies that have had a significant impact on the field. Notably, Aljoufie et al. (2013), Levinson (2008), Garcia-López (2012), and Goetz (1992) recorded high citation counts and are recognized as foundational works on the relationship between transportation infrastructure and population dynamics. Collectively, these studies cover a broad range of topics, including high-speed transport networks, land use, urban spatial structure, and the effects

of air and rail infrastructure, and have served as critical references that shaped subsequent research in this field.

IV. Findings from the Systematic Literature Review

The reviewed journal articles are classified according to the types of interactions between transportation infrastructure and population dynamics, as shown in <Table 2>. Broadly, they fall into two main categories. Type 1 includes studies that examine the effects of transportation infrastructure provision on population change, whereas Type 2 comprises studies that investigate how population change influences the development of transportation infrastructure. Within Type 1, three subtypes are identified based on observed patterns of population change following infrastructure provision: the ‘Win-Win effect,’ the ‘Win-Lose effect,’ and the ‘Lose-Lose effect.’ Rather than applying a predefined theoretical framework, this study adopted an inductive approach, deriving a typology from recurrent causal patterns and narrative structures identified during the review process. Each subtype is defined according to the combination of regions experiencing population growth or decline after the provision of transportation infrastructure.

Table 2. Classification of interactions between transportation infrastructure and population dynamics

Causal types	Description	Journal articles
1. Transportation → Population	Win-Win effect Transportation infrastructure expansion leads to population growth in all affected regions	Goetz (1992), Ribeiro et al. (2010), Loo et al. (2017), Coronado et al. (2019), Bjarnason (2021), Sheard (2021), Jedwab & Storeygard (2022), Faiyetole & Adewumi (2024)
	Win-Lose effect Transportation infrastructure development fosters population growth in some areas while causing population decline in others	Levinson (2008), Garcia-López (2010, 2012), Meijers et al. (2012), Wood et al. (2016), Lin & Chung (2017), Yudhistira et al. (2019), Li et al. (2020), Forouhar (2022), Li & Chen (2023), Wang et al. (2023), He et al. (2024)
2. Population → Transportation	Population growth induces transportation infrastructure expansion	Makkonen et al. (2013), Aljoufie (2021)

The 'Win-Win effect' refers to cases where transportation infrastructure expansion leads to population growth in all affected regions. This pattern typically results from improved accessibility and interregional connectivity, which stimulate local economic revitalization and enhance residential attractiveness, thereby fostering widespread population inflows. The 'Win-Lose Effect' describes situations where transportation infrastructure development promotes population growth in some areas while causing population decline in others. In such cases, improved accessibility in certain locations increases their attractiveness as economic and residential hubs, while adjacent areas with relatively lower competitiveness experience out-migration, resulting in spatial imbalances. The 'Lose-Lose Effect' refers to cases in which population decline occurs across all affected regions despite substantial transportation infrastructure investment. This subtype typically pertains to shrinking cities or persistently depopulating regions, where large-scale public funding for transportation infrastructure fails to reverse population decline due to limited socio-economic revitalization effects. However, no studies in the reviewed literature empirically confirm this effect, which may be attributable to the scarcity of research focusing on such regions, limitations in the scale or timing of infrastructure investments, or data constraints that hinder empirical analysis.

Studies examining the influence of population change on transportation infrastructure development (Type 2) can be categorized into two distinct scenarios. The first involves cases in which infrastructure expansion corresponds proportionally to population growth, thereby effectively accommodating increased mobility demands. The second scenario includes cases of mismatch, where infrastructure provision lags behind population growth, resulting in persistent congestion, overburdened networks, and spatial mismatches. These typological distinctions underscore that the responsiveness of infrastructure development to demographic shifts is not uniform, but is highly contingent upon regional socio-economic conditions and spatial planning contexts. The main findings of the systematic literature review are summarized in <Table 3> and are explained in detail in the following section.

1. Effects of Transportation Infrastructure Supply on Population Change

1) Win-Win Effect

The most common assessment of the population growth effect resulting from transportation infrastructure provision is that improved accessibility enhances residential conditions and stimulates economic activity in the region, thereby promoting population inflows. Such population increases following infrastructure expansion are generally anticipated outcomes and are well-documented in the literature.

Among them, a significant portion of the literature has analyzed the positive effects of road expansion. Specifically, Voss and Chi (2006) applied a spatial econometric model to administrative regions in Wisconsin, U.S., confirming that highway expansion leads to population growth. Similarly, Iacono and Levinson (2016) employed Granger causality tests on counties in Minnesota, U.S., concluding that local road network expansion drives population growth. Furthermore, Kasu and Chi (2018) used spatial econometric models on counties across the United States and found that an increase in highway density had a positive effect on population growth. Similar results have been observed in studies focusing on developing cities. Jedwab and Storeygard (2022) applied an instrumental variable approach based on distant road upgrades in sub-Saharan African countries and found that a 10% increase in market access over a 30-year period, resulting from these road improvements, was associated with a 0.8%~1.3% increase in urban population. Faiyetole and Adewumi (2024) conducted correlation and regression analyses on Akure, Nigeria, and found a significant relationship between road network expansion and population growth. Aljoufie et al. (2013) performed spatial comparisons between transportation infrastructure and demographic indicators in Jeddah, Saudi Arabia, and concluded that transportation infrastructure expansion played a crucial role in fostering urban population growth during the early stages of city development. Additionally, some studies have explored the effects of road development in geographically isolated and underdeveloped areas. Bjarnason (2021) analyzed population pyramids and net migration patterns in two Icelandic cities expected to be most affected by the opening of the Héðinsfjörður Tunnel and found that the rate of population decline had slowed in those regions.

Table 3. Summary of the systematic literature review findings

Causal types	Transportation infrastructure types	Contextual conditions	Journal articles	
1. Transportation → Population	Roads (Highways, local roads)	<ul style="list-style-type: none"> • Road expansion including increased highway density, broader network coverage, early-stage investment directly drives population growth. • Stronger effects occur near highway expansions and where local roads are improved. • Indirect effects emerge via enhanced economic flows and better socioeconomic conditions. • Impacts vary by time, space, and road type – diminishing with network maturity, stronger in small and remote cities, and greater for local roads than highways. 	Voss & Chi (2006), Ribeiro et al. (2010), Aljoufie et al. (2013), Iacono & Levinson (2016), Kasu & Chi, (2018), Jedwab & Storeygard (2022), Faiyetole & Adewumi (2024)	
	Win-Win effect	Rail (Rail transit, HSR)	<ul style="list-style-type: none"> • Rail transit promotes population growth, particularly in greenfield or less developed areas. • HSR induces higher population growth, especially within the first decade after opening. • Stronger and more sustained population growth effects occur in large metropolitan and administrative centers, and regions near capital cities. • Weaker or less persistent effects are found in smaller cities, industrial-dependent areas, or economically lagging regions. 	Loo et al. (2017), Coronado et al. (2019), Han et al. (2023)
		Airports	<ul style="list-style-type: none"> • Serve as key growth poles that stimulate economic development and population growth in major metropolitan areas. • Long-term effects differ by context – increasing with global integration, but declining over time due to saturation and reduced differentiation. 	Goetz (1992), Sheard (2021), Kasu & Chi (2018)
		Seaports	<ul style="list-style-type: none"> • Population growth increases with closer proximity to ports. • Ports have a long-term causal effect on regional population growth regardless of industrial structure. 	Breidenbach & Mitze (2016)
		Roads (Highways)	<ul style="list-style-type: none"> • Highways may exert a stronger suburbanizing effects than railways in some regions. • Proximity to major roads increases population density in adjacent areas, while weakening population concentration in central and suburban areas. • Effects vary by distance and life stage of population – families with children tend to relocate to peripheral areas, while young adults concentrate in central areas. 	Meijers et al. (2012), Garcia-López (2012), Yudhistira et al. (2019)
	Win-Lose effect	Rail (rail transit, HSR)	<ul style="list-style-type: none"> • Railway expansion contributes to suburbanization by serving as a redistributive force – shifting population from city centers to suburban or peripheral areas. • Transit systems in central cities can mitigate or even reverse population decline within central business districts. • Transit systems can trigger gentrification and displacement – may favor younger, wealthier, and more educated residents while displacing elderly and low-income. • HSR may have a siphon effect, facilitating population outflows to major cities, which can exacerbate regional disparities. • Invert U-shaped effects by distance. 	Levinson (2008), Garcia-López (2012), Wood et al. (2016), Lin & Chung (2017), Kasu & Chi (2018), Li et al. (2020), Forouhar (2022), Li & Chen (2023), Wang et al. (2023), Han et al. (2023)
2. Population → Transportation		<ul style="list-style-type: none"> • Population growth increases transportation demand and drives infrastructure expansion, particularly for ports facilities. • Effects vary by infrastructure type – local roads exhibit bidirectional causality with population growth, whereas highways show a unidirectional effect, primarily influencing but not responding to population change. 	Voss & Chi (2006), Makkonen et al. (2013), Breidenbach & Mitze (2016), Iacono & Levinson (2016)	

While many studies emphasize the direct relationship between road expansion and population growth, others suggest that transportation infrastructure can indirectly influence population growth by improving regional characteristics. Ribeiro et al. (2010) used a spatial autoregressive model (SAR) to examine the time-lagged effects of road accessibility on population change in northern and central Portugal. Their findings revealed that road accessibility was not statistically significant in explaining population change. However, when excluding variables related to higher education levels, the effect of road accessibility became significant. This implies that road expansion may indirectly contribute to population growth by enhancing socio-economic factors such as educational opportunities. Similarly, Kasu and Chi (2018) argued that highways do not directly induce population growth but rather serve as catalysts that facilitate economic flows and regional development.

However, some studies also indicate that the effects of road expansion on population growth are uneven across temporal and spatial contexts. Iacono and Levinson (2016) asserted that as road networks mature, the additional economic benefits of further expansion tend to diminish. Likewise, Faiyetole and Adewumi (2024) emphasized that the relationship between road network expansion and population growth is not linear, and at a certain threshold, the population growth effect begins to decline. Kasu and Chi (2018) found that highway-induced population growth peaked in the 1980s but has since weakened, with highways now playing a more complementary role to airports. Similarly, Voss and Chi (2006) found that population growth effects of highway expansion were more pronounced in the 1990s, when the overall population growth rate in Wisconsin was higher, and that significant population increases were observed in areas located within 20 miles of highway expansions. In addition, Jedwab and Storeygard (2022) highlighted that the effects of road infrastructure tended to be stronger in small and remote cities, while being weaker in politically advantaged or agriculturally suitable areas. Several studies have examined the impact of road hierarchy and function. Iacono and Levinson (2016) reported that local roads significantly influenced population growth, while highways did not yield statistically significant results. This finding contradicts the results of Voss and Chi (2006), who emphasized the positive effects of highways on popula-

tion growth. Studies categorized under the 'Win-Lose Effect,' discussed in later sections, have even suggested that highways may have negative effects on population growth in certain regions.

While road networks often generate localized population growth, rail infrastructure shows distinct spatial patterns, particularly between greenfield and urbanized areas. Loo et al. (2017), for example, conducted a comparative analysis of rail transit in Hong Kong and found that infill areas within already developed urban centers experienced an average population growth rate of 11.1% over ten years following the opening of the rail transit. In contrast, newly developed greenfield areas experienced a dramatic 74.9% increase in population. It is intuitive that the impacts of transportation infrastructure are greater in previously underdeveloped areas. However, many studies that examine the effects of railways at the urban scale tend to emphasize the 'Win-Lose effect,' and a more detailed analysis of this will be discussed in the following section. In fact, a growing body of recent research has focused on how the construction of HSR influences population change across regions. Coronado et al. (2019) analyzed growth index variations in Spanish cities based on HSR operations and found that cities with HSR services exhibited higher population growth rates than those without, particularly after the 2007 global financial crisis, with the gap widening from 2012 onward. This suggests that HSR investments may play a crucial role in economic recovery and revitalization during financial downturns. Similarly, Han et al. (2023) conducted a difference-in-differences (DID) analysis on 1,838 county-level administrative units in China and concluded that counties with HSR services had significantly higher population densities than those without.

However, the effects of HSR on population growth can vary across time and regional contexts. Coronado et al. (2019) found that during the first decade following the opening of Spain's HSR network, the population growth effect was pronounced in some small cities. However, over the longer term, the effects tended to either persist or diminish depending on the local context, such as the city's industrial structure, administrative functions, proximity to major metropolitan areas, and the presence or absence of station-area development. In particular, cities with high industrial dependency did not experience the expected

transformation effects despite improved accessibility, whereas cities with administrative roles and good access to larger metropolitan areas tended to exhibit more sustained positive impacts. Similarly, Han et al. (2023) reported that the population agglomeration effect was most evident in municipal districts and in economically advanced regions such as the eastern and southern parts of China, whereas it was relatively weaker in county-level cities and in less developed inland and northern regions. Furthermore, some studies have suggested that even in regions served by HSR, population decline may still occur, an issue further discussed in the ‘Win-Lose Effect’ section.

Several studies have also examined the impacts of airports and ports on population growth. Unlike roads and railways, which primarily enhance regional connectivity through linear linkages, airports and ports function as hubs that facilitate broader, often global, economic exchanges. Most studies consistently indicate that airports and ports contribute positively to population growth. Goetz (1992) conducted a simple regression analysis on the 50 largest U.S. metropolitan areas and found a positive correlation between air passenger volume and urban population growth. Sheard (2021) applied OLS and two-stage least squares (2SLS) regression to U.S. Core-Based Statistical Areas (CBSA) and determined that a 1% increase in air traffic volume corresponded to a 0.010% increase in local population. Kasu and Chi (2018) also reported a strong positive relationship between airports and population growth, arguing that airports serve as key growth poles that stimulate economic development. However, perspectives on the long-term influence of air transportation infrastructure have varied. Kasu and Chi (2018) argued that airports have become increasingly influential since the 1980s, largely due to growing global economic integration. In contrast, Goetz (1992) noted that the population-inducing effects of airports have gradually declined since the 1960s, attributing this trend to the increasing number of airports and the subsequent reduction in their differentiation. In the case of seaports, Breidenbach and Mitze (2016) analyzed German regions using OLS and instrumental variable methods and found that seaports had a long-term causal effect on increasing regional population levels regardless of current industrial structure. They also demonstrated a significant distance decay effect, showing that proximity to ports functions as a persistent agglomera-

tion force that reinforces regional population concentration.

In summary, the reviewed studies suggest that transportation infrastructure, such as roads, rail, airports, and seaports, generally exerts a positive influence on regional population growth. In the case of roads, the effect is often found to vary depending on the maturity of the network, the characteristics of the areas traversed, and the hierarchical level of the infrastructure. For instance, in regions where the road network has already reached a mature stage, the marginal effect of additional road expansion on population growth tends to decline, whereas small and remote cities often experience more pronounced growth effects. From a hierarchical perspective, several analyses indicate that highways are less likely to generate significant population growth effects compared to local roads.

With respect to rail infrastructure, its role as a means of public transportation tends to yield greater population growth effects in greenfield or less developed areas than in already developed urban centers. While many studies have analyzed rail transit at the urban scale, a more contentious issue lies in the impact of HSR as a component of a broader interregional transport network. Several empirical studies have reported that areas traversed by HSR experience population growth. However, some argue that such effects remain limited in smaller cities or peripheral regions. As will be discussed in later sections, rail and other forms of high-capacity regional transit may also contribute to population decline in certain areas, as demonstrated by the frequently reported ‘Win-Lose effect,’ thereby warranting more cautious and context-sensitive evaluation.

Airports and seaports, unlike roads and railways, serve as core infrastructure that provide interregional and international connectivity, and are generally found to have a positive impact on population growth. In the case of airports, a statistically significant positive correlation has been observed between rising air traffic demand and population increases. Likewise, several studies have demonstrated a causal relationship between port infrastructure and regional population growth. Nonetheless, the effects of aviation infrastructure may differ by time period and regional context, and some studies have noted a possible attenuation of impact due to the diffusion and standardization of such infrastructure.

2) Win-Lose Effect

A growing body of literature has highlighted that the expansion of transportation infrastructure can lead to a reconfiguration of accessibility and spatial structure, thereby promoting population inflows in some areas while triggering population decline in others. This suggests that transportation infrastructure may not only contribute to the growth of specific hub regions but also function as a mechanism that absorbs population and functions from surrounding areas, potentially exacerbating interregional disparities.

One of the most commonly discussed themes in the literature is suburbanization, which refers to the phenomenon of population shifting from central cities to suburban areas along expanded road and rail networks. This highlights the spatial restructuring effects of transportation infrastructure on population distribution. Levinson (2008), using a spatial regression model for boroughs in London, UK, found that railway expansion increased population density in suburban areas while decreasing residential density in central areas. Similarly, Kasu and Chi (2018) analyzed U.S. counties and observed that railways contributed to population decline in central cities while simultaneously increasing population in suburban areas, acting as a redistributive factor. Garcia-López (2012) applied a two-stage least squares (2SLS) model to analyze the Barcelona Metropolitan Region (BMR) in Spain, and found that improvements in highway and railroad systems encouraged population growth in suburban areas, while the transit system helped mitigate or reverse population decline within the central business district (CBD).

Several studies further suggest that highways exert a stronger suburbanization effect than railways. For instance, Yudhistira et al. (2019) employed an instrumental variable estimation method on the Jakarta Metropolitan Area (JMA) in Indonesia, and showed that improved railway accessibility stimulated suburban population growth but had no significant effect on central areas. By comparison, highway accessibility significantly influenced both population decline in central areas and population growth in suburban areas. These findings collectively suggest that while both railways and highways can promote suburbanization, their magnitude and spatial extent of their effects vary by regional and contextual factors.

Then, is the suburbanization effect of highways robust

under all circumstances? Meijers et al. (2012) analyzed the impact of the Western Scheldt Tunnel, a highway tunnel located in the southwestern Netherlands, and reported that highway development led to greater population growth in central areas. A key insight from their study is the recognition that the distributive effects of transportation infrastructure may differ significantly across age groups. According to their analysis, the marked increase in population density in central areas was largely driven by the concentration of young adults who were more attracted to the amenities of central locations (Meijers et al., 2012). In contrast, families with children tended to relocate not to the central areas but to periphery areas with better highway accessibility. This was attributed to the ability to access cultural, educational, and leisure services in the urban core at lower housing costs (Meijers et al., 2012). These findings underscore the importance of analyzing transportation impacts in relation to the demographic composition of affected areas. In a different approach, some studies have shifted the analytical focus away from the central-suburban dichotomy and instead highlighted the role of physical distance from the infrastructure itself. Garcia-López (2010) employed a locally weighted regression (LWR) model in the Barcelona Metropolitan Region and revealed that net population density tended to increase in areas near major roads, thereby weakening population concentration in both central and suburban areas.

In this context, it is necessary to reconsider whether suburbanization inherently implies the decline of central cities. Levinson (2008) observed that although the population of central London decreased due to rail development, commercial land development in the area was nevertheless stimulated. Similarly, Garcia-López (2012) described suburbanization in the Barcelona metropolitan area not as a negative phenomenon, but as part of a broader functional restructuring of the city. These perspectives evaluate suburbanization from the standpoint of alleviating negative externalities associated with urban over-concentration. In contrast, Meijers et al. (2012) reported that while population density increased in central areas, employment growth declined, and conversely, in peripheral areas, population growth slowed but employment growth rose. This further suggests that increases in central area population may not translate into economic gains, highlighting the need to

analyze demographic and economic changes in tandem.

Beyond the suburbanization debate, other research has analyzed the impact of public transit expansion with a focus on intra-urban areas or urban cores. These studies highlight that the effects of such interventions vary across regions and population groups, and may exacerbate socio-spatial inequalities. Wood et al. (2016) analyzed age distribution changes in U.S. transit-oriented development (TOD) areas and found that the proportion of elderly residents had declined relative to national averages, suggesting that while TOD strategies may be attractive to younger demographics, they may not be as favorable for elderly populations. Similarly, Lin and Chung (2017) conducted panel and regression analyses on administrative districts in Taipei, Taiwan, and found that improved metro accessibility was associated with increasing proportions of high-income and highly educated residents, suggesting that public transit improvements could contribute to gentrification. However, even in such cases, population growth may not necessarily correspond to economic prosperity. Forouhar (2022) analyzed areas surrounding rail transit stations in Tehran, Iran, and found that population density significantly declined in high-income neighborhoods in the northern part of the city, while it increased in low-income neighborhoods in the south. Through in-depth interviews, the study further revealed the underlying mechanisms: in high-income areas, economic revitalization occurred through commercial development and mixed land use, but existing residents moved out due to concerns over the loss of neighborhood identity and privacy. In contrast, the population increase in low-income areas was driven by the influx of residents with high dependency on rail transit, while original residents were displaced in a process of gentrification. These findings underscore the complex and uneven effects of transportation infrastructure even within the same city. Recent studies have also identified a decoupling phenomenon, in which transportation infrastructure development does not correspond to population changes. He et al. (2024) analyzed administrative regions in Guangdong Province, China, and pointed out that in many cities, transportation infrastructure has been excessively supplied relative to population changes, resulting in significant mismatches between supply and demand.

Finally, a growing body of studies has analyzed the impact

of high-speed transport networks on intercity and interregional relationships. In particular, growing attention has been paid to the so-called 'siphon effect,' whereby HSR facilitates the out-migration of population from less developed regions to major cities, thereby exacerbating regional disparities. Li et al. (2020) applied a synthetic control method (SCM) to analyze Chinese cities and found that economically stronger cities experienced population growth following HSR development, whereas economically weaker cities experienced population outflows. In some areas, a bypass effect was observed, meaning that HSR had minimal impact on population dynamics. Similarly, Li and Chen (2023) applied difference-in-differences (DID) and two-stage least squares (2SLS) estimations to cities in Northeast China, a region characterized by economic decline, and found that both HSR expansion and road network expansion accelerated population out-migration. Wang et al. (2023) used DID and propensity score matching (PSM) to examine counties in the middle and lower Yangtze River region, reporting that HSR reduced urban housing vacancy rates by 1.64% while simultaneously increasing rural housing vacancy rates by 1.16%, further exacerbating regional disparities. Some studies have examined the spatial range of the siphon effect and identified an inverted U-shaped pattern. Han et al. (2023) and Li and Chen (2023) consistently found that regions within 100 km of a major city experienced a strong siphon effect, suppressing population growth or even causing out-migration, whereas regions 100–200 km away benefited from a trickle-down effect, resulting in peak population concentration. Beyond 200 km, the population impact diminished.

In summary, previous studies have highlighted that railways and high-speed interregional transport networks may induce population growth in certain areas, while contributing to population decline in others. In the context of central-peripheral dynamics, both rail and highway infrastructure have been found to promote suburbanization, with highways generally exerting a stronger dispersal effect on population distribution than railways. Some studies also report cases in which both modes of transport have contributed to population increases in central areas, suggesting that residential preferences vary by life cycle stage and that more detailed, population group-specific analyses are needed. Studies focusing on intra-urban or core urban areas point

out that the expansion of public transit infrastructure may inadvertently undermine social equity by disproportionately benefiting certain regions or socioeconomic groups. Crucially, population decline at the urban scale does not necessarily imply economic decline. As the alleviation of over-concentration or the conversion of residential land to commercial use may enhance economic indicators, a more integrated analysis of demographic and economic changes is warranted. Meanwhile, at a broader regional scale, HSR is found to exacerbate spatial disparities through the siphon effect, drawing population away from underdeveloped areas into large metropolitan centers. This contradicts studies that emphasize the population growth potential (Win-Win effect) of HSR. Some research reconciles this discrepancy by identifying an 'inverted U-shaped' spatial structure, wherein the siphon effect is strongest near large cities but population inflows peak at intermediate distances (e.g., 100–200 km) from the urban core.

2. Effects of Population Change on the Development of Transportation Infrastructure

Population dynamics play a critical role in shaping transportation infrastructure expansion and operational strategies. As population growth increases transportation demand, it places constraints on existing infrastructure capacity, thereby driving the need for transportation network expansion and facility improvements. In particular, urban population concentration prompts investments to enhance accessibility and alleviate congestion, leading to the development of road networks and public transit systems. Thus, population change is not only a driver of infrastructure expansion but also a determinant of urban and regional spatial structures.

Empirical studies generally confirm that population growth stimulates transportation infrastructure expansion. For instance, Makkonen et al. (2013) examined the Pargas Archipelago in southwestern Finland and found that islands with larger populations had higher levels of transportation accessibility, as measured by travel time, ferry frequency, and ferry capacity, suggesting that transportation infrastructure expansion tends to align with population distribution. Similarly, Breidenbach and Mitze (2016) identified a strong posi-

tive correlation between port infrastructure and population size in Germany and confirmed that this relationship was causal. Their findings indicate that key transportation hubs such as ports tend to expand in the long run in response to population growth, reinforcing the connection between demographic changes and infrastructure development.

Furthermore, some studies emphasize the bidirectional nature of this relationship. Iacono and Levinson (2016) applied a Panel-Corrected Standard Errors (PCSE) model and Granger causality to data from Minnesota, U.S., and found that a 10% increase in population density was associated with approximately a 0.5% increase in local road density. Conversely, increases in local road density were also positively associated with subsequent growth in population density, indicating a mutually reinforcing relationship in which population growth drives local road expansion and, in turn, local road expansion promotes population growth. In contrast, no statistically significant relationship was found between highway density and population change, and in some cases correlations were weak or inconsistent. These findings suggest that local road networks respond more directly to population dynamics, whereas large-scale infrastructure such as highways is influenced more by strategic or policy-driven considerations than by local demographic trends. The impact of highway infrastructure is further highlighted in the study by Voss and Chi (2006). Using a spatial regression model to analyze data from Wisconsin, U.S., they found that highway expansion had a positive effect on population growth, with evidence suggesting a potential growth spillover effect into neighboring areas. Although they initially hypothesized a bidirectional relationship, the empirical results indicated a unidirectional causal structure, where highway expansion tends to stimulate population growth, but population change does not exert a statistically significant influence on subsequent highway expansion. This suggests that highway development is more often shaped by higher-level planning and investment decisions rather than responding to local demographic trends.

Meanwhile, other studies highlight cases where population growth outpaces infrastructure expansion, creating congestion and inefficiencies. Aljoufie et al. (2013) showed that in Jeddah, Saudi Arabia, population growth after 1980 exceeded the rate of transportation infrastructure expansion, which exacerbated traffic congestion. Subsequently,

Aljoufie (2021) reported that as population density increased, road density decreased while parking demand and traffic volume surged by 100–133%, resulting in severe road capacity shortages, congestion, and parking scarcity. These findings underscore the risks of transportation infrastructure planning that fails to keep pace with demographic changes and suggest that inadequate road infrastructure expansion in response to population growth can exacerbate urban transportation problems. A similar pattern is observed in non-urban areas. Makkonen et al. (2013) examined the Pargas Archipelago in southwestern Finland and identified persistent spatial mismatches across several prominent islands. They noted that in the remote Archipelago regions, transportation services do not always adjust proportionally to shifting demographic patterns, particularly due to seasonal population fluctuations and high maintenance costs. This suggests that population growth or redistribution can lead to regional disparities in transportation accessibility not only in urban but also in peripheral island areas.

Overall, the reviewed studies have empirically demonstrated that population growth serves as a key driver for the provision of transportation infrastructure, underscoring an interactive relationship between the two. However, when infrastructure expansion lags behind demographic change, adverse economic and social impacts such as urban congestion may result. Moreover, some analyses reveal that large-scale infrastructure projects, including highways, are not always a direct response to population growth, but can be deployed to attract residents or stimulate economic activities, often shaped by political priorities or regional equity goals. These findings highlight that the relationship between transportation infrastructure and population change is not a simple linear process, but rather a complex and context-dependent dynamic influenced by local and regional characteristics.

V. Conclusion and Implications

This study conducts a systematic literature review to examine the interaction between transportation infrastructure and population dynamics. A total of 28 peer-reviewed studies were analyzed, with attention to how these effects vary by infrastructure type and regional context.

First, road infrastructure is generally associated with a positive relationship to population growth, demonstrating the ‘Win-Win effect’ (Voss and Chi, 2006; Aljoufie et al., 2013; Iacono and Levinson, 2016; Kasu and Chi, 2018; Jedwab and Storeygard, 2022; Faiyetole and Adewumi, 2024). However, this effect is not uniform across all contexts. In regions where road networks are already well developed, the marginal benefits of additional road expansion tend to diminish, suggesting that the impact of road infrastructure on population growth is not linear, but conditional upon temporal and spatial conditions (Voss and Chi, 2006; Iacono and Levinson, 2016; Kasu and Chi, 2018; Jedwab and Storeygard, 2022; Faiyetole and Adewumi, 2024). In particular, the effects of road infrastructure overall are greater in small and remote cities (Jedwab and Storeygard, 2022), and local roads have been found to have a statistically significant impact on population growth (Iacono and Levinson, 2016). In the case of highways, some studies have pointed to the ‘Win-Lose effect,’ in which population is dispersed from urban cores to suburban or outer areas, thus promoting suburbanization (Garcia-López, 2012; Yudhistira et al., 2019). Nonetheless, the degree of suburbanization varies depending on demographic characteristics, tending to be minimal or even reversed in areas with a high proportion of young adults who prefer the amenities of central locations, while becoming more pronounced in areas with many households with children seeking lower housing costs (Meijers et al., 2012).

Second, rail infrastructure also contributes to improved accessibility and mobility within cities, and thus tends to have a greater effect on population growth in less developed or newly developing areas (Loo et al., 2017; Coronado et al., 2019; Han et al., 2023). However, this process may result in a ‘Win-Lose effect,’ where the benefits are concentrated in specific regions or among certain social groups, potentially leading to unintended socio-spatial disparities such as gentrification. In areas that have undergone a certain degree of urbanization, rail infrastructure has been associated with the outward movement of population from city centers, contributing to suburbanization, a pattern observed in multiple urban cases (Levinson, 2008; Garcia-López, 2012; Kasu and Chi, 2018). Nevertheless, as a mode of enhancing public transit convenience within urban cores, railways are generally considered a weaker driver of population decen-

tralization compared to highways (Yudhistira et al., 2019). In the case of HSR, several studies have reported a Win-Lose effect, where some transit regions experienced population growth, while many small- and medium-sized cities or surrounding underdeveloped areas saw population decline, leading to increased concentration in major cities (Li et al., 2020; Li and Chen, 2023; Wang et al., 2023; Han et al., 2023). This phenomenon is often explained by the siphon effect, in which improved accessibility to large cities leads to the outflow of population and resources from nearby smaller cities to major urban centers. Notably, the closer a region is to a large city along the HSR corridor, the stronger the outflow effect tends to be, whereas areas located beyond a certain distance generally experience population inflows, creating an inverted U-shaped pattern (Li and Chen, 2023; Han et al., 2023).

Third, airports and seaports have generally functioned as regional growth poles, contributing to population inflow and economic revitalization, thereby exemplifying the Win-Win effect (Goetz, 1992; Breidenbach and Mitze, 2016; Kasu and Chi, 2018; Sheard, 2021). By offering broader regional and international connectivity than roads or railways, they have played a key role in enhancing regional competitiveness.

Fourth, an important implication is that population change influences the provision and expansion of transportation infrastructure. Some studies have analyzed that population growth drives the expansion of road networks and public transit systems (Makkonen et al., 2013; Breidenbach and Mitze, 2016), suggesting the possibility of interactive, bidirectional causal relationships (Iacono and Levinson, 2016). However, when infrastructure provision lags behind the pace of population growth, it may lead to negative effects such as traffic congestion and decreased accessibility (Aljoufie et al., 2013; Aljoufie, 2021). Conversely, in areas experiencing population decline, oversupply of infrastructure may result in a mismatch between supply and demand.

Based on the synthesized evidence from the systematic literature review, the following implications can be drawn for future research and policy implementation. First, transportation infrastructure does not produce uniform outcomes across regions as its effects are conditional upon spatial, demographic, and temporal factors. For instance, the impacts of road infrastructure tend to be greater in small

and remote areas (Jedwab and Storeygard, 2022), and the expansion of local roads can further stimulate population inflows (Iacono and Levinson, 2016). In contrast, highway development in already urbanized regions may accelerate suburbanization or lead to spatial dispersion of population (Garcia-López, 2012; Yudhistira et al., 2019). These findings suggest that transportation infrastructure investments should be tailored to specific regional contexts. In growth regions or areas anticipating future population increases, proactive infrastructure expansion may be appropriate. However, in regions facing persistent decline, strategies should prioritize the efficient operation of existing infrastructure and link transportation planning with employment and industrial development policies.

Second, the findings underscore the need to integrate demographic and economic indicators when evaluating the effects of transportation infrastructure. Population decline does not necessarily entail economic decline, and some studies report that infrastructure-induced decentralization has alleviated congestion or created opportunities for commercial redevelopment (Levinson, 2008; Garcia-López, 2012). Therefore, a narrow focus on population figures may lead to misguided conclusions. Future research should adopt a multi-dimensional evaluation framework that considers socio-economic outcomes alongside demographic trends.

Third, the effects of transportation infrastructure are typically realized over the medium to long term. For example, the inverted U-shaped impact of HSR on population redistribution (Li and Chen, 2023; Han et al., 2023) illustrates the importance of spatial proximity and timing. Accordingly, long-term monitoring and flexible planning systems are essential. Rather than relying solely on short-term indicators such as traffic volume or land value changes, infrastructure planning should address broader socio-spatial transformations, including gentrification, suburbanization, or regional disparity. In particular, in rural areas experiencing severe population decline and aging, transportation strategies should be aligned with integrated service systems encompassing housing, healthcare, and transport welfare, and should support balanced development between urban and rural regions.

Fourth, this study confirms not only the unidirectional causal relationship in which transportation infrastructure

affects population change, but also the reverse causality in which population growth drives infrastructure expansion (Makkonen et al., 2013; Breidenbach and Mitze, 2016; Iacono and Levinson, 2016). Failure to account for such mutual interactions may lead to mismatches between demand and supply, for example, congestion and reduced accessibility in areas where infrastructure lags behind population growth (Aljoufie et al., 2013; Aljoufie, 2021), or resource inefficiency due to oversupply of infrastructure in shrinking regions. Therefore, adaptive transportation infrastructure policies that respond to real-time demographic trends are essential.

Lastly, most of the reviewed studies are concentrated in the United States, Europe, China, and certain parts of Asia and other developing countries. As such, the applicability of their findings to the institutional and spatial context of South Korea remains limited. In particular, considering the rapid population decline and the accelerating risk of local extinction outside the Seoul metropolitan area, there is a pressing need for empirical research focusing on South Korean cases. Moreover, this study only proposed the possibility of a 'Lose-Lose effect' at a conceptual level and did not include empirical verification or specific case analyses. Future studies should more thoroughly examine the structural barriers that hinder the effectiveness of transportation investments in shrinking regions. This will contribute to more precise and context-sensitive policy design in South Korea.

References

- Aljoufie, M., 2021. "The Impact Assessment of Increasing Population Density on Jeddah Road Transportation Using Spatial-Temporal Analysis", *Sustainability*, 13(3): 1455.
- Aljoufie, M., Zuidgeest, M., Brussel, M., and van Maarseveen, M., 2013. "Spatial-temporal Analysis of Urban Growth and Transportation in Jeddah City, Saudi Arabia", *Cities*, 31: 57-68.
- Aschauer, D.A., 1990. "Highway capacity and economic growth", *Economic Perspectives*, 14: 14-24.
- Banister, D. and Berechman, J., 2000. *Transport Investment and Economic Development*, London: UCL Press.
- Baum-Snow, N., 2007. "Did Highways Cause Suburbanization?", *The Quarterly Journal of Economics*, 122(2): 775-805.
- Baum-Snow, N., Brandt, L., Henderson, J.V., Turner, M.A., and Zhang, Q., 2017. "Roads, Railroads, and Decentralization of Chinese Cities", *The Review of Economics and Statistics*, 99(3): 435-448.
- Bjarnason, T., 2021. "Tunnelling the Peninsula of Trolls: A Case Study of Road Infrastructure Improvement and Demographic Dynamics in Northern Iceland", *European Countryside*, 13(2): 368-387.
- Boarnet, M.G., 1998. "Spillovers and the Locational Effects of Public Infrastructure", *Journal of Regional Science*, 38(3): 381-400.
- Breidenbach, P. and Mitze, T., 2016. "The Long Shadow of Port Infrastructure in Germany: Cause or Consequence of Regional Economic Prosperity?", *Growth and Change*, 47(3): 378-392.
- Chandra, A. and Thompson, E., 2000. "Does Public Infrastructure Affect Economic Activity? Evidence from the Rural Interstate Highway System", *Regional Science and Urban Economics*, 30(4): 457-490.
- Coronado, J.M., de Ureña, J.M., and Miralles, J.L., 2019. "Short- and Long-term Population and Project Implications of High-Speed Rail for Served Cities: Analysis of All Served Spanish Cities and Re-evaluation of Ciudad Real and Puertollano", *European Planning Studies*, 27(3): 434-460.
- Deng, T., Wang, D., Yang, Y., and Yang, H., 2019. "Shrinking Cities in Growing China: Did High Speed Rail Further Aggravate Urban Shrinkage?", *Cities*, 86: 210-219.
- Faiyetole, A.A. and Adewumi, V.W., 2024. "Urban Expansion and TRANSPORTATION INTERACTION: Evidence from Akure, Southwestern Nigeria", *Environment and Planning B: Urban Analytic and City Science*, 51(1): 57-74.
- Forouhar, A., 2022. "Rail Transit Station and Neighbourhood Change: A Mixed-Method Analysis with Respect to Neighbourhood Context", *Journal of Transport Geography*, 102: 103389.
- Garcia-López, M.À., 2010. "Population Suburbanization in Barcelona, 1991-2005: Is Its Spatial Structure Changing?", *Journal of Housing Economics*, 19(2): 119-132.
- Garcia-López, M.À., 2012. "Urban spatial Structure, Suburbanization and Transportation in Barcelona", *Journal of Urban Economics*, 72(2-3): 176-190.
- Goetz, A.R., 1992. "Air Passenger Transportation and Growth in the U.S. Urban System, 1950-1987", *Growth and Change*, 23(2): 217-238.
- Han, D., Attipoe, S.G., Han, D., and Cao, J., 2023. "Does Transportation Infrastructure Construction Promote Population Agglomeration? Evidence from 1838 Chinese County-level Administrative Units", *Cities*, 140: 104409.
- He, J., Yang, S., Deng, S., Ye, J., and Chen, H., 2024. "Research on the Decoupling Relationship between Transportation Land and Population Growth: A Case of Guangdong Province in China", *Land*, 13(4): 484.
- Hirschman, A.O., 1958. *The Strategy of Economic Development*,

New Haven, CT: Yale University Press.

21. Iacono, M. and Levinson, D., 2016. "Mutual Causality in Road Network Growth and Economic Development", *Transport Policy*, 45: 209-217.
22. Jedwab, R. and Storeygard, A., 2022. "The Average and Heterogeneous Effects of Transportation Investments: Evidence from Sub-Saharan Africa 1960-2010", *Journal of the European Economic Association*, 20(1): 1-38.
23. Jo, J.U. and Woo, M., 2014. "The Impacts of High Speed Rail on Regional Economy and Balanced Development: Focused on Gyeongbu and Gyeongjeon Lines of Korea Train eXpress (KTX)", *Journal of Korea Planning Association*, 49(5): 263-278.
24. Jung, I.H. and Lee, S.W., 2011. "The Effects of KTX on Population Distribution between 2004 and 2009", *Journal of the Korean Regional Science Association*, 27(3): 121-138.
25. Kasu, B.B. and Chi, G., 2018. "The Evolving and Complementary Impacts of Transportation Infrastructures on Population and Employment Change in the United States, 1970-2010", *Population Research and Policy Review*, 37: 1003-1029.
26. Kim, J. and Han, J.H., 2016. "Straw Effects of New Highway Construction on Local Population and Employment Growth", *Habitat International*, 53: 123-132.
27. Kim, S.J. and Yang, H.J., 2023. "A Systematic Literature Review on Inclusionary Zoning: Socioeconomic Effects of Land Value Capture as a Funding Source for Affordable Housing", *Journal of Korea Planning Association*, 58(3): 137-148.
28. Levinson, D., 2008. "Density and Dispersion: The Co-development of Land Use and Rail in London", *Journal of Economic Geography*, 8(1): 55-77.
29. Li, X., Wu, Z., and Zhao, X., 2020. "Economic Effect and its Disparity of High Speed Rail in China: A Study of Mechanism Based on Synthesis Control Method", *Transport Policy*, 99: 262-274.
30. Li, Y. and Chen, Z., 2023. "Does Transportation Infrastructure Accelerate Factor Outflow from Shrinking Cities? An Evidence from China", *Transport Policy*, 134: 180-190.
31. Lin, J.J. and Chung, J.C., 2017. "Metro-induced Gentrification: A 17-year Experience in Taipei", *Cities*, 67: 53-62.
32. Loo, B.P.Y., Cheng, A.H.T., and Nichols, S.L., 2017. "Transit-oriented Development on Greenfield versus Infill Sites: Some Lessons from Hong Kong", *Landscape and Urban Planning*, 167: 37-48.
33. Makkonen, T., Salonen, M., and Kajander, S., 2013. "Island Accessibility Challenges: Rural Transport in the Finnish Archipelago", *European Journal of Transport and Infrastructure Research*, 13(4): 274-290.
34. McAlister, F.A., Clark, H.D., van Walraven, C., Straus, S.E., Lawson, F.M., Moher, D., and Mulrow, C.D., 1999. "The Medical Review Article Revisited: Has the Science Improved?", *Annals of Internal Medicine*, 131(12): 947-951.
35. Meijers, E., Hoekstra, J., Leijten, M., Louw, E., and Spaans, M., 2012. "Connecting the Periphery: Distributive Effects of New Infrastructure", *Journal of Transport Geography*, 22: 187-198.
36. Munnell, A.H., 1992. "Policy Watch: Infrastructure Investment and Economic Growth", *The Journal of Economic Perspectives*, 6: 189-198.
37. Myrdal, G., 1957. *Economic Theory and Underdeveloped Region*. London: Gerald Duckworth.
38. Oh, J.W. and Jung, J.C., 2024. "A Systematic Literature Review of Urban Social Diversity Research", *Journal of Korea Planning Association*, 59(4): 85-96.
39. Ono, M. and Asano, M., 2005. "The Study of the Straw Effect Produced by the High-Speed Transportation: The Verification of the Area Along the Nagano Shinkansen by the Statistical Data", In *Proceeding of Annual Conference Japan Society of Civil Engineering*, 32(CD-ROM): 75 (in Japan).
40. Page, M.J., McKenzie, J.E., Bossuyt, P.M., Boutron, I., Hoffmann, T.C., Mulrow, C.D., Shamseer, L., Tetzlaff, J.M., Akl, E.A., Brennan, S.E., Chou, R., Glanville, J., Grimshaw, J.M., Hróbjartsson, A., Lalu, M.M., Li, T., Loder, E.W., Mayo-Wilson, E., McDonald, S., McGuinness, L.A., Stewart, L.A., Thomas, J., Tricco, A.C., Welch, V.A., Whiting, P., and Moher, D., 2021. "The PRISMA 2020 Statement: An Updated Guideline for Reporting Systematic Reviews", *BMJ*, 372: n71.
41. Petticrew, M. and Roberts, H., 2008. *Systematic Reviews in the Social Sciences: A Practical Guide*, New Jersey: John Wiley and Sons.
42. Reggiani, M. and Ortiz-Moya, F., 2022. "The Impact of High-speed Rail on the Trajectories of Shrinking Cities: The Case of the Extension of the Shinkansen Network in Northern Japan", *International Planning Studies*, 27(1): 91-106.
43. Ribeiro, A., Antunes, A.P., and Páez, A., 2010. "Road Accessibility and Cohesion in Lagging Regions: Empirical Evidence from Portugal Based on Spatial Econometric Models", *Journal of Transport Geography*, 18(1): 125-132.
44. Rietveld, P. and Bruinsma, F., 1998. *Is Transport Infrastructure Effective? Transport Infrastructure and Accessibility: Impacts on the Space Economy*, Heidelberg: Springer.
45. Seo, M.G. and Song, J., 2023. "A Systematic Literature Review of Green Gentrification Research", *Journal of Korea Planning Association*, 58(6): 158-170.
46. Sheard, N., 2021. "The Network of US Airports and Its Effects on Employment", *Journal of Regional Science*, 61(3): 623-648.
47. Vickerman, R., 2015. "High-speed Rail and Regional Development: The Case of Intermediate Stations", *Journal of Transport Geography*, 42: 157-165.
48. Voss, P.R. and Chi, G., 2006. "Highways and Population Change", *Rural Sociology*, 71(1): 33-58.
49. Wang, Z., Ma, J., Zhang, B., Yang, Y., Wang, B., and Zhao, W., 2023. "Does High Speed Railway Alleviate Housing Vacancy Rates? Evidence from Smart Meter Data of Household Electricity Consumption", *Transportation Research Part A: Policy and Practice*, 176: 103787.
50. Wood, B.S., Horner, M.W., Duncan, M., and Valdez-Torres, Y., 2016. "Aging Populations and Transit-Oriented Development: Socioeconomic, Demographic, and Neighborhood

Trends from 2000 and 2010”, *Transportation Research Record*, 2598(1): 75-83.

51. Yudhistira, M.H., Indriyani, W., Pratama, A.P., Sofiyandi, Y., and Kurniawan, Y.R., 2019. “Transportation Network and Changes in Urban Structure: Evidence from the Jakarta Metropolitan Area”, *Research in Transportation Economics*, 74: 52-63.

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