

Differentiated Rail Accessibility and Housing-Price Capitalization around an Interchange Station: Evidence from Pangyo, South Korea

Seoyoung Kim

sykim16@yonsei.ac.kr

Yonsei University

Research Article

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Abstract

Rail investment is often assumed to generate spatially uniform effects on transit-oriented development and housing markets. This study challenges that assumption by examining whether rail lines with different accessibility functions produce different patterns of housing-price capitalization. Focusing on Pangyo Station in South Korea, where the Shinbundang Line and Gyeonggang Line opened sequentially, the study compares a core-oriented accessibility shock with a connectivity-expanding shock. Using apartment transaction data from 2007 to 2021, difference-in-differences models with apartment-complex and month fixed effects are estimated across distance bands around the station. The results show that the Shinbundang Line produced a localized capitalization pattern, with a significant price increase only in the 0.5–1.0 km band. In contrast, the Gyeonggang Line generated a broader spatial pattern, with significant price increases across the 0.0–1.5 km area. These findings suggest that rail-induced housing-price effects depend not only on station proximity but also on the functional role of the line within the metropolitan network. The study implies that rail-led development and station-area planning should be differentiated according to the type of accessibility improvement produced by each line.

Keywords: rail-led development; housing-price capitalization; transit-oriented development; station-area planning

1. Introduction

Transit-oriented development (TOD) is commonly understood as a planning approach that integrates land use and transport by concentrating relatively dense, mixed-use, and accessible development around transit nodes in order to reduce automobile dependence and enhance accessibility. In practice, however, TOD has also been used as a broader spatial strategy for restructuring urban and regional development. In South Korea, metropolitan-scale planning has explicitly linked land development around major transit nodes to a public-transport-oriented spatial structure, emphasizing transit passenger stations and subway stations as preferred locations for coordinated development (Korea Research Institute for Human Settlements, 2007). In the Paris region, the Grand Paris Express has been framed not merely as a transport project, but as an urban, social, and economic project intended to connect the major strategic territories and development poles of Île-de-France (Société du Grand Paris, 2018). In the United Kingdom, the Elizabeth line has likewise been evaluated not only in transport terms but also in relation to planning, regeneration, property-market change, and housing and employment growth around stations (Comber & Arribas-Bel, 2017; Transport for London & Department for Transport, 2022). In Japan, TOD has long been institutionalized through integrated railway and suburban development, with the Ministry of Land, Infrastructure, Transport and Tourism explicitly presenting railway-based urban development as a core model of urbanization and documenting the historical integration of railway construction and residential land development by private railway companies (Ministry of Land, Infrastructure, Transport and Tourism, 2024; Yajima & Ieda, 2020). These cases suggest that rail investment is not simply a means of reducing travel time, but a policy instrument through which states and metropolitan authorities attempt to reorganize accessibility, guide urban development, and reshape wider territorial structure (Cervero & Kockelman, 1997; Dittmar & Ohland, 2004).

48 Among such investments, high-speed rail (HSR) has become especially important
49 because it can compress travel time across wider territories than conventional urban transit
50 and thereby reshape patterns of accessibility, development opportunity, and interregional
51 interaction. The developmental significance of HSR lies not merely in faster movement, but
52 in its capacity to reorganize spatial relations. By reducing effective distance between selected
53 locations, HSR can widen commuting sheds, alter residential location preferences, and
54 modify the geography of economic interaction. Prior studies have shown that transport
55 infrastructure can influence urban and regional development through multiple channels,
56 including accessibility enhancement, agglomeration effects, and changes in land and property
57 markets. Real estate markets provide one of the most observable channels through which the
58 benefits of accessibility improvement are capitalized, because housing prices respond
59 sensitively to changes in locational advantage and network connectivity (Ahlfeldt &
60 Feddersen, 2018; Debrezion et al., 2007; Gibbons & Machin, 2005; Givoni, 2006;
61 Lakshmanan, 2011).

62 At the same time, HSR effects are not spatially uniform. Existing research suggests
63 that the impacts of rail accessibility vary by station context, network position, and
64 metropolitan structure (Mohino et al., 2019; Ureña et al., 2009). This point is especially
65 important for TOD-oriented interpretation. If rail lines differ in their functional roles within a
66 metropolitan or regional system, then the development outcomes associated with those lines
67 may also differ. A line that primarily strengthens access to a dominant urban core may
68 generate a different housing-market response from a line that broadens connectivity across
69 outer or non-core areas. Recognizing such variation is important because a uniform
70 understanding of rail-led development can obscure how different forms of accessibility
71 reorganization are translated into land-use change, housing demand, and localized
72 development pressure.

The existing literature, however, still leaves an important gap. Prior studies have already shown that the development effects of HSR are not spatially uniform and vary according to station context, metropolitan integration, and the type of connection established by the line (Mohino et al., 2019; Ureña et al., 2009). Research on rail and property markets has likewise demonstrated that accessibility gains can be capitalized into housing and land values, but that the magnitude and spatial reach of these effects differ across projects and local contexts (Chen & Haynes, 2015; Debrezion et al., 2007). However, much of this literature has examined either broad inter-city effects, average station effects, or single-line impacts in settings where line function, neighborhood context, and local market structure are difficult to disentangle. As a result, the literature provides limited evidence on whether rail lines with different functional roles produce different capitalization patterns within the same local housing market. This limitation is analytically important because treating rail investment as a homogeneous intervention risks obscuring how different forms of accessibility reorganization are translated into differentiated housing-market responses and station-area development dynamics (Debrezion et al., 2007; Mohino et al., 2019).

This study examines the housing-price effects of two rail systems in South Korea that intersect at Pangyo Station but differ in their functional roles within the wider network. More specifically, the study compares a line that primarily strengthens access to the metropolitan core with a line that broadens regional connectivity, and asks whether these differentiated accessibility shocks generate different spatial patterns of housing-price capitalization. To do so, the analysis uses a quasi-experimental difference-in-differences framework combined with distance-band comparisons around the station area, allowing the study to trace how the capitalization effect of each line varies across space within a shared local housing market. Because both lines are anchored at the same interchange node, the analysis does not claim to isolate the general effect of rail-line function independent of the Pangyo-specific setting.

Rather, it uses the sequential openings at Pangyo Station to examine whether a core-oriented accessibility shock and a connectivity-expanding shock are associated with different spatial patterns of housing-price capitalization under a common local market context. In this way, the study contributes to the literature by moving beyond the assumption of rail homogeneity, linking differentiated line functions to localized property-market responses, and providing cautious empirical evidence on how different forms of accessibility improvement may be capitalized in station-area housing markets.

The remainder of this paper is organized as follows. Section 2 reviews the theoretical and empirical literature on TOD, HSR, accessibility capitalization, and differentiated line functions. Section 3 presents the study area, data, variables, and empirical strategy. Section 4 reports empirical results. Section 5 discusses the main findings and draws out their theoretical and policy implications. Section 6 concludes.

2. Theoretical framework: rail accessibility, housing-price capitalization, and differentiated line functions

TOD provides a useful conceptual starting point for understanding how transport infrastructure reshapes urban form and land markets. In its broadest sense, TOD emphasizes the integration of transport and land use through relatively dense, mixed-use, and accessible development around transit nodes in order to reduce automobile dependence and improve accessibility (Cervero & Kockelman, 1997; Dittmar & Ohland, 2004). Although TOD has most often been discussed in relation to urban and metropolitan transit, its core logic is also relevant to HSR where major station areas function not only as transport nodes but also as strategic sites of land-use intensification, redevelopment, and regional integration (Dittmar & Ohland, 2004; Givoni, 2006). In this respect, HSR can be understood not simply as transport

technology, but as infrastructure with the potential to influence station-area development, locational advantage, and wider urban-regional structure.

The relevance of HSR to urban and regional development stems from its capacity to reduce effective distance across space. By sharply improving accessibility between selected locations, HSR can alter commuting possibilities, widen labor-market interactions, and reshape the geography of agglomeration (Ahlfeldt & Feddersen, 2018; Lakshmanan, 2011). Prior studies have shown that transport infrastructure investments can generate broader economic consequences through changes in accessibility, productivity, and interaction costs, and HSR is often treated as a particularly powerful form of such intervention because of its speed, capacity, and regional reach (Givoni, 2006; Lakshmanan, 2011). However, these development effects do not arise uniformly across space. Rather, they depend on where stations are located, how lines are embedded in broader metropolitan and regional systems, and what kinds of accessibility gains they generate (Mohino et al., 2019; Ureña et al., 2009).

For this reason, HSR should not be treated as a spatially homogeneous intervention. Even when lines belong to the same broad HSR family, their developmental effects may differ according to functional role and network orientation. Some lines primarily strengthen access to dominant urban cores by connecting peripheral or suburban areas to central employment concentrations. Other lines improve connectivity between non-core nodes or extend accessibility across a wider regional geography. These differences matter because accessibility gains are translated into land and housing markets through context-specific capitalization processes rather than through a single uniform mechanism (Debrezion et al., 2007; Gibbons & Machin, 2005). In other words, the same general type of infrastructure may generate different spatial patterns of price response depending on how it restructures relative accessibility.

Building on this premise, this study uses a functional distinction between core-oriented accessibility improvement and connectivity-expanding accessibility improvement. The first type primarily reinforces accessibility to major urban cores, thereby potentially generating stronger capitalization in locations where improved access to established employment and service centers is especially valuable. The second type primarily broadens connectivity across outer areas or between non-core nodes, thereby potentially diffusing accessibility gains over a wider catchment. This distinction is not intended to classify HSR systems in general or to isolate line-function effects independently of local context. Rather, it provides an analytical framework for examining whether two sequential rail openings at the same interchange node are associated with different housing-market responses. Such a perspective is consistent with prior research showing that the urban effects of HSR vary according to network integration, metropolitan position, and station context (Mohino et al., 2019).

A key mechanism through which these differentiated effects can be observed is property-value capitalization. In urban and transport economics, housing prices are widely used to capture the value of accessibility because they reflect households' willingness to pay for locational advantages created by transport improvements (Gibbons & Machin, 2005). A large body of research has shown that rail investments can be capitalized into real estate prices, although the magnitude and spatial extent of such effects vary across markets and project types (Debrezion et al., 2007). This logic also applies to HSR. Empirical studies have found that HSR can affect housing values by changing the accessibility and relative attractiveness of locations, though the direction and strength of the effect depend on local conditions, network position, and the scale of improvement (Chen & Haynes, 2015). Therefore, housing prices offer an analytically appropriate outcome through which to examine whether different HSR line functions produce different development effects.

From a TOD perspective, these capitalization patterns are substantively meaningful because they indicate how transport investment may translate into differentiated station-area and corridor-level development pressures. If one HSR type generates steeper price effects near stations while another produces broader but more spatially diffuse effects, then a uniform planning response may fail to match the underlying accessibility logic of each line. Examining such heterogeneity is particularly relevant in South Korea, where HSR-related investment has been tied not only to transport efficiency but also to broader efforts to improve territorial connectivity and support more balanced spatial development. Against this background, this study asks how housing-price capitalization patterns differ between a core-oriented accessibility shock and a connectivity-expanding accessibility shock within a shared local housing market.

RQ. How do housing-price capitalization patterns differ between a core-oriented accessibility shock and a connectivity-expanding accessibility shock?

3. Research methods

3.1. Study area

This study focuses on Pangyo Station and its surrounding apartment market in Bundang-gu, Seongnam, within the southeastern part of the Seoul metropolitan area. Pangyo provides an analytically useful setting because it serves as a shared interchange node for two rail services that differ in their functional roles within the wider regional network: the Shinbundang Line (SBD) and the Gyeonggang Line (GG). This shared-node configuration makes it possible to compare differentiated housing-price capitalization patterns under a common local market context rather than across fundamentally different station environments. At the same time, this setting should be understood as a single-node research

design rather than as a design that fully separates line-function effects from Pangyo-specific market dynamics. In this respect, Pangyo is not simply another station area. It is a metropolitan node where distinct accessibility functions were introduced sequentially within the same neighborhood context.

The first rail shock examined in this study is the SBD. The SBD primarily strengthened direct access between Pangyo and the Gangnam Business District (GBD), which is one of the most important employment and commercial centers in the Seoul metropolitan area. Before the line opened, travel from Pangyo to the GBD typically took about 45 minutes, but the opening of the SBD reduced this travel time to approximately 16 minutes (Ministry of Land, Infrastructure and Transport, 2016). The opening of the SBD therefore represented a discrete improvement in core-oriented metropolitan accessibility and increased the relative locational advantage of residential areas near Pangyo Station. Table 1 summarizes the major implementation milestones of the project, including the proposal for private investment in 2006, the concession agreement in 2009, the start of construction in 2011, and the opening of Phase 1 (Gangnam–Jeongja) in 2011 (Gyeonggi Railroad Co., Ltd., 2024). For the purposes of the empirical analysis, the opening of Phase 1 of the SBD on October 28, 2011, is treated as the first opening-based accessibility shock.

Table 1. Major implementation milestones of the Shinbundang Line.

Date	Project details
September 28, 2006	Proposal for a private investment project
November 26, 2008	Designation of the preferred negotiation partner
December 29, 2009	Concession agreement signed
December 30, 2010	Approval of the implementation plan
February 8, 2011	Construction commenced
October 28, 2011	Opening of phase 1 (Gangnam–Jeongja)

The second rail shock is the GG. In contrast to SBD, the GG did not primarily reinforce access to the metropolitan core. Instead, it expanded connectivity between Pangyo

and eastern outer areas, including Yeosu, and was later extended toward Gangneung. Analytically, the importance of the GG lies not in introducing a wholly separate station environment, but in adding a second and functionally distinct layer of accessibility at the same node. Whereas the SBD intensified core-oriented access to an established metropolitan employment center, the GG broadened regional connectivity beyond the core. The Pangyo–Yeosu section opened on September 24, 2016, followed by the Wonju–Gangneung extension in December 2017 (Ministry of Land, Infrastructure and Transport, 2017). For the purposes of the empirical analysis, the opening of the Pangyo–Yeosu section on September 24, 2016, is treated as the second opening-based accessibility shock.

Table 2. Major implementation milestones of the Gyeonggang Line.

Date	Project details
November 25, 2006	Construction started in the Seongnam section
...	...
November 29, 2015	Preliminary feasibility study approved for Wolgot–Pangyo section
September 24, 2016	Pangyo–Yeosu section opened to the public
December 22, 2017	Seowonju–Gangneung section opened to the public

This setting is particularly valuable because it allows the analysis to compare two sequential rail openings with different accessibility functions within the same local housing market. The study does not treat the two lines as equivalent transport interventions. Rather, it interprets them as distinct accessibility shocks: the SBD as a core-oriented shock that strengthened access to the metropolitan center, and the GG as a connectivity-expanding shock that widened access across a broader regional geography. Figure 1 illustrates the route structure of the two lines and the position of Pangyo Station within the network. By examining both lines at the same interchange node, this study can assess whether different rail functions are associated with different spatial patterns of housing-price capitalization around the station area.

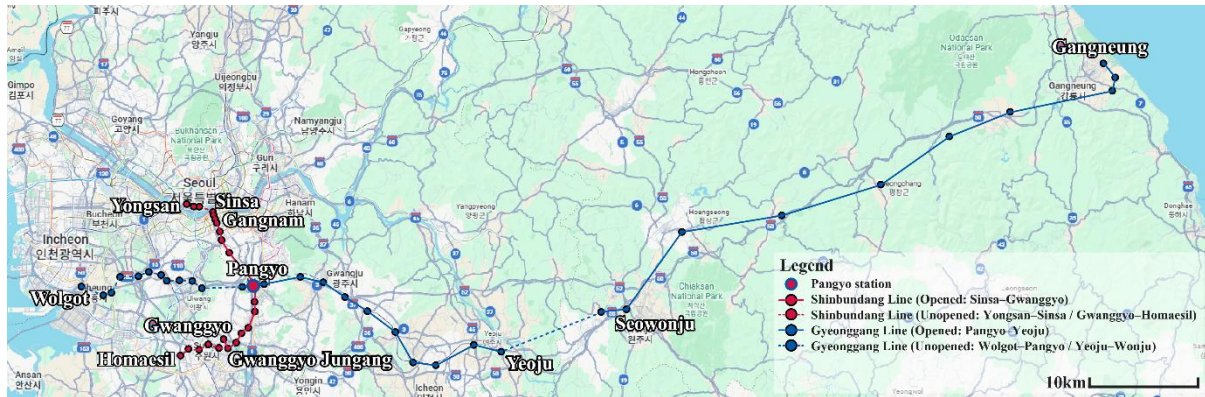


Figure 1. Route map of the Shinbundang and Gyeonggang lines.

3.2. Data and analytical scope

The empirical analysis uses apartment transaction records from the Ministry of Land, Infrastructure and Transport's Real Transaction Price Disclosure System, which provides transaction-level information on housing transactions in South Korea. The raw dataset includes the transaction date, transaction price, floor area, floor level, construction year, and apartment-complex address. Apartments were selected as the analytical housing type for two reasons. First, apartments are the most prevalent housing type in South Korea. According to the 2023 Population and Housing Census, 53.1% of general households resided in apartments, and recent official statistics likewise identify apartments as the dominant residential form in the Korean housing system (Statistics Korea, 2024). Second, apartments provide a more standardized housing product than detached or low-rise multi-family housing, which makes them particularly suitable for quasi-experimental analysis of accessibility capitalization because unit characteristics are more readily comparable across transactions. This choice is also consistent with prior research that uses apartment or housing transaction prices to identify the capitalization of transport and development-related accessibility changes into residential property values (Gibbons & Machin, 2005; Hyun & Milcheva, 2019).

Spatially, the analysis is restricted to apartment transactions located within a 2.5 km radius of Pangyo Station. This boundary was chosen to preserve a local comparison frame

within the same station-area housing submarket while allowing sufficient spatial variation to examine heterogeneous capitalization patterns across distance bands. Prior research shows that rail-induced property value effects are not spatially uniform but generally decay with increasing distance from stations (Debrezion et al., 2007), and rail-access premiums tend to be concentrated relatively near stations and rarely extend far beyond roughly 2 km (Rennert, 2022).

The study area is further divided into 500 m distance bands as shown in Figure 2. This banded specification was adopted for both substantive and methodological reasons. Substantively, accessibility benefits from rail stations are experienced over relatively short walking distances, so a 500 m interval provides a meaningful spatial scale at which households are likely to perceive differences in station proximity. Methodologically, prior studies suggest that capitalization effects often vary nonlinearly over space, with steeper gradients in near-station areas and weaker or mixed effects farther away, making discrete distance bands more informative than a single continuous distance term (Debrezion et al., 2007; Hyun & Milcheva, 2019). Accordingly, the outermost 2.00–2.50 km ring is treated as a conservative outer comparison ring within the same local housing submarket, where capitalization effects are expected to be substantially weaker than in the inner bands. This outer ring is not assumed to be completely unaffected by station-area accessibility changes; rather, it provides a relative comparison group for examining spatially differentiated price changes within the same local market.

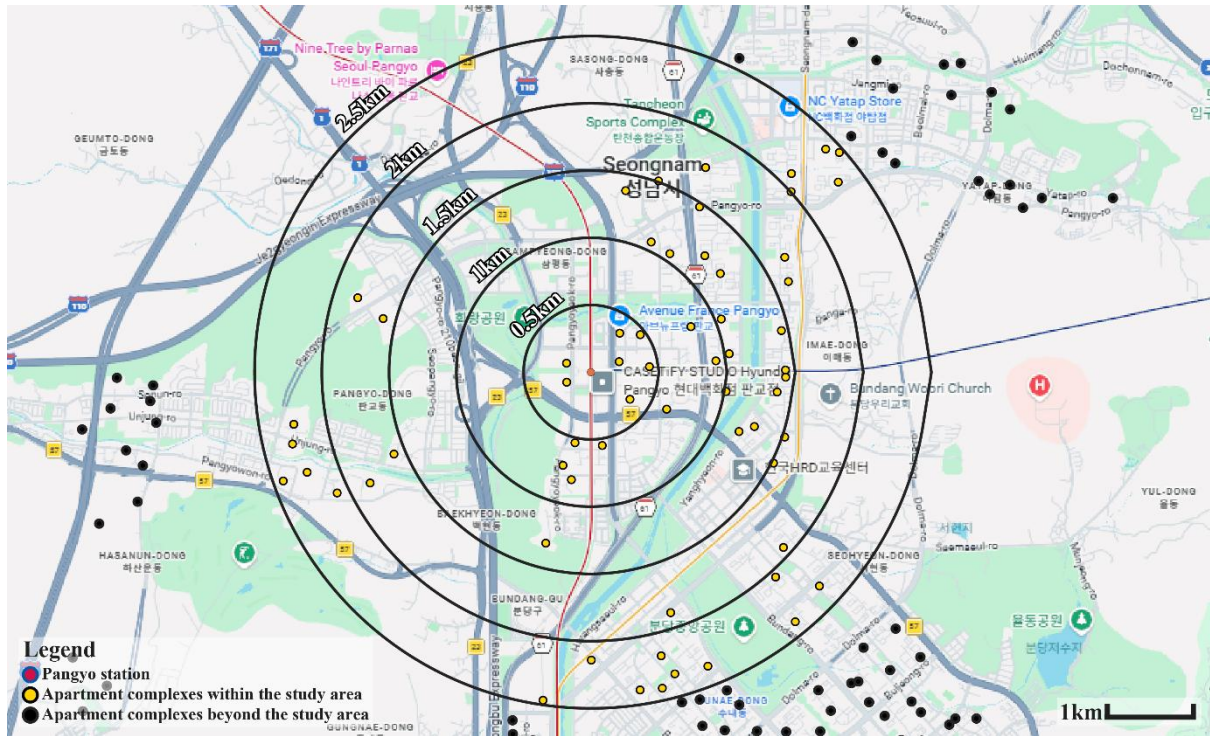


Figure 2. Apartment complex distribution near Pangyo Station.

Temporally, the descriptive scope and the estimation scope should be distinguished explicitly. For descriptive purposes, the full sample covers January 2007 to June 2021 within the 2.5 km boundary. In the final monthly difference-in-differences specification, however, narrower equal pre- and post-opening windows are used, and the month of line opening itself is excluded as a one-month buffer period. For the SBD, the estimation window is defined as January 2007 to September 2011 for the pre-period, October 2011 as the buffer period, and November 2011 to July 2016 for the post-period. For the GG, the corresponding window is December 2011 to August 2016 for the pre-period, September 2016 as the buffer period, and October 2016 to June 2021 for the post-period.

3.3. Variables

The dependent variable is the natural logarithm of the apartment transaction price per exclusive-use area. This specification was adopted because housing-price capitalization is

commonly examined using unit prices that normalize for size differences across dwellings, while the log transformation reduces skewness and allows estimated coefficients to be interpreted approximately as percentage changes. The dependent and explanatory variables are summarized in Table 3. In transport and urban economics, housing prices are widely used as an outcome variable because they reflect households' willingness to pay for accessibility improvements created by transport investments (Debrezion et al., 2007; Gibbons & Machin, 2005).

The key explanatory variables consist of spatial, temporal, and interaction terms. First, the spatial variable measures residential location relative to Pangyo Station using 500 m distance bands within a 2.5 km radius. In the full analytical sample, transactions are distributed across five rings: 0.00–0.50 km, 0.50–1.00 km, 1.00–1.50 km, 1.50–2.00 km, and 2.00–2.50 km. Each spatial band is operationalized as a dummy variable that takes the value of 1 if a transaction belongs to the corresponding distance band and 0 otherwise. In the DiD estimation, the outermost 2.00–2.50 km band is omitted as the reference category. Accordingly, the coefficients on the included spatial dummies indicate how the baseline price level of each inner band differs from that of the 2.00–2.50 km comparison ring. In the fixed-effects specification, however, these time-invariant distance-band main effects are absorbed by apartment-complex fixed effects and are therefore not separately estimated.

Second, the temporal variable is coded separately for each rail shock. For the SBD model, the monthly DiD sample uses a pre-opening period from January 2007 to September 2011, excludes October 2011 as a gap month, and defines the post-opening period as November 2011 to July 2016. For the GG model, the pre-opening period runs from December 2011 to August 2016, September 2016 is excluded as a gap month, and the post-opening period is defined as October 2016 to June 2021. This temporal variable is also specified as a dummy variable: it takes the value of 1 for observations in the post-opening period of the

Table 3. Variables

Category	Variable	Unit	Description	Mean	SD	Min	Max	
Dependent variable	Apartment price	10,000 KRW/m ²	Natural log of transaction price divided by exclusive-use area	828.59	319.56	50.87	2,540.67	
	Log-transformed apartment price	ln(10,000 KRW/m ²)		6.66	0.35	3.93	7.84	
Key explanatory variables	Spatial variable	0.00–0.50 km	Dummy	1 if located within 0.00–0.50 km of Pangyo Station, 0 otherwise	0.05	0.21	0	1
		0.50–1.00 km	Dummy	1 if located within 0.50–1.00 km of Pangyo Station, 0 otherwise	0.07	0.25	0	1
		1.00–1.50 km	Dummy	1 if located within 1.00–1.50 km of Pangyo Station, 0 otherwise	0.29	0.46	0	1
		1.50–2.00 km	Dummy	1 if located within 1.50–2.00 km of Pangyo Station, 0 otherwise	0.20	0.4	0	1
		2.00–2.50 km	Dummy	1 if located within 2.00–2.50 km of Pangyo Station, 0 otherwise	0.39	0.49	0	1
	Temporal variable	Post-SBD	Dummy	1 in the post-opening period of the SBD estimation window, 0 in the corresponding pre-opening period	0.39	0.49	0	1
		Post-GG	Dummy	1 in the post-GG period, 0 in the post-SBD/pre-GG period	0.42	0.49	0	1
	Interaction variable	Distance band × opening	Dummy	Differential opening effect for each band relative to the 2.00–2.50 km band	-	-	-	-
Control variables	Area	m ²	Exclusive use area	95.42	36.39	28.16	265.55	
	Floor	Floor	Floor level of the transacted apartment unit	9.37	6.24	1	35	
	Building age	Years	Transaction year – construction year +1	18.57	7.63	1	31	
	Centralized building age	Years	Building age centered at the sample mean	–1.12	7.63	–18.69	11.31	

Abbreviations. SBD = Shinbundang Line; GG = Gyeonggang Line

Note. $N = 28,474$

relevant rail line and 0 for observations in the corresponding pre-opening period. Therefore, the coefficient on the temporal dummy captures the average before-and-after price change in the reference group, namely the outer 2.00–2.50 km ring, between the two time periods.

Third, the differential opening effect is estimated through interaction terms between the spatial bands and the post-opening indicator. In substantive terms, these interactions measure whether price changes after each rail opening were larger or smaller in the inner distance bands than in the outer comparison ring. More specifically, each interaction term equals 1 only for observations that belong both to a given spatial band and to the post-opening period, and 0 otherwise. The coefficient on each interaction term therefore represents the additional post-opening change in that distance band relative to the post-opening change observed in the reference group. In other words, these coefficients show whether the differential post-opening price change in each inner band is greater than, smaller than, or statistically indistinguishable from the change observed in the 2.00–2.50 km comparison ring.

The control variables included in the final specification are limited to four structural housing attributes: exclusive-use area, floor level, building age, and the squared term of building age. Area, floor, and building age capture basic structural heterogeneity across apartment transactions. The squared age term is included to allow the price–age relationship to be non-linear, which is common in hedonic property models. Prior research shows that age effects often do not follow a simple linear depreciation pattern, and that property values may reflect both the declining use value of aging structures and, in some contexts, the redevelopment option associated with older properties (Clapp & Lindenthal, 2022).

3.4. Model specification

3.4.1. Difference-in-differences model

The empirical strategy uses a difference-in-differences (DiD) design to estimate how apartment prices changed after each rail opening across distance bands from Pangyo Station. The basic logic of DiD is to compare the before-and-after change in the treated group with the contemporaneous change in a comparison group. Under the parallel-trends assumption, this comparison can be interpreted as a treatment effect after differencing out time-invariant group differences and period-specific shocks common to all groups (Abadie, 2005; Callaway & Sant’Anna, 2021).

This study estimates two separate equal window DiD models rather than a single pooled model. One model is estimated for the SBD opening, and the other is estimated for the GG opening. This design was chosen because the two openings occurred at different times and under different network conditions, so each shock is examined within its own balanced pre- and post-opening window. For each rail shock, the opening month itself is excluded as a one-month transition buffer to avoid mixing anticipatory and immediate adjustment effects into either the pre- or post-period. Because the two projects had long planning and construction histories, the opening-based design is interpreted as capturing price changes around the start of service rather than the full capitalization process from the earliest announcement or planning stage. The monthly baseline specification is as follows.

$$\ln(P_{it}) = \alpha + \sum_{b \neq r} \beta_b (DistanceBand_{ib} \times Post_t) + \mathbf{X}'_{it} \theta + \mu_i + \tau_t + \varepsilon_{it}$$

where P_{it} is the apartment transaction price per exclusive-use area for apartment complex i in month t , and $\ln(P_{it})$ is its natural logarithm. $DistanceBand_{ib}$ denotes the set of distance-band indicators, where b indexes the 500 m rings and the outer 2.00–2.50 km band is omitted as the

reference category r . $Post_t$ equals 1 in the post-opening period of the relevant rail shock and 0 in the corresponding pre-opening period. X_{it} is a vector of transaction-level housing controls, including exclusive-use area, floor level, building age, and the squared term of building age. μ_i denotes apartment-complex fixed effects, τ_t denotes month fixed effects, and ε_{it} is the error term. Standard errors are two-way clustered by apartment complex and month.

The coefficients of substantive interest are the interaction terms, β_b . Each β_b captures whether apartment prices in distance band b changed more or less after the relevant rail opening than prices in the outer 2.00–2.50 km comparison ring. In other words, the interaction coefficients represent differential post-line opening price changes across space within the same local housing submarket. These coefficients should therefore be interpreted as relative spatial differences in post-opening price changes.

This fixed-effects specification is appropriate because apartment-complex fixed effects absorb all time-invariant characteristics of each complex, while month fixed effects absorb shocks common to all transactions in each month. In panel DiD settings, unit fixed effects remove time-invariant heterogeneity and time fixed effects remove period-specific shocks shared across units (Abadie, 2005; Callaway & Sant’Anna, 2021).

Accordingly, although the spatial and temporal dimensions are conceptually defined using distance-band dummies and post-opening indicators, their main effects are not separately identified in the final fixed-effects specification. The distance-band indicators are time-invariant at the apartment-complex level and are therefore absorbed by the apartment-complex fixed effects. Likewise, the post-opening indicator is common to all observations within a given month and is therefore absorbed by the month fixed effects. As a result, the coefficients of substantive interest are the interaction terms between distance bands and the post-opening period. These interaction terms estimate whether apartment prices in each inner

distance band changed more or less than prices in the outer comparison ring after the rail opening, net of time-invariant complex characteristics and month-specific common shocks.

3.4.2. Parallel-trend diagnostic

The credibility of the difference-in-differences design depends on the parallel-trends assumption. The parallel-trends assumption states that the average change in untreated potential outcomes would have been the same across treated and comparison groups over time. In substantive terms, this assumption means that, in the absence of the rail opening, apartment prices in the inner distance bands and those in the outer comparison ring would have followed the same average time trend, even if their price levels differed at baseline (Abadie, 2005; Callaway & Sant'Anna, 2021). At the same time, this assumption is not directly testable in a strict causal sense because the untreated counterfactual path for the treated group is never observed. Researchers can inspect pre-treatment outcome patterns to assess whether the treated and comparison groups exhibit conspicuous divergence before treatment, but such evidence remains diagnostic rather than conclusive. In particular, recent methodological work emphasizes that conventional pre-trend tests often have low statistical power, so a failure to reject the null of no pre-trend does not by itself establish that the parallel-trends assumption holds (Roth, 2022). Moreover, event-study estimates can be informative about possible anticipation effects or visible pre-treatment divergence, but they cannot prove that the treated group's unobserved counterfactual trend was truly parallel to that of the comparison group (Marcus & Sant'Anna, 2021; Roth, 2022).

For that reason, this study treats the event-study exercise as a parallel-trend diagnostic rather than a formal test of identification. The specification replaces the single post-opening indicator with a sequence of leads and lags relative to the opening period and interacts them

with the distance-band indicators. This diagnostic is estimated separately for the SBD and the GG. The event-study uses a quarterly specification because the number of observations in some inner distance bands is too limited to support a stable monthly diagnostic. When transaction counts are sparse, highly disaggregated event-time estimates can become excessively noisy, making it difficult to distinguish meaningful pre-treatment movement from sampling volatility. Quarterly aggregation therefore provides a more stable and interpretable diagnostic presentation for assessing whether strong pre-opening divergence is evident across distance bands. Accordingly, this study employs an event-study specification as a parallel-trend diagnostic:

$$\ln(P_{it}) = \alpha + \sum_{b \neq r} \sum_{k \neq -1} \delta_{bk} (DistanceBand_{ib} \times EventTime_{kt}) + X'_{it}\theta + \mu_i + \tau_t + \varepsilon_{it}$$

where P_{it} is the apartment transaction price per exclusive-use area for apartment complex i at time t , $DistanceBand_{ib}$ denotes the set of 500 m distance-band indicators, r is the omitted outer 2.00–2.50 km reference ring, and $EventTime_{kt}$ indicates event time k relative to the rail opening. The period immediately before opening ($k = -1$) is omitted as the reference period. The coefficients δ_{bk} trace how the price gap between each inner band and the outer comparison ring evolves before and after the opening. Under a more credible DiD design, the pre-opening coefficients should not display strong or systematic directional movement relative to zero.

In the present study, the quarterly event-study figures provide diagnostic evidence that is broadly consistent with the DiD design (Figures 3 and 4). For the SBD, the pre-opening coefficients in the outer and intermediate bands remain relatively stable overall, although some closer bands display short-run fluctuation. For the GG, the pre-opening patterns are also not perfectly flat across all bands, but they do not indicate a level of systematic pre-treatment

divergence that would clearly invalidate the empirical design. Accordingly, the quarterly event-study is interpreted here as providing limited but useful diagnostic support for the DiD framework, while also indicating that estimates for the closest bands warrant more cautious interpretation. These results suggest that the parallel-trends assumption is not clearly contradicted at the quarterly level, especially for the outer and intermediate rings. At the same time, the nearest bands exhibit greater volatility and should therefore be interpreted with additional caution, particularly because thin observations in some pre-opening periods may make highly disaggregated pre-trend estimates more sensitive to sampling variability.

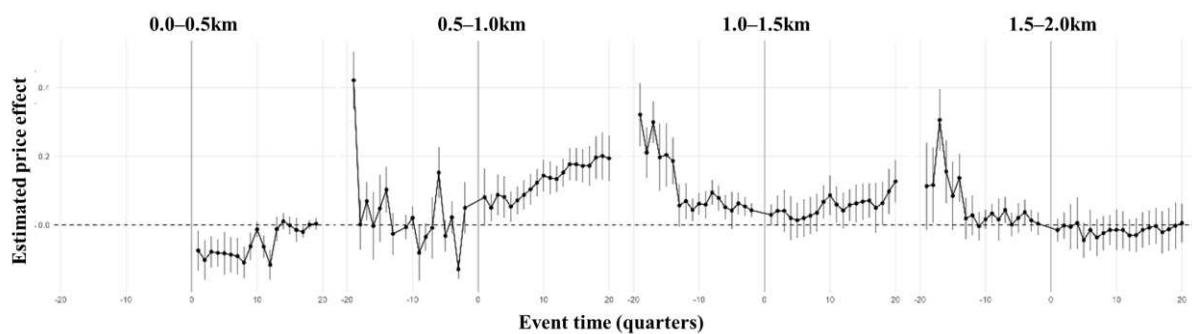


Figure 3. Quarterly event-study estimates of apartment price effects around the Shinbundang Line by 500 m distance bands (reference: 2.0–2.5 km).

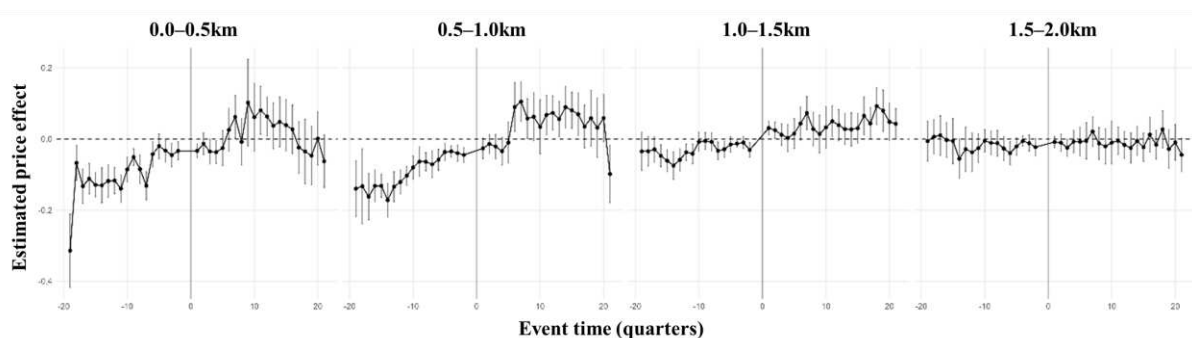


Figure 4. Quarterly event-study estimates of apartment price effects around the Gyeonggang Line by 500 m distance bands (reference: 2.0–2.5 km).

4. Results

4.1. Descriptive statistics

Table 4 presents descriptive statistics for apartment transactions across the three study phases: pre-SBD, post-SBD/pre-GG, and post-GG. The mean apartment price per exclusive-use area increased from 623.65 to 680.36 (10,000 KRW/m²) between the pre-SBD and post-SBD/pre-GG phases, and then rose further to 1,057.67 in the post-GG phase. The corresponding mean of the log-transformed apartment price also increased monotonically from 6.42 to 6.50 and then to 6.91. The descriptive characteristics of traded apartments also changed across phases. Mean exclusive-use area increased from 90.17 m² in the pre-SBD period to 94.51 m² in the post-SBD/pre-GG period and 98.66 m² in the post-GG period. Mean floor level rose slightly from 9.06 to 9.41 and 9.47, while mean building age remained similar between the first two phases at around 17 years and then increased to 20.52 years in the post-GG period.

Table 5 reports the distribution of transaction volumes across 500 m distance bands. Before the SBD opening, transactions were heavily concentrated in the outer rings, especially the 2.0–2.5 km band, which accounted for 2,693 of 5,495 transactions, or approximately 49.0% of the total. In the same period, no transactions were recorded in the 0.0–0.5 km band, and only 113 transactions occurred in the 0.5–1.0 km band. After the SBD opening, the number of transactions increased substantially to 10,967, and the inner rings began to account for a larger share of transactions, including 523 transactions in the 0–0.5 km band and 938 in the 0.5–1.0 km band. In the post-GG phase, total transaction volume increased further to 12,012, with continued concentration in the 1.0–1.5 km and 2.0–2.5 km bands. This descriptive evidence indicates that both prices and transaction volumes changed substantially over time. It also shows that the spatial distribution of transactions was uneven across phases.

478 **Table 4. Descriptive statistics of apartment attributes across study phases.**

Category		Unit	Pre-SBD (<i>N</i> = 5,495)				Post-SBD / Pre-GG (<i>N</i> = 10,967)				Post-GG (<i>N</i> = 12,012)			
			Mean	<i>SD</i>	Min	Max	Mean	<i>SD</i>	Min	Max	Mean	<i>SD</i>	Min	Max
Dependent variable	Apartment price	10,000 KRW/m ²	623.65	120.36	50.87	1,566.6	680.36	156.37	304.41	1,410.9	1057.67	348.38	372.27	2,540.6
	Log-transformed apartment price	ln(10,000 KRW/m ²)	6.42	0.19	3.93	7.36	6.5	0.23	5.72	7.25	6.91	0.32	5.92	7.84
Control variables	Area	m ²	90.17	40.3	28.16	244.56	94.51	33.74	28.16	265.55	98.66	36.5	28.16	265.55
	Floor	Floor	9.06	5.95	1	34	9.41	6.23	1	35	9.47	6.36	1	35
	Building age	Years	17.17	3.42	1	21	17.14	7.98	1	26	20.52	8.25	2	31

Abbreviations. SBD = Shinbundang Line; GG = Gyeonggang Line

Note. “Pre/Post” refer to line openings: Shinbundang Line on Oct 28, 2011; Gyeonggang Line on Sep 24, 2016.

479 **Table 5. Transaction volumes by distance band and phase.**

Category	0–0.5 km	0.5–1.0 km	1.0–1.5 km	1.5–2.0 km	2.0–2.5 km	Total
Pre-SBD	0	113	1,579	1,110	2,693	5,495
Post-SBD / Pre-GG	523	938	3,432	2,107	3,967	10,967
Post-GG	789	877	3,355	2,416	4,575	12,012
Total	1,312	1,928	8,366	5,633	11,235	28,474

Abbreviations. SBD = Shinbundang Line; GG = Gyeonggang Line

In particular, the absence of pre-SBD transactions in the 0.0–0.5 km ring implies that the closest band is descriptively thin for the first rail shock, which is important to keep in mind when interpreting the subsequent model estimates.

4.2. Difference-in-differences results

Table 6 reports the monthly difference-in-differences estimates from the final two-way fixed-effects specification. As noted in the model section, the main effects of distance bands and post-opening periods are absorbed by apartment-complex fixed effects and month fixed effects, respectively. Accordingly, the coefficients of substantive interest are the interaction terms between each distance band and the line-opening dummy, which indicate whether apartment prices in each inner band changed more or less than those in the reference band of 2.0–2.5 km after each rail opening. These estimates should be interpreted as relative post-opening price changes across distance bands within the Pangyo station-area market, rather than as comparisons with an entirely unaffected control area.

Table 6. Difference-in-differences estimates of apartment price effects by distance band.

Category	Variable	Coefficient (Robust SE)
Spatial variable	0–0.5 km	-
	0.5–1.0 km	-
	1.0–1.5 km	-
	1.5–2.0 km	-
	2.0–2.5 km	Reference
Temporal variable	SBD opening	-
	GG opening	-
Interaction variable	SBD opening × 0–0.5 km	-
	SBD opening × 0.5–1.0 km	0.158*** (0.037)
	SBD opening × 1.0–1.5 km	–0.037 (0.041)
	SBD opening × 1.5–2.0 km	–0.064 (0.035)
	SBD opening × 2.0–2.5 km	Reference
	GG opening × 0–0.5 km	0.084* (0.033)
	GG opening × 0.5–1.0 km	0.112** (0.036)
	GG opening × 1.0–1.5 km	0.060* (0.024)

	GG opening × 1.5–2.0 km	0.012 (0.024)
	GG opening × 2.0–2.5 km	Reference
Control variables	Area	–0.003*** (0.000)
	Floor	0.004*** (0.000)
	Building age	0.012 (0.027)
	Squared term of the building age	0.001*** (0.000)
	Constant	–
	R-squared	0.371

Abbreviations. SBD = Shinbundang Line; GG = Gyeonggang Line

Note1. * $p < .05$, ** $p < .01$, *** $p < .001$.

Note2. Two-way fixed effects with apartment-complex fixed effects and month fixed effects. Standard errors are clustered by apartment complex and month. Reference distance band = 2.0–2.5 km.

Note3. The constant is absorbed by the fixed effects and is therefore not separately reported.

The results suggest that the spatial patterns of post-opening price changes differed between the two line openings. For the SBD, only the 0.5–1.0 km band shows a statistically significant positive interaction effect ($\beta = 0.158, p < .001$), implying that apartment prices in this band increased more than those in the 2.0–2.5 km reference band after the opening. Interpreted as a percentage change, this corresponds to an additional increase of about 17.1% relative to the outer comparison ring. By contrast, the coefficients for the 1.0–1.5 km band and the 1.5–2.0 km band are not statistically significant at conventional levels. This means that, in the final specification, there is no statistically significant evidence that the SBD generated additional price appreciation beyond the reference band outside the 1.0 km zone. The coefficient for the 0.0–0.5 km band is not reported in the final table, and this should be interpreted cautiously considering the descriptive result that no pre-SBD transactions were observed in this closest ring.

The GG shows a broader pattern of positive differential post-opening price changes. The interaction term is positive and statistically significant in the 0.0–0.5 km band ($\beta = 0.084, p < .05$), the 0.5–1.0 km band ($\beta = 0.112, p < .01$), and the 1.0–1.5 km band ($\beta = 0.060, p < .05$). These coefficients correspond approximately to additional price increases of 8.8%,

11.8%, and 6.2%, respectively, relative to the 2.0–2.5 km comparison ring. In contrast, the coefficient for the 1.5–2.0 km band is small and statistically insignificant, indicating that the additional capitalization effect did not extend robustly into that outer-inner band. Thus, unlike the SBD, whose robust positive effect is concentrated in the 0.5–1.0 km band, the GG is associated with positive differential price changes across a wider zone extending to 1.5 km from Pangyo Station.

The control variables also behave largely as expected. Exclusive-use area has a negative coefficient ($\beta = -0.003$, $p < .001$), indicating that larger units tend to have lower prices per unit area, while floor level has a positive coefficient ($\beta = 0.004$, $p < .001$). Building age is not statistically significant in linear form, but the squared age term is positive and significant ($\beta = 0.001$, $p < .001$), which is consistent with a non-linear price–age relationship in the study area (Lee et al., 2005).

5. Discussion

5.1. Interpreting the differentiated capitalization patterns

This study set out to examine whether two rail openings at the same interchange node were associated with different patterns of housing-price capitalization according to their accessibility functions. The empirical results suggest that they were. Around Pangyo Station, the opening of the SBD is associated with a statistically significant additional price change only in the 0.5–1.0 km band relative to the 2.0–2.5 km reference ring, whereas the opening of the GG is associated with significant additional price changes across the 0.0–0.5 km, 0.5–1.0 km, and 1.0–1.5 km bands. In substantive terms, the SBD pattern appears more spatially concentrated, while the GG pattern appears broader in reach but smaller in magnitude by band. This contrast is consistent with the study’s expectation that rail investments should not be

treated as spatially homogeneous interventions, because their local market effects depend on how each line restructures accessibility rather than on station proximity alone (Debrezion et al., 2007; Gibbons & Machin, 2005).

The SBD result is most plausibly interpreted as a concentrated capitalization pattern associated with strengthened access to an already dominant metropolitan core. In the study design, the SBD is conceptualized as a core-oriented accessibility shock because it sharply improved Pangyo's connection to the GBD, one of the most important employment and commercial concentrations in the Seoul metropolitan area. Where new rail infrastructure enhances access to a strong existing center, the accessibility premium is likely to be capitalized most strongly where the time-saving benefit is most directly usable in everyday travel. This interpretation is consistent with work showing that transport improvements can intensify agglomeration advantages by reducing effective distance to major centers, while the resulting gains are often uneven across space and concentrated around locations best positioned to exploit those gains (Ahlfeldt & Feddersen, 2018; Givoni, 2006; Lakshmanan, 2011). In the present case, the fact that only the 0.5–1.0 km band remains significant suggests not a broad corridor-wide uplift, but a relatively narrow capitalization zone within the local housing submarket.

By contrast, the GG results point to a more spatially distributed pattern of capitalization. The significant interaction terms in the 0.0–0.5 km, 0.5–1.0 km, and 1.0–1.5 km bands indicate that the additional price changes associated with the GG opening were not confined to the immediate station-adjacent area. This wider footprint is consistent with the interpretation of the GG as a connectivity-expanding accessibility shock. Unlike the SBD, which primarily strengthened access to a pre-existing metropolitan core, the GG expanded eastward regional connectivity from Pangyo and added a different layer of network accessibility at the same node. Prior studies on HSR and intercity rail have repeatedly shown

that development outcomes vary depending on metropolitan integration, station position, and the type of connection established by the line, rather than following a uniform rule across all corridors (Mohino et al., 2019; Ureña et al., 2009). Read in that light, the broader GG pattern suggests that the market valued not only immediate station access but also the enlarged opportunity set associated with wider regional connectivity.

This difference between the two lines also clarifies an important theoretical point for the broader HSR–TOD discussion. The findings do not imply that one line type is categorically “stronger” than the other. Rather, they suggest that the spatial expression of accessibility gains differs by function. In this case, the core-oriented shock is associated with a sharper and more localized premium, whereas the connectivity-expanding shock is associated with a wider but more moderate premium across adjacent rings. This interpretation fits the broader literature showing that rail investments can generate heterogeneous land-market responses depending on network role, local market structure, and pre-existing accessibility conditions (Chen & Haynes, 2015; Debrezion et al., 2007; Mohino et al., 2019). It also helps explain why a single undifferentiated understanding of “HSR effects” is analytically inadequate. However, because both openings are observed at a single interchange node, this interpretation should be read as evidence from the Pangyo case rather than as a general test of line-function effects across rail systems.

5.2. Policy implications

The findings suggest two main policy implications. First, rail-led development should not be pursued through a uniform development template. The results of this study suggest that different rail functions may be associated with different spatial patterns of capitalization even at the same interchange node. This implies that planning and development strategies should be

differentiated according to the type of accessibility reorganization produced by each line, rather than treating all metropolitan rail investments as equivalent interventions. For a core-oriented line such as the SBD, where the additional price change is concentrated within the near-station area, the more appropriate strategy is a focused station-area approach: intensive pedestrian-centered design, fine-grained land-use mix, housing and commercial intensification within the immediate catchment, and targeted value-capture or housing-management tools in the areas where the premium is actually capitalized. This is broadly consistent with international TOD practice in dense metropolitan settings, where planning tools are often concentrated within a relatively tight station catchment. For example, Taipei's TOD strategy provided floor-area-ratio incentives for qualifying development within a 500 m radius of major transit stations, explicitly linking concentrated station-area development with land-value capture and transit-oriented urban form. Recent evidence from the Tokyo metropolitan area likewise suggests that the effective TOD extent tends to be smaller in central, high-density rail environments and larger in peripheral settings, indicating that station-area planning should vary by urban and network context rather than rely on a single fixed radius for all rail projects (Gao et al., 2024; Yen et al., 2023).

By contrast, for a connectivity-expanding line such as the GG, the policy priority should extend beyond a narrowly defined station-core model. Because the additional price changes in this study reach a broader set of distance bands, the relevant development strategy is not simply denser construction immediately adjacent to the station, but a wider framework of corridor coordination, feeder-system integration, secondary access improvement, and broader neighborhood linkage. In other words, where a line widens regional connectivity rather than merely deepening access to a single dominant core, the development response should also be spatially broader. This is consistent with prior work showing that station-area development around major rail investments varies according to metropolitan integration and the type of

connection created by the line. It is also reflected in current European practice. In the Grand Paris Express project, for example, the new network is explicitly tied not only to station construction but also to surrounding neighborhood transformation, public-space redesign, and mixed-use development around dozens of stations. The project's route was designed to support urban development across a large suburban geography, with hundreds of development projects located within Grand Paris station neighborhoods, illustrating a strategy much closer to connectivity-expanding regional integration than to a narrowly bounded core-station intensification model (Mohino et al., 2019; Société du Grand Paris, 2018).

Second, improved rail accessibility does not automatically produce balanced regional development. In some cases, faster and stronger connections to dominant metropolitan centers may instead intensify concentration by drawing population, firms, spending, and higher-order functions toward already advantaged core areas. This is the classic concern associated with the straw effect. Existing research has long warned that major transport investments can generate polarized accessibility gains, especially in monocentric systems where travel-time reductions are disproportionately oriented toward the main metropolis. Recent work on European rail accessibility notes that studies in countries such as France, Spain, and the UK have often found accessibility gains to be closely tied to reductions in travel time to the primary metropolis, raising concerns about uneven territorial effects. Related discussions in Taiwan's HSR experience have likewise framed straw effects as a real policy concern when high-speed connectivity strengthens the pull of larger urban centers rather than fostering distributed regional growth (Feng, 2014; Wenner & Thierstein, 2022).

For that reason, rail investment aimed at regional balance should not be treated as a self-executing development policy. If a new line improves accessibility but local employment, business ecosystems, and urban service functions remain weak, the likely result is easier outward commuting to stronger centers rather than autonomous local development. The policy

implication is that transport planning should be accompanied by complementary territorial measures, such as employment decentralization, strategic office and innovation functions near stations, industrial or service clustering policies, and land-use controls that help retain local activity. Internationally, the risk of straw effects has been discussed not only for HSR but also for other major transport infrastructures. Evidence from Korea's highway development, for example, found potential straw effects on local population and industry growth, reinforcing the broader point that accessibility gains alone do not guarantee territorially balanced outcomes. In that sense, the key lesson is not to avoid major rail investment, but to embed it within a wider framework of regional planning that can convert improved connectivity into locally anchored development rather than one-sided extraction toward the dominant core (Kim & Han, 2016).

5.3. Contributions, limitations, and directions for future research

This study contributes to the literature by showing that rail-induced housing-price effects are conditioned not only by station proximity but also by the functional role of the line within the wider metropolitan network. By comparing two sequential rail openings at the same interchange node, the study shows that a core-oriented accessibility shock and a connectivity-expanding accessibility shock are associated with different spatial patterns of capitalization within a shared local housing market. This contribution is relevant beyond the Korean case because many rapidly urbanizing or developing countries, as well as highly monocentric metropolitan systems, face similar pressures of concentrated growth, uneven accessibility, and corridor-led development. At the same time, the findings also speak to transit-mature contexts such as South Korea, where TOD is already institutionally well established, by suggesting that even in advanced rail-oriented planning systems, station-area development should not be guided by a single uniform template. Instead, the developmental implications of rail investment

depend on whether a line primarily reinforces access to an existing core or broadens connectivity across a wider regional geography (Ahlfeldt & Feddersen, 2018; Debrezion et al., 2007; Mohino et al., 2019; Ureña et al., 2009).

At the same time, several limitations should be acknowledged. First, this study focuses on a single interchange node, Pangyo Station, and the findings should therefore not be generalized mechanically to other station areas. The Pangyo case is analytically useful because it allows a comparison of two sequential rail openings within the same local market context, but the magnitude and spatial reach of capitalization effects are likely to vary across places depending on land-use conditions, pre-existing accessibility, market structure, and metropolitan position (Debrezion et al., 2007; Mohino et al., 2019). More importantly, the single-node design limits the ability to separate line-function effects from Pangyo-specific dynamics and overlapping local market conditions. The present findings should thus be understood as evidence from a strategically selected case rather than as a universal pattern applicable to all rail-served areas.

Second, the identification strategy is constrained by limited transaction availability in some bands, most notably the 0.0–0.5 km band for the SBD, where transaction counts were too sparse to support a stable estimate in the final specification. More broadly, the event-study diagnostics do not support a strong claim that parallel trends are fully satisfied across all distance bands. Although the pre-treatment patterns do not indicate uniform and systematic divergence, some bands show instability, and the diagnostic power of pre-trend tests is limited when observations are thin or noisy. Recent DiD scholarship likewise cautions that pre-trend tests should be interpreted as diagnostic rather than definitive evidence of identification (Marcus & Sant’Anna, 2021; Roth, 2022). Accordingly, the results should be read as providing cautious quasi-causal evidence rather than unconditional causal proof.

Third, the empirical design uses the official opening dates as treatment timing, although both projects had long planning, approval, and construction histories. As a result, some accessibility gains may have been partially capitalized before service began, and the estimates may not capture the full capitalization process from the earliest announcement or planning stage. This limitation is particularly relevant in station-area housing markets, where expectations about future accessibility improvements can be incorporated into prices before actual operation begins.

Fourth, the analysis relies on repeated cross-sectional transaction data rather than repeat-sales data at the individual unit level. While the model includes key structural controls and apartment-complex fixed effects to absorb observed and time-invariant heterogeneity, some compositional change in transacted units may still remain. In addition, transaction-based estimates may reflect not only changes in willingness to pay for accessibility but also changes in the mix of units brought to market over time. Future research could address these limitations by using repeat-sales data, finer network-based accessibility measures, alternative comparison areas, announcement-based treatment timing, and explicit spatial spillover models to test whether the differentiated capitalization patterns identified here remain robust under stricter measurement conditions.

6. Conclusion

This study examined whether two rail openings with different accessibility functions were associated with different housing-price capitalization patterns around the same interchange node. Focusing on Pangyo Station, where the SBD and the GG were introduced sequentially, the analysis compared two distinct accessibility shocks within a shared local housing market. The results suggest that the two openings were not associated with the same

spatial pattern of capitalization. Overall, the SBD was associated with a more localized and selective price response, whereas the GG was associated with a broader pattern extending across a wider set of distance bands. In substantive terms, the findings suggest that rail-induced housing-price effects are shaped not only by proximity to a station but also by the functional role of the line within the wider metropolitan network.

This distinction is important because it suggests that rail infrastructure should not be treated as a spatially homogeneous intervention. In the present case, the SBD functioned primarily as a core-oriented shock that strengthened access to a dominant metropolitan center, while the GG functioned as a connectivity-expanding shock that widened access across a broader regional geography. The implication is that even when two lines intersect at the same node, the geography of capitalization may differ according to how each line reorganizes relative accessibility. This point extends the literature by showing that differentiated rail functions may be associated with differentiated housing-market responses even within the same local context.

The broader significance of the study lies in its relevance to metropolitan regions facing concentrated growth, uneven accessibility, and corridor-led development pressure. For rapidly urbanizing countries, strongly monocentric urban systems, and even transit-mature contexts such as South Korea, the findings suggest that rail-led development should not be approached through a single uniform station-area template. Instead, planning responses should be differentiated according to whether a line primarily reinforces access to an existing core or broadens connectivity across a wider regional geography. In this respect, the study contributes not only to the empirical literature on transport capitalization but also to the planning discussion on how rail investment may translate into different forms of urban development pressure.

At the same time, the results should be interpreted with appropriate caution. Because the analysis is based on a single interchange node, because some near-station bands—especially the 0.0–0.5 km band for the SBD—contained limited transactions, because the official opening dates may not capture the full process of expectation-driven capitalization, and because the study relies on transaction data rather than repeat-sales data, the findings are better understood as case-based evidence of differentiated capitalization patterns than as universally generalizable estimates. Even so, the Pangyo case illustrates that the developmental meaning of rail investment depends not only on whether accessibility improves, but also on what kind of accessibility is being produced.

References

- Abadie, A. (2005). Semiparametric difference-in-differences estimators. *The Review of Economic Studies*, 72(1), 1–19. <https://doi.org/10.1111/0034-6527.00321>
- Ahlfeldt, G. M., & Feddersen, A. (2018). From periphery to core: Measuring agglomeration effects using high-speed rail. *Journal of Economic Geography*, 18(2), 355–390. <https://doi.org/10.1093/jeg/lbx005>
- Callaway, B., & Sant’Anna, P. H. (2021). Difference-in-differences with multiple time periods. *Journal of Econometrics*, 225(2), 200–230. <https://doi.org/10.1016/j.jeconom.2020.12.001>
- Cervero, R., & Kockelman, K. (1997). Travel demand and the 3Ds: Density, diversity, and design. *Transportation Research Part D: Transport and Environment*, 2(3), 199–219. [https://doi.org/10.1016/S1361-9209\(97\)00009-6](https://doi.org/10.1016/S1361-9209(97)00009-6)
- Chen, Z., & Haynes, K. E. (2015). Impact of high-speed rail on housing values: An observation

754 from the Beijing–Shanghai line. *Journal of Transport Geography*, 43, 91–100.
755 <https://doi.org/10.1016/j.jtrangeo.2015.01.012>

756 Clapp, J. M., & Lindenthal, T. (2022). Urban land valuation with bundled good and land
757 residual assumptions. *Journal of Housing Economics*, 58, 101872.
758 <https://doi.org/10.1016/j.jhe.2022.101872>

759 Comber, S., & Arribas-Bel, D. (2017). Waiting on the train: The anticipatory (causal) effects of
760 Crossrail in Ealing. *Journal of Transport Geography*, 64, 13–22.
761 <https://doi.org/10.1016/j.jtrangeo.2017.08.004>

762 Debrezion, G., Pels, E., & Rietveld, P. (2007). The impact of railway stations on residential and
763 commercial property value: A meta-analysis. *The Journal of Real Estate Finance and*
764 *Economics*, 35(2), 161–180. <https://doi.org/10.1007/s11146-007-9032-z>

765 Dittmar, H., & Ohland, G. (Eds.). (2004). *The new transit town: Best practices in transit-*
766 *oriented development*. Island Press.

767 Feng, C. M. (2014). New prospects of transportation mobility. *IATSS Research*, 38(1), 22–26.
768 <https://doi.org/10.1016/j.iatssr.2014.05.005>

769 Gao, Y., Cui, X., & Sun, X. (2024). Land Use Characteristics of Commuter Rail Station Areas
770 and Their Impact on Station Ridership: A Case Study of Japan Railways in the Tokyo
771 Metropolitan Area. *Land*, 13(12), 2045. <https://doi.org/10.3390/land13122045>

772 Gibbons, S., & Machin, S. (2005). Valuing rail access using transport innovations. *Journal of*
773 *Urban Economics*, 57(1), 148–169. <https://doi.org/10.1016/j.jue.2004.10.002>

774 Givoni, M. (2006). Development and impact of the modern high-speed train: A review.
775 *Transport Reviews*, 26(5), 593–611. <https://doi.org/10.1080/01441640600589319>

776 Gyeonggi Railroad Co., Ltd. (2024). Project status update.
777 http://www.shinbundang2.co.kr/menu1_2.php

778 Hyun, D., & Milcheva, S. (2019). Spatio-temporal effects of an urban development
779 announcement and its cancellation on house prices: A quasi-natural experiment. *Journal*
780 *of Housing Economics*, 43, 23–36. <https://doi.org/10.1016/j.jhe.2018.09.008>

781 Kim, J. Y., & Han, J. H. (2016). Straw effects of new highway construction on local population
782 and employment growth. *Habitat International*, 53, 123–132.
783 <https://doi.org/10.1016/j.habitatint.2015.11.009>

784 Korea Research Institute for Human Settlements. (2007). 2020 area-wide urban planning for
785 the capital region. *KRIHS Gazette*, 29.

786 Lakshmanan, T. R. (2011). The broader economic consequences of transport infrastructure
787 investments. *Journal of Transport Geography*, 19(1), 1–12.
788 <https://doi.org/10.1016/j.jtrangeo.2010.01.001>

789 Lee, B. S., Chung, E. C., & Kim, Y. H. (2005). Dwelling age, redevelopment, and housing
790 prices: The case of apartment complexes in Seoul. *Journal of Real Estate Finance and*
791 *Economics*, 30(1), 55–80. <https://doi.org/10.1007/s11146-004-4831-y>

792 Marcus, M., & Sant’Anna, P. H. (2021). The role of parallel trends in event study settings: An
793 application to environmental economics. *Journal of the Association of Environmental*
794 *and Resource Economists*, 8(2), 235–275. <https://doi.org/10.1086/711509>

795 Ministry of Land, Infrastructure and Transport. (2016, August 30). *Construction of the Sinsa-*
796 *Gangnam section of the Shinbundang Line extension* [Press release]. Ministry of Land,
797 Infrastructure and Transport.
798 https://www.molit.go.kr/USR/NEWS/m_71/dtl.jsp?lcmspage=1&id=95077946

799 Ministry of Land, Infrastructure and Transport. (2017, November 27). *Wonju–Gangneung*
800 *railway to open on December 22 (Friday)* [Press release]. Ministry of Land,
801 Infrastructure and Transport.
802 https://www.molit.go.kr/USR/NEWS/m_71/dtl.jsp?lcmspage=2&id=95079982

803 Ministry of Land, Infrastructure, Transport and Tourism. (2024). *What is TOD*. Government of
804 Japan. <https://www.mlit.go.jp/report/press/content/001747258.pdf>

805 Mohíno, I., Delaplace, M., & de Ureña, J. M. (2019). The influence of metropolitan integration
806 and type of HSR connections on developments around stations: The case of cities
807 within one hour from Madrid and Paris. *International Planning Studies*, 24(2), 156–
808 179. <https://doi.org/10.1080/13563475.2018.1524289>

809 Rennert, L. (2022). A meta-analysis of the impact of rail stations on property values: Applying
810 a transit planning lens. *Transportation Research Part A: Policy and Practice*, 163, 165–
811 180. <https://doi.org/10.1016/j.tra.2022.06.013>

812 Roth, J. (2022). Pretest with caution: Event-study estimates after testing for parallel
813 trends. *American Economic Review: Insights*, 4(3), 305–322.
814 <https://doi.org/10.1257/aeri.20210236>

815 Société du Grand Paris. (2018). *Greenhouse gas emissions balance of the Grand Paris Express*
816 *project (2018 update)*. [https://www.societedesgrandsprojets.fr/sites/default/files/2024-](https://www.societedesgrandsprojets.fr/sites/default/files/2024-09/Greenhouse%20gas%20emissions%20balance%20of%20the%20Grand%20Paris%20Express%20project%20%282018%20update%29%20EN.pdf)
817 [09/Greenhouse%20gas%20emissions%20balance%20of%20the%20Grand%20Paris%2](https://www.societedesgrandsprojets.fr/sites/default/files/2024-09/Greenhouse%20gas%20emissions%20balance%20of%20the%20Grand%20Paris%20Express%20project%20%282018%20update%29%20EN.pdf)
818 [0Express%20project%20%282018%20update%29%20EN.pdf](https://www.societedesgrandsprojets.fr/sites/default/files/2024-09/Greenhouse%20gas%20emissions%20balance%20of%20the%20Grand%20Paris%20Express%20project%20%282018%20update%29%20EN.pdf)

819 Statistics Korea. (2024, July 29). *Results of the 2023 Population and Housing Census*
820 *(complete enumeration)*. Korea Policy Briefing.
821 <https://www.korea.kr/briefing/policyBriefingView.do?newsId=156643294>

- 822 Transport for London, & Department for Transport. (2022). *Crossrail Baseline Evaluation –*
823 *Economy, Planning and Regeneration Impacts Report*.
824 <https://content.tfl.gov.uk/economy-planning-and-regeneration-report-acc.pdf>
- 825 Ureña, J. M., Menerault, P., & Garmendia, M. (2009). The high-speed rail challenge for big
826 intermediate cities: A national, regional and local perspective. *Cities*, 26(5), 266–279.
827 <https://doi.org/10.1016/j.cities.2009.07.001>
- 828 Wenner, F., & Thierstein, A. (2022). High speed rail as urban generator? An analysis of land
829 use change around European stations. *European Planning Studies*, 30(2), 227–250.
830 <https://doi.org/10.1080/09654313.2021.1946485>
- 831 Yajima, T., & Ieda, H. (Eds.). (2020). *TOD practice in Japan: Tokyo, a global city created by*
832 *railways*. Ministry of Land, Infrastructure, Transport and Tourism.
- 833 Yen, B. T., Feng, C. M., & Lee, T. C. (2023). Transit-oriented development strategy in Taiwan:
834 An application of land value capture. *Asian Transport Studies*, 9, 100094.
835 <https://doi.org/10.1016/j.eastsj.2022.100094>