

Research on AI-driven Research on Spatial Vitality Identification and Micro-renewal Mechanism of Commercial Districts in China and South Korea

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Abstract: Amid rapid advances in artificial intelligence, regeneration of historic commercial districts is shifting from experience-based intervention to data-informed decision-making. Comparing Myeongdong business district in Seoul and the ZhongLou business district in Xi'an, this study integrates spatial production theory, urban vitality theory, and micro-renewal into an AI-driven "spatial perception-vitality identification-renewal feedback" framework. Historical street-view imagery, POIs, field surveys, ArcGIS data, and consumer behavior data are used to reconstruct ground-floor commercial changes from 2008 to 2025. Computer vision, text classification, spatial statistics, and stage-based comparison assess business types, vacancy, street interfaces, accessibility, and activity intensity. Results show that multi-source data integration reveals street-segment relationships among spatial form, pedestrian activity, and consumer behavior. The ZhongLou district displays stronger node-based commercial agglomeration, while Myeongdong performs better in pedestrian continuity and public-space quality. Both face vitality decline under external shocks, functional homogenization, and uneven active frontages. Accordingly, the study proposes context-sensitive strategies for vacant-space reuse, functional diversification, pedestrian-interface repair, and adaptive monitoring.

Keywords: Commercial Districts, Spatial Vitality identification, Artificial Intelligence (AI).

1. Introduction

Street vitality is a key expression of vitality at both district and city scales, and it is especially consequential in streets undergoing regeneration. At the ground-floor level, the density and mix of business types, storefront transparency, and tenant turnover directly shape pedestrians' visual perception and activity choices.

Gehl (2010) links urban vitality to the diversity of pedestrian behavior, opportunities for staying, and continuity across time. Lefebvre's theory of the production of space further distinguishes spatial practice (perceived space), representations of space (conceived space), and representational space (lived space). Together, these perspectives show that vitality can be reduced neither to pedestrian volume nor to a static property of urban form.

At the level of spatial practice, business district are undergoing a dual transition: e-commerce, high rents, changing tourism markets, and the COVID-19 pandemic have destabilized established retail structures.

At the level of representations of space, planning and urban-regeneration policies have shifted intervention from large-scale demolition toward small, reversible, and incremental actions.

At the level of representational space, social groups' experiences, identities, and cultural responses drive the social reconstruction of space through interactions between capital and power.

This study focuses on the dynamic coupling among these three dimensions to clarify how spatial vitality is produced in business districts. By combining quantitative analysis of

pedestrian activity across space and time with qualitative interpretation of spatial narratives, it develops an integrated framework linking the physical environment, policy direction, and social perception. The framework helps reveal negotiation among multiple actors and supports more inclusive and sustainable regeneration capable of strengthening endogenous vitality and cultural resilience.

Conventional surveys remain essential, but their low frequency cannot capture rapid tenant turnover. POIs can represent functional supply, pedestrian heatmaps can approximate activity intensity, street-view imagery can record interface conditions, and online reviews can indicate aspects of lived experience. Integrating these urban data sources extends the temporal and spatial scope of observation.

Three gaps remain in the literature. First, many studies rely on single-year grid data and therefore cannot explain storefront-scale transformation. Second, cross-national comparisons often contrast aggregated indicators without harmonizing platform-specific business classifications or observation dates. Third, AI-based diagnosis is rarely connected to explicit micro-renewal decisions. This study therefore asks: How did street-front business structures and spatial vitality change in Myeongdong and the ZhongLou business district between 2008 and 2025? How do the cases differ in spatial form, behavioral activity, and consumption mechanisms? How can AI-assisted diagnosis be translated into feasible, low-disruption micro-renewal actions?

The contribution is a comparative workflow rather than a fully automated planning system. AI accelerates storefront detection, optical character recognition, semantic labeling, and change detection, while researchers review ambiguous labels and interpret policy contexts. This human-in-the-loop approach improves traceability and avoids treating platform

classifications as ground truth.

2. Methodology

2.1 Cases and Longitudinal Data

Myeongdong in Seoul and the ZhongLou business district in Xi'an are historic central-city commercial areas with strong symbolic value, intensive tourism, and substantial restructuring since 2008. Myeongdong is characterized by small blocks, dense street-front retail, and international tourism. In 2012, its mean hourly pedestrian volume reached 5,869, approximately 15 times the Seoul average, after which the district was designated for pedestrian-environment improvements (Seoul Metropolitan Government, 2013). Located within the Xi'an City Wall, the ZhongLou district combines department stores, shopping centers, heritage attractions, and distinctive alley networks. In 2023, the Beilin District's "one axis and three zones" policy area contained eight large commercial complexes and nearly 2,000 merchants (Xi'an Daily, 2024), indicating strong but node-centered commercial agglomeration.

The unit of analysis is every street-visible ground-floor commercial premise on both sides of the selected core streets. For large buildings, only units directly visible or accessible from the street were coded. Historical street-view imagery from KakaoMap, Amap, and Baidu Maps was aligned with the observation nearest each stage boundary. Missing years were cross-validated using historical POI archives, business directories, news records, and field photographs. Field surveys in 2022, 2023, and 2025 verified current street interfaces, vacancy, and pedestrian conditions.

Using China's Classification of Retail Formats (GB/T 18106-2021) as a reference, platform categories were cross-walked into nine comparable classes: fashion, sports, beauty, accessories, food, electronics, public services, daily goods, and non-operating premises.

Table 1: Multi-source data, derived indicators, and analytical roles

Data source	Derived indicators	Analytical role
Street-view imagery	Business type; vacancy; transparency	Perceived space
POIs	Density; diversity; tenant turnover	Functional supply
ArcGIS	Integration; choice; path continuity	Accessibility
Pedestrian heatmaps	Time-specific relative pedestrian intensity	Activity demand
Review data	Volume; ratings; sentiment; experiential terms	Lived space

2.2 AI-Driven Vitality Identification

The workflow comprises three linked stages (Figure 1). During spatial perception, candidate storefronts are detected in street-view imagery, a vision-language model proposes business categories, and semantic segmentation estimates street-front building interfaces and pedestrian space. POIs are then matched to facades by name, distance, and address; low-confidence or temporally inconsistent records are manually reviewed. The process produces a longitudinal storefront inventory and interface metrics for each street segment.

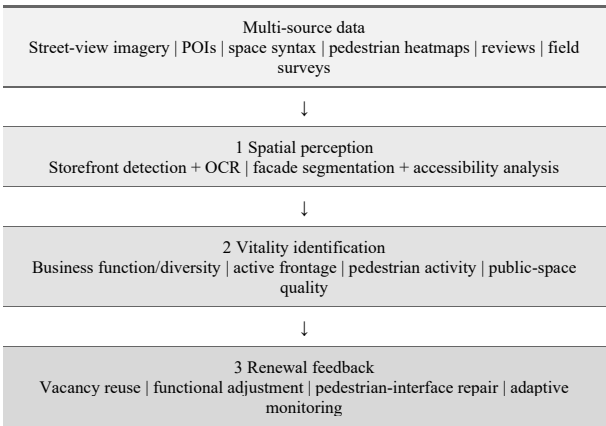


Figure 1: AI-driven framework of spatial perception, vitality identification, and renewal feedback

Vitality identification integrates five standardized dimensions: functional vitality F (active-frontage ratio, shop density, and Shannon diversity), morphology and accessibility M (integration, choice, interface continuity, and enclosure), pedestrian activity P , consumer response C (review activity and sentiment), and public-space quality Q (effective walking width, transparency, greenery, and seating). For street segment s at time t , the composite diagnostic score is $V(s,t) = 0.20[F(s,t) + M(s,t) + P(s,t) + C(s,t) + Q(s,t)]$.

Equal weights are used in this comparative experiment to avoid imposing market-specific preferences, while the five component scores remain available for policy users to reweight. Platform-dependent variables are standardized separately within each city and observation period; the comparison therefore emphasizes spatial patterns and trajectories rather than absolute cross-platform counts.

2.3 Comparative Analysis

Each case is divided into three stages according to breakpoints in business composition, vacancy, and active frontage. Transition matrices identify persistence and conversion among business types, and hotspot overlays test whether functional density, pedestrian intensity, and consumer response co-locate with highly accessible street segments. The spatial-production triad is then used to interpret differences: observable form and pedestrian movement represent perceived space, planning and commercial policy represent conceived space, and online reviews and experiential uses represent lived space. The method identifies association and temporal co-occurrence rather than strict causal effects.

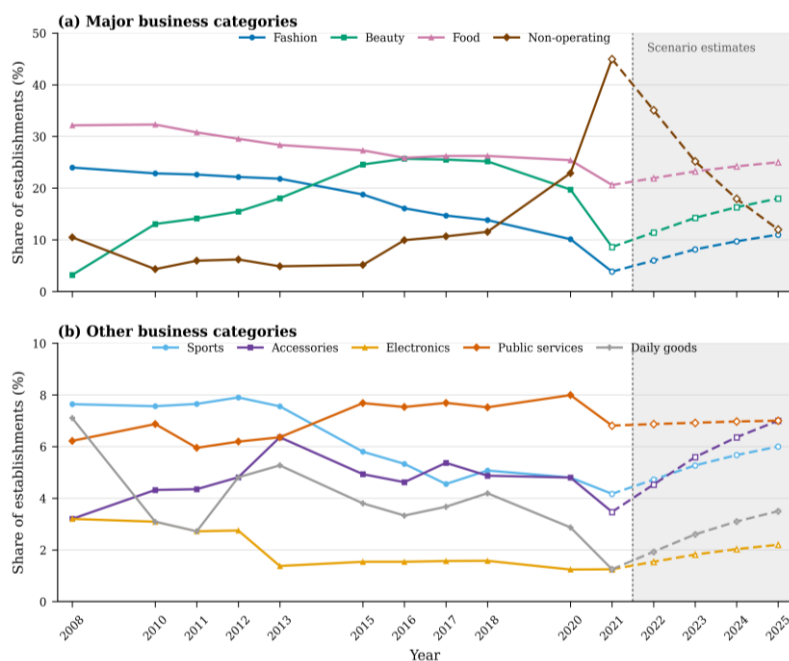
3. Results

3.1 Business-Type Evolution, 2008-2025

The reconstructed series indicates a demand-driven path of specialization and recovery in Myeongdong. Between 2008 and 2016, cosmetics progressively replaced local retail and food-service uses; the storefront inventory shows an increase from 43 cosmetics stores in 2008 to approximately 151 in 2013. From 2016 to 2019, high rents and dependence on international tourism reinforced high-margin specialization but reduced commercial resilience.

The pandemic then produced an exceptional vacancy shock. The scenario trajectory for 2022-2025 indicates contracting vacancy and diversification toward an experiential mix of Korean beauty, fashion, food, lifestyle goods, and

visitor-oriented convenience retail. Recovery thus involves not only reoccupation but also a semantic repositioning from volume shopping toward experience consumption.



Solid lines: values transcribed from the source figure (2008-2021); dashed lines and gray shading: scenario estimates (2022-2025).

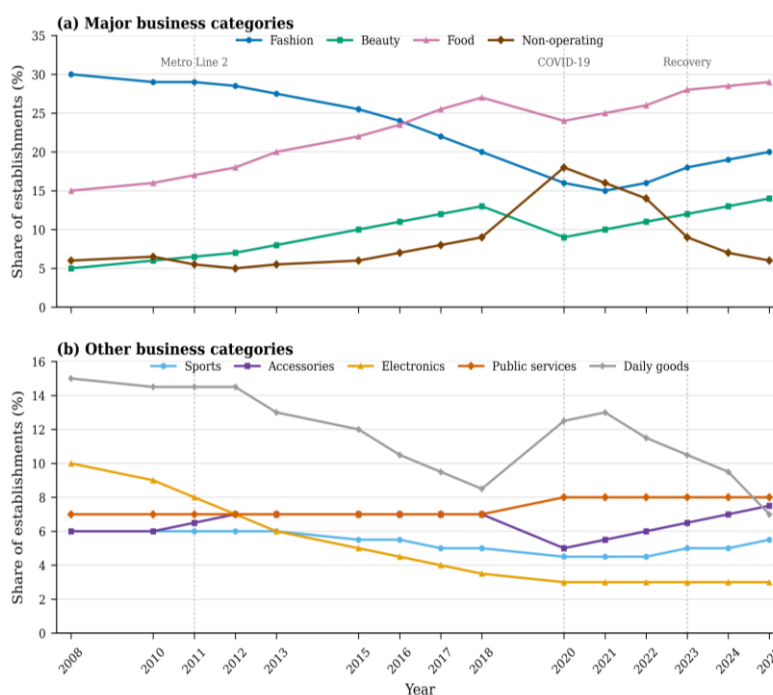
Figure 2: Changes in the business-type composition of Myeongdong, 2008-2025

Notes: Solid lines represent values transcribed from the source figure for 2008-2021; dashed lines and gray shading indicate scenario estimates for 2022-2025.

Development-history-based scenario estimates suggest that the ZhongLou business district followed a path of structural decline and selective micro-renewal. From 2008 to 2012, department stores and street-front retail remained the principal anchors, commercial continuity.

Between 2013 and 2019, department-store closures and competition from emerging subcenters increased inactive

frontage and fragmented connections between destinations. From 2020 to 2025, small cultural and leisure streets around FenXiang and XiangZi Temple appeared although East Avenue redevelopment weakened to recover first as food, cafes, bars, cultural retail, and nighttime uses expanded; established shopping centers also introduced beauty, lifestyle, and new dining brands. The result is partial recovery without systematic reconstruction of the wider commercial network.



All values are development-history-based scenario estimates for the Bell Tower-South Avenue core commercial district; they are not field observations.

Figure 3: ZhongLou-South Avenue business-type scenario. All values are development-history-based scenario estimates rather than field observations

3.2 Comparative Mechanisms of Spatial Vitality

AI-assisted overlay analysis helps explain why commercial scale and street vitality do not always move together.

In the ZhongLou business district, POIs and pedestrian hotspots cluster around large commercial complexes, metro entrances, and heritage attractions, producing strong node-based agglomeration. Street segments between these nodes, however, score lower in active frontage and public-space quality, particularly where wide intersections, underpasses, or enclosed shopping-center facades interrupt pedestrian sequences. The district therefore contains abundant commercial resources but distributes them unevenly.

Table 2: Comparative diagnosis of spatial vitality in the Korean and Chinese cases.

Dimension	Myeongdong	ZhongLou district
Agglomeration	Fine-grained; high turnover	Strong node-based clustering
Pedestrian environment	Continuous, walkable network	High flows; interrupted connections
Public space	Relatively continuous frontage	Uneven shade, seating, and frontage
Primary risk	Tourism dependence and rent volatility	Anchor decline and spatial fragmentation
2025 condition	Broad experience-oriented recovery	Localized alley-oriented recovery

Myeongdong shows a finer-grained correspondence between accessibility and active frontage. Small blocks, dense entrances, and pedestrian-oriented streets sustain continuous street interaction even when individual tenants change. Pedestrian activity and public-space scores are generally higher than in the ZhongLou business district, while functional scores fluctuate more strongly in response to tourism demand and rent. Myeongdong's early concentration of cosmetics stores and the ZhongLou business district's dependence on department stores represent different forms of homogenization: category concentration across many small units in the former and anchor concentration within large units in the latter.

3.3 Shared Challenges

The comparison reveals three shared challenges. First, vitality is sensitive to external shocks: a collapse in international tourism can generate vacancy in Myeongdong, while shifts in the urban commercial hierarchy can weaken the ZhongLou business district. Second, rapid replication of high-margin formats can reduce functional diversity and erode local identity. Third, high aggregate pedestrian volumes can conceal low-vitality street segments.

These findings support diagnosis at the street-segment scale rather than reliance on a single district-wide score. Urban form, commercial operation, and lived experience must be interpreted together: a busy destination may still lack pedestrian continuity, while a visually upgraded street may remain commercially fragile.

4. Conclusion

The comparison extends urban-vitality theory in two ways. First, it distinguishes commercial agglomeration from

street-network continuity. Large anchors in the ZhongLou business district generate strong concentration effects, whereas Myeongdong's fine-grained network more consistently converts pedestrian movement into visible street activity. Second, it operationalizes spatial production as measurable relationships: policy and investment shape conceived and accessible form; perceived form guides pedestrian behavior; and lived experience appears through consumer choice and online reviews. Imbalance emerges when one layer dominates, for example when commercial intensity is high but public space is weak, or when tourism demand is strong but tenant structure is highly homogeneous.

The study has four limitations. First, historical imagery dates are not fully synchronized across platforms. Second, heatmaps and review indicators are relative and cannot support absolute cross-national comparisons. Third, the storefront inventory excludes upper-floor uses and online-only businesses. Fourth, AI labels still require manual review when signs are obscured, multilingual, or outdated. The analysis can therefore identify robust comparative trends but cannot estimate the causal effects of renewal. Future research should report intercoder reliability, model precision and recall, storefront-level panel data, and before-and-after evaluation of implemented micro-renewal projects.

Where high density coincides with low diversity, incentives should support cultural uses, daily services, and independent businesses. Where destination intensity is high but route continuity is weak, crossings, wayfinding, and ground-floor permeability should be improved. Stable and balanced street segments require continued monitoring rather than physical intervention.

For Myeongdong, the priority is to retain post-pandemic functional diversity while preventing a new monoculture. Storefront-scale renewal should support small independent operators, reactivate vacant premises on side streets, manage pedestrian congestion, and distribute visitor-oriented programs from the main axis into surrounding streets.

For the ZhongLou business district, the priority is to connect high-intensity commercial anchors with vital alley networks. Enclosed department-store frontages can be subdivided into visible short-lease units. Continuous shade, seating, crossings, and nighttime way-finding should link metro entrances, heritage attractions, shopping centers, and cultural alleys. Cultural and experiential uses should be located along low-vitality connectors rather than concentrated only at destination nodes.

This study develops an AI-assisted, human-verified workflow of spatial perception, vitality identification, and renewal feedback. Longitudinal comparison identifies two distinct trajectories: Myeongdong shifted from general retail to cosmetics specialization and then toward an experience-oriented mix, whereas the ZhongLou business district moved from department-store dominance to frontage decline and localized alley-based recovery.

The ZhongLou business district exhibits stronger node-based commercial agglomeration, while Myeongdong provides better pedestrian continuity and public-space quality. Both

cases face uneven spatial vitality and the risk of functional homogenization. Micro-renewal should therefore respond to street-segment diagnosis by reusing vacant premises, diversifying functions, repairing pedestrian interfaces, connecting isolated commercial anchors, and continuously monitoring change after intervention.

Fund

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References

- [1] Sun Yu, From Direction to Path: Thinking about the Active Development of Urban Streets in China, *Architectural Journal*, 2020 (S1): 154-158
- [2] Lefebver H. The production of space[M]. Oxford, UK: Blackwell, 1991.
- [3] Zhou Min, Spatial Development Characteristics and Transformation Implications of Manufacturing in the London Metropolitan Area from the Perspective of Spatial Production Theory. [J/OL]. *Urban Planning International*, 1-18[2026-08-23]. <https://doi.org/10.19830/j.upi.2024.731>.
- [4] <https://news.seoul.go.kr/traffic/archives/13957>
- [5] Gehl, J. (2010) *Cities for People*. Washington, DC: Island Press.
- [6] Hillier, B. and Hanson, J. (1984) *The Social Logic of Space*. Cambridge: Cambridge University Press.
- [7] Jacobs, J. (1961) *The Death and Life of Great American Cities*. New York: Random House.
- [8] Korea Real Estate Board (2025) *Commercial Real Estate Lease Trend Survey: Vacancy Rates by Commercial District*. Korean Statistical Information Service.