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# Environmental and Other Co-benefits of Developing a High Speed Rail System in California: A Prospective Vision 2010-2050

## Symposium

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## California High Speed Rail and Economic Development

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## Abstract

Investment in California's proposed High-Speed Rail (HSR) system has been justified partly on economic grounds, as a potential stimulus to employment and income growth. However, international experiences raise questions about the net economic development impacts of these costly mega-investments. Do they largely redistribute growth and investment, or do they have truly generative economic effects by virtue of the accessibility and agglomeration benefits they confer? This remains a largely open question for California, though one which is too important to ignore. This paper examines job and labor market profiles of 26 proposed HSR station-areas in California in 2002 and 2008. These trends are compared to experiences around Shinkansen HSR stations in Japan. Empirical findings on corridor-level job distributions, cross-industrial typologies, and station-level density gradients suggest that the new HSR project is likely to induce knowledge- and service-based business agglomeration benefits, though these are mostly limited to large, globally connected cities. Growth can also shift to HSR-served edge cities, airports, and leisure-entertainment hubs. Such shifts, however, could be at the expense of small intermediate cities. This paper concludes that the spatial redistributive effects of California's HSR investment need not be a simple "zero-sum" game. When leveraged through far-sighted, proactive public policies, increased agglomerations that take form through redistribution can indeed have "generative" (i.e., real) economic qualities, to the benefit of the state at large.

## 1. Introduction

In the United States, there has been growing interest in building High-Speed Rail (HSR) systems as an economic stimulus. Following the American Recovery and Reinvestment Act (ARRA) of 2009, the Obama Administration committed US$8 billion to HSR projects on 13 corridors across 31 states. California is slated to be the largest beneficiary, to receive a federal contribution of $2.34 billion. The passage of Proposition 1A in 2008 contributes further financial support, authorizing US$9.95 billion in the state's general obligation bonds toward the project. Still, these sums fall far short of the $45+ billion price tag of the project, which critics claim will rise even more over time. However, California's foray into HSR infrastructure has its backers. According to America 2050's assessment, HSR corridors between Los Angeles, San Francisco, San Diego, San Jose, and Sacrament are all ranked in the top 50 city-pairs in terms of potential HSR ridership (Hagler and Todorovich, 2009).

The California HSR system, initially running from San Francisco to Los Angeles/Anaheim via the Central Valley (at an estimated cost of US$45 billion) and later to Sacramento and San Diego at speeds of up to 220 miles per hour (354 kilometers per hour), will provide a new intercity mobility option to air and highway travel. Proponents claim it will materially reduce travel times, congestion and accidents on regional transportation systems, and generate various downstream benefits on a statewide scale (Catz and Christian, 2010; United States Conference of Mayors, 2010; Leinback, 2004). For example, the California HSR Authority (CHSRA) currently predicts that the project will directly create 600,000 construction-related jobs and indirectly induce 450,000 permanent new jobs over the next 25 years.

While there has been concern about the full costs of a HSR system in comparison to those of highway and airport systems, a number of analysts have questioned the net downstream economic development benefits (Levinson, 2010; Levinson et al., 1999; Levinson et al., 1997; Givoni, 2006). One might argue that the public spending in railway systems is likely to generate smaller accessibility improvements and economic advantages as the linkage between transportation and land use has diminished in the wake of telecommunication advances (Giuliano, 2004; 1995; Graham and Marvin, 1996). Indeed, past studies (Castells, 2000; Harvey, 1989; Hall, 2002) contend that the economic impacts of contemporary railway investment tend to be: (i) spatially redistributive within a city-region where urban transportation networks are already well-developed and (ii) highly localized in high-access, hub-node places where urban redevelopment agencies proactively assemble land parcels and arrange development incentives (Banister and Berechman, 2000; Bertolini and Spit, 1998; Cervero and Landis, 1997). Having the clusters of knowledge- and service-based activities around global and regional hub-node places could also yield net generative benefits – by substantially increase private business productivity, creativity, and profitability through improved face-to-face communications, amplified knowledge spillovers and enlarged external transactions within dense and compact central locations (Cervero and Aschauer, 1998; Porter, 2000; 1997; Sassen, 2001).

There remains a paucity of quantitative research that investigates the economic development potential of California proposed HSR project. This paper probes this question by examining recent job and labor market trends in proposed California HSR station areas and comparing these

to the kinds of trends that have unfolded in other international settings with HSR systems in place, most notably Japan. Emphasis is placed on identifying:

- The spatial distribution of economic activities across global and regional business centers, edge cities, aerotropolises, leisure cities, and small intermediate cities that might be affected by the initiation of HSR services in California;

- The physical coordination of transit-oriented developments, international airport terminals, and local access facilities that might contribute to agglomeration benefits in Calfiornia's knowledge- and service-based sectors; and

- The financial application of value capture techniques to recoup the costs of the California HSR project from rail-induced accessibility and agglomeration benefits.

## 2. A Literature Review

HSR investments have transformed the economic geography of city-regions of Asia and Europe. Countries like Korea, Taiwan, France, and Spain continue to invest in HSR on economic grounds. Nonetheless, spending scarce financial resources on HSR projects to grow local and regional economies remains a subject of intense debate in good part because evidence on such impacts are unclear and hard to quantify (Givoni, 2006). Experiences to date in Japan and Europe have been mixed and inconclusive.

One of the most frequently reviewed HSR cases is the Japanese "Shinkansen" (new trunk line) network since the Tokaido Line, the world's first HSR corridor, was opened from Tokyo to Osaka in 1964. Sands (1993) reviewed the development effects of the Shinkansen in Japan as of the early 1990s. This review concluded that the Shinkansen projects led to higher employment and population growth rates, which were positively associated with: high growth in information exchange industries (business services, banking services, real estate); attraction of centers of higher education; and leveraging of growth along secondary transit systems that connected to Shinkansen stations . However, the causality between the Shinkansen and economic development and the redistributive effects of the Shinkansen network were questioned. Banister and Berechman (2000) concluded that the Shinkansen (and other railway systems) influenced Japan's employment growth patterns at the regional and local levels and increased station-are land values as a function of travel times to Tokyo station and other large cities. Cervero and Bernick (1996), on the other hand, concluded that by the early 1990s, the Shinkansen had failed to induce significant employment and population shifts along the corridor between Tokyo and Osaka and had weakened the economic roles of intermediate cities. In the last decade, Takagi (2005) reported that the Tokaido Shinkansen Line's high-speed services became slower because of too many intermediate stops, so those intermediate stations were undesirable for passengers not getting on and off between Tokyo and Osaka.

In the case of Europe, economic development benefits of HSR systems have also largely accrued to major cities at the expense of smaller and less profitable intermediate cities. Vickerman (1997) predicted that long-term economic development in peripheral small cities would be suppressed if

more global and regional firms located in more large cities are able to capture the bulk of HSR's accessibility benefits. In London, for example, new HSR links have been regarded as a catalyst for urban regeneration in the designated Central Activity Zones and Opportunity Areas that would accommodate about 560,000 global finance and business service jobs around central terminal stations, such as King's Cross-St Pancras (GLA, 2008; Bertolini and Spit, 1998). These global and regional hubs have claimed a large share of London's creative businesses, thriving on face-to-face communications for the exchange of knowledge and ideas (Freeman, 2007). Gutierrez et al. (1996) estimated the accessibility benefits of the future HSR network in Europe, predicting that the HSR network would increase the territorial polarization between Europe's major cities and their hinterlands, with major urban centers like London and Paris becoming the chief beneficiaries of this new spatial order.

In France, the TVG has also been regarded as a catalyst for Paris-based global and regional firms to expand their potential markets in Europe. Nevertheless, Cervero and Bernick (1996) argued that the TGV had generated greater development impacts on secondary cities, such as Lyon and Lille, than on the nation's capital city, Paris. Gutierrez (2001) also directly measured the accessibility impacts of the future Madrid-Barcelona-French border HSR line. This estimate implied that, while the new HSR line would increase territorial inequity at the national level, the same line would reduce accessibility disparity at the European and corridor level (because peripheral small and medium-sized cities would gain greater accessibility benefits than central large cities). In Spain and France, Garmendia et al. (2008) looked at the development impacts of HSR lines on small and large intermediate cities. The impacts of the new HSR line on residential development in small cities were found to be relatively small, though small cities took on a larger economic role in attracting intra-provincial immigrants and housing investments. Urbena et al. (2009) classified the hierarchical characteristics of Spain and France's HSR networks at national, regional and local levels. The authors concluded that the HSR systems helped large intermediate cities attract mid-level business and technical consultancy firms, urban tourism, and interregional conferences and increased the regional centrality of those large intermediate cities in relation to smaller cities.

The spatial implications of new HST systems have become even more complex in today's hyper-informational era. Looking ahead, Hall (2009) stresses the potential advantages of "edge city" station locations (Garreau, 1991), especially where HSR services are directly linked to major international airport terminals. Kasarda (2001; 1999) developed the concept of "aerotropolis", consisting of an airport city and outlying high-speed corridors and stretching the clusters of aviation-linked businesses and associated residential development up to 20 miles (30 kilometers) outward from some major international airports. He points out that a number of those airport-based business clusters have become globally competitive edge cities representing postmodern urban development and the economic potential of airport-linked commercial development in edge-city locations could be higher than that of transit-oriented redevelopment in a traditional central business districts (Kasarda, 2010; 2009). The integration of a HSR station with an airport terminal had already occurred on the eastern edge of Lyon by 1994. Since then, hotel, conference and parking facilities have been developed around the terminal, and the Satolas airport TGV station has become a focal point of Lyon's marketing and economic development strategy. Thompson (1995) contended that the HSR-airport interchange provided an essential hub-node place with state-of-the-art telecommunication facilities in a wider regional context and

enhanced Lyon's ability to agglomerate, distribute and marshal regional flows without experiencing the diseconomies of congestion.

## 3. Methodology

In this section, we examine the locational characteristics of job and labor markets around the planned HSR stations in California. The analysis does not try to predict the economic development impacts of the California HSR project over coming decades but rather attempts to characterize market trends around planned stations with an eye toward exploring whether public policies might be able to harness and leverage these trends to induce greater economic benefits. California trends are then compared to job and labor market experiences in Japan. Such comparisons, we believe, shed light on the kinds of long-term economic development impacts that might occur in California and importantly the kinds of public policy interventions that might meaningfully influence outcomes.

*Units of analysis*

The California HSR Authority (CHSRA) has proposed 26 HSR stations on the statewide routes from San Francisco to Los Angeles/Anaheim/Irvine via the Central Valley (including Hanford/Visalia/Tulare) to Sacramento and San Diego (Figure 1). This analysis assumes that the economic development impacts of the California HSR project will be localized around the proposed 26 HSR stations. In many transit studies, "station catchment area" is often defined as a 500 meter (or 0.5 miles in the United States) radius buffer from the station. However, the California HSR project must economically and socially encompass a larger radius (e.g., 1-3 miles) around the proposed stations than the 500 meter radius (Catz and Christian, 2010). In addition, the exact sitings of many of the 26 HSR stations are unknown, so the station catchment areas are likely to shift more than 500 meters when all is said and done. For these two reasons, this paper examines job and labor market profiles in 5 km (3.1 miles) of the proposed 26 HSR stations in California (Figure 2).

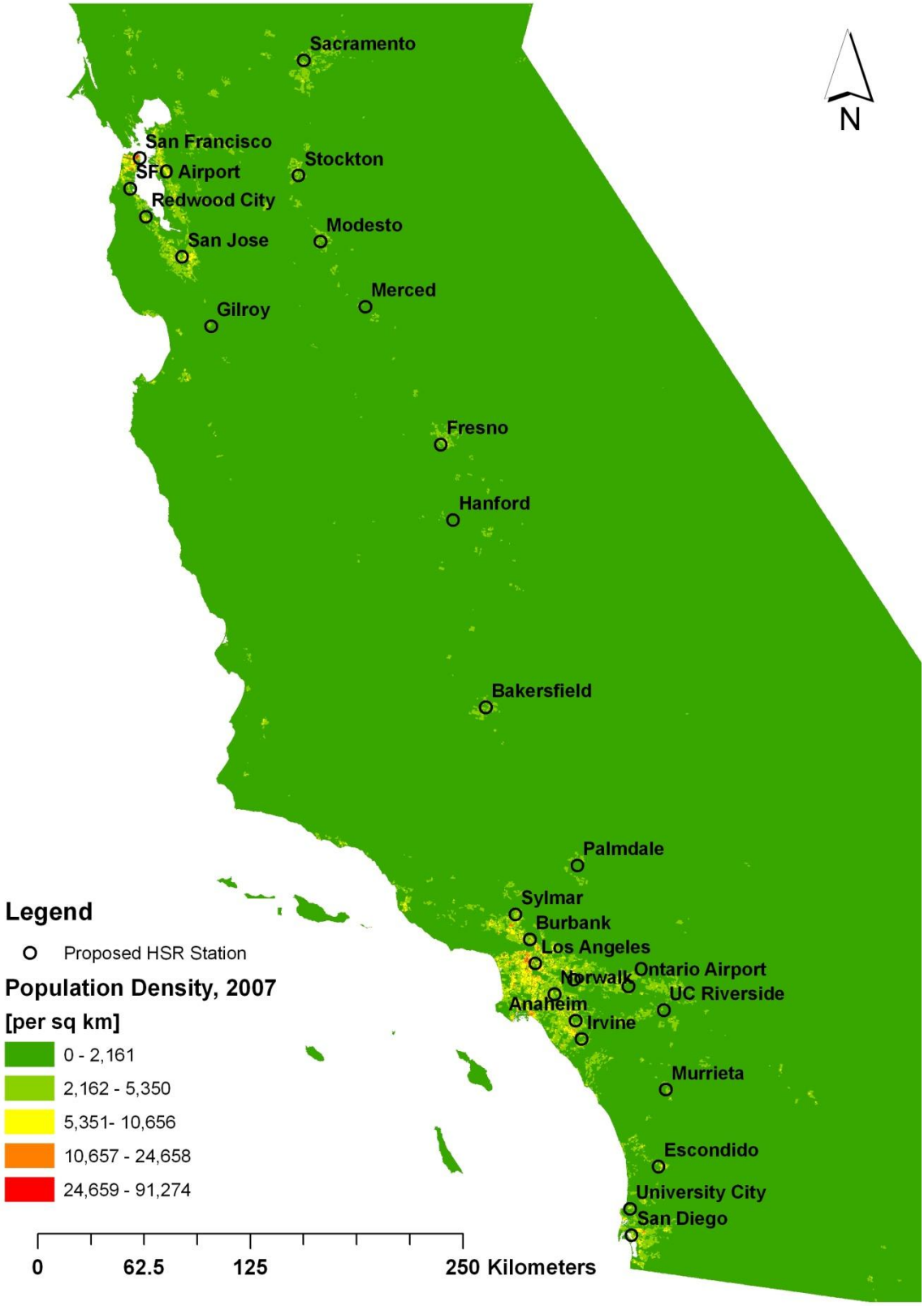
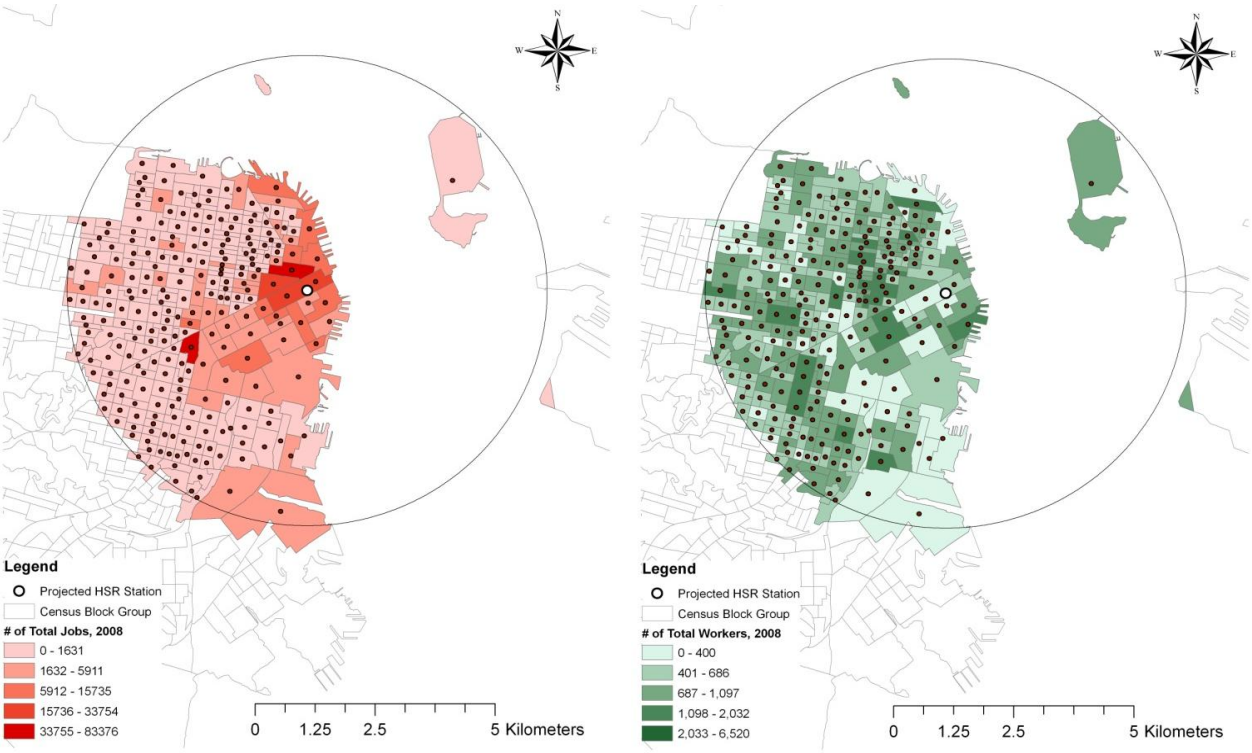



**Figure 1. Unit of Analysis 1: Proposed 26 HSR Stations in California and Population Density, 2007**




(a) Total Job Distribution in 5km of the San Francisco Transbay Terminal, 2008

(b) Total Labor Distribution in 5km of the San Francisco Transbay Terminal, 2008

**Figure 2. Units of Analysis 2: Job and Labor Markets in 5 km of the Proposed California HSR Station (the San Francisco Transbay Terminal), 2008**

In the same way, this study assumes that the economic development impacts of the Japanese Tokaido Shinkansen Line have been largely localized, occurring within 5 km of the existing 17 stations on the 552.6 km (344 mi) service corridor between Tokyo and Osaka (Figure 3; Figure 4). We analyzes the latest job and labor market data in these 17 station catchment areas. Worldwide, the Tokaido Shinkansen Line is generally regarded as the most successful HSR corridor in terms of ridership, averaging 378,000 passengers per day and capturing 82 % of the intercity passenger flows between Tokyo and Osaka in FY 2009. The world's most profitable HSR line is somewhat comparable to the California HSR project in terms of service and geographic characteristics (Table 1). Notably, the average numbers of jobs and workers within 5 km of the Tokaido Shinkansen stations in 2006/2005 were 4.37 and 3.24 times larger (denser) than the count of jobs and workers within 5 km of the proposed California HSR station in 2008.

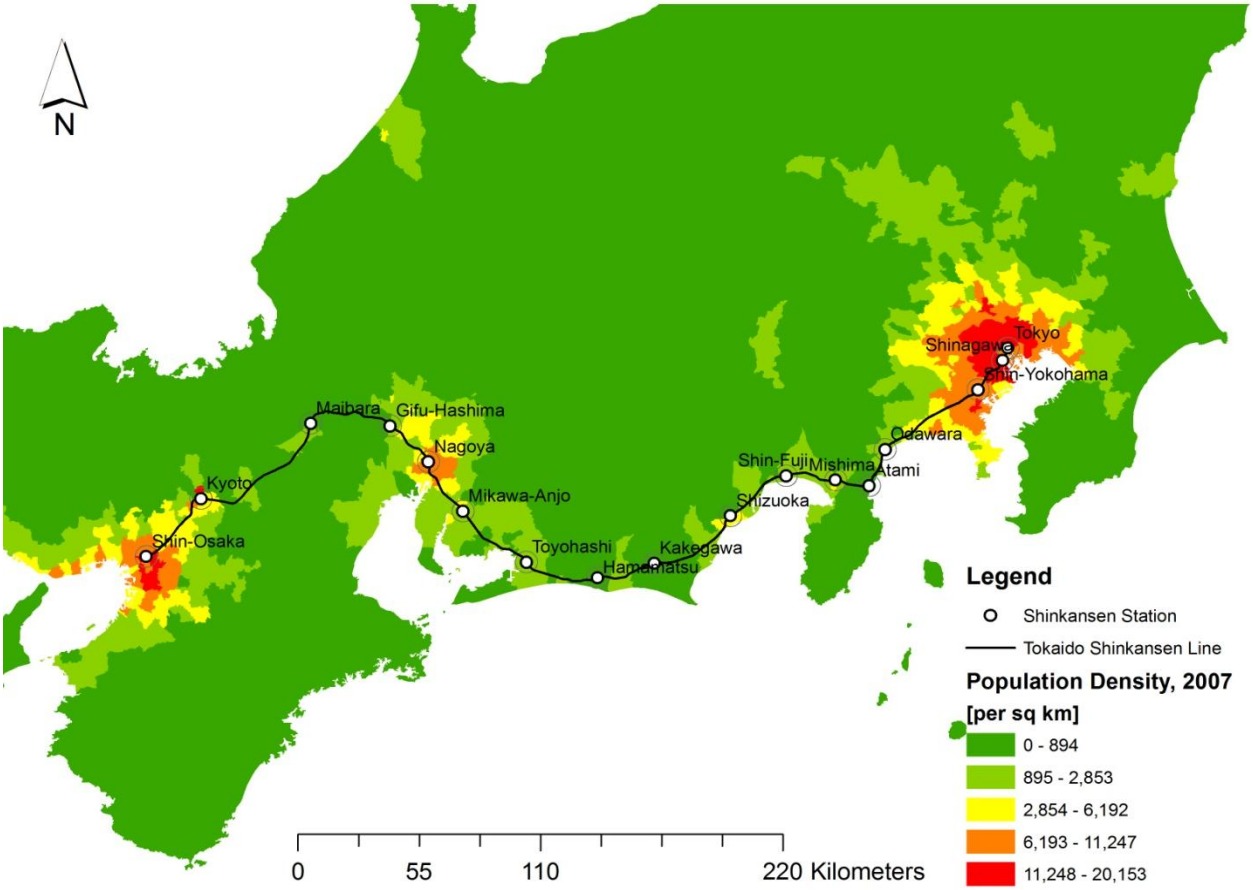
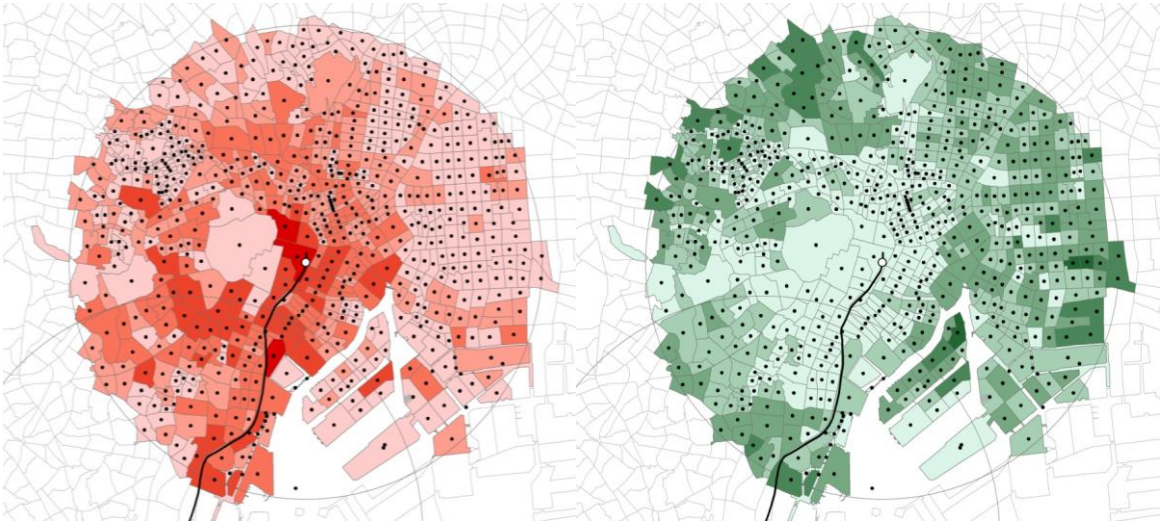



**Figure 3. Units of Analysis 1: 17 Stations on the Japanese Tokaido Shinkansen Line and Population Density, 2007**



(a) Total Job Distribution in 5km of the Tokyo Station, 2006

(b) Total Labor Distribution in 5km of the Tokyo Station, 2005

**Figure 4. Units of Analysis 2: Job and Labor Markets in 5 km of the Tokaido Shinkansen Station (the Tokyo Station), 2006/2005**

**Table 1. Comparative Statistics on the California HSR Project and the Japanese Tokaido Shinkansen Line**

| | **California HSR** | **Tokaido Shinkansen** | **Tokaido/ California** |
|---|---|---|---|
| Open Year | **-** | **1964** (46 years) | **-** |
| Service Distance km | **695.2** (San Francisco and Los Angeles) | **552.6** (Tokyo and Shin-Osaka) | **0.80** |
| Max. Speed kph | **354** | **270** | **0.76** |
| Travel Time | **2 hrs 40 mins** (Estimate in 2010) | **2 hrs 20 mins** (2010) | **0.88** |
| Passengers per day | **91,000~194,000** (Phase I Estimate for 2030) | **378,000** (FY2009) | **1.95~4.15** |
| Initial Costs per km US$M | **5.63** (Estimate in 2008) | **1.79** (1964) | **0.32** |
| Ave. # of Jobs in 5 km | **117,837** (2008) | **514,345** (2006) | **4.37** |
| Ave. # of Workers in 5 km | **65,771** (2008) | **212,769** (2005) | **3.24** |

Notes: the estimated costs to build the 800 mile system was about US$ 45billion in 2008; US$1 = JPY360 in 1964.
Sources: California High-Speed Rail Authority (2010); U.S. Census Bureau LEHD (2010); Central Japan Railway Company (2010); Taniguchi (1993); Government of Japan (2010a; 2010b).

*Analytical approaches*

The job and labor market analysis conducted in this paper: (i) illustrates the distributions of economic activities along the California HSR corridor and Tokaido Shinkansen Line; (ii) classifies types of economic agglomerations across the proposed 26 HSR and developed 17 Shinkansen station areas with respect to their market sizes, business specializations, and job-labor balances; and (iii) examines the relationships between station proximity and market density within 5 km of each the proposed 26 HSR and developed 17 Shinkansen stations by business sectors.

To build a typology of the 26 HSR and 17 Shinkansen station areas, cluster analysis is applied. The technique of agglomerative hierarchical clustering systematically combines a number of different station cases into a reasonable set of clusters on the basis of their similarities (i.e., squared Euclidean distances) across job and labor market variables (Aldenderfer and Blashfield, 1984). Table 2 lists the job and labor market variables complied for each of the 26 HSR and 17 Shinkansen stations. The job and labor market profiles in 5 km of the HSR and Shinkansen stations are quantified by three measures: total number (TN) for market size; location quotients (LQ) for industrial specialization; and gap index (GI) for job-labor force balance. The descriptive statistics of variables used in the cluster analysis are shown in Appendix A.

**Table 2. Variables on Job Market, Labor Market, and Job-Labor Force Balance Used in Building Cluster Analysis Typologies**

| Typologies | Variables | Data Year | |
|---|---|---|---|
| | | California | Japan |
| Job Market | -Total # of Jobs (TN) in 5 km of HSR Station (California)<br>-Job Location Quotient (LQ) in the Sector i (California)<br>-Total # of Jobs (TN) in 5 km of HSR Station (Japan)<br>-Job Location Quotient (LQ) in the Sector j (Japan) | 2002 & 2008 | 2006/05 |
| Labor Market | -Total # of Workers(TN) in 5 km of HSR Station (California)<br>-Worker Location Quotient (LQ) in the Sector i (California)<br>-Total # of Workers (TN) in 5 km of HSR Station (Japan)<br>-Worker Location Quotient (LQ) in the Sector j (Japan) | | |
| Job-Labor Force Balance | -Job-Labor Gap Index (GI) in the Sector i (California)<br>-Job-Labor Gap Index (GI) in the Sector j (Japan) | | |

**Location Quotient (LQ)**

= [(# of jobs or workers in the sector i or j in 5 km of a station)/(total # of jobs or workers in 5 km of a station)]/[(# of jobs or workers in the sector i or j in California or Japan)/(total # of jobs or workers in California or Japan)]

**Gap Index (GI)**

**= |JOB-LABOR|/(JOB+LABOR)**

wherein
LQ indicates job or labor market specialization in 5km of a station
GI indicates job-labor balance in 5km of a station, ranging from -1 for "dominated by workers" to +1 for "dominated by jobs"
JOB is # of jobs in the sector i or j in 5 km of HSR station
LABOR is # of workers in the sector i or j in 5 km of HSR station
i is the industrial categories in California (i = 1~20)
j is the industrial categories in Japan (j = 1~16)

In addition, this study assumes that the accessibility benefits of existing intercity railway facilities around the proposed HSR stations and the developed Shinkansen stations in the knowledge- and service-based sectors are reflected by differences in density gradients within each of the 5km catchment areas. Ordinary least square (OLS) regression analysis is applied to examine the relationship between station proximity and market density within 5 km of each of the HSR and Shinkansen stations by the industrial sectors. "Station proximity" is expressed by the straight distance from each of the proposed HSR stations and developed Shinkansen stations and "market density" is calculated on the census block group scale in California and on the small district scale in Japan. Linear, semi-log, and log-log function models are tested for each of the proposed 26 HSR stations and developed 17 Shinkansen stations by the industrial codes.

*Data sources*

As already mentioned, many of the proposed 26 HSR station locations in California are still under review and thus preliminary. Some of the HSR stations are to be connected to existing

intercity railway terminals and local transit centers, while others might be sited on the edge of cities like Bakersfield and Fresno. The current proposed station locations were identified based on public outreach materials and preliminary alternatives analysis on the California High-Speed Rail Authority's official website (CHSRA, 2010). Their geographic information system (GIS) point shapefiles were originally created by using online satellite imagery techniques (Monkkonen, 2008). In the case of the 17 Shinkansen stations, precise location information were obtained from the GIS shapefile provided by the National and Regional Planning Bureau (GOJ, 2009).

For California, the job and labor market data within 5km of the proposed 26 HSR stations were extracted from the Longitudinal Employer-Household Dynamics (LEHD) in 2002 and 2008 (U.S. Census Bureau, 2010) and disaggregated into the 20 North American Industry Classification System (NAICS) 2-digit codes on the census block group scale. For Japan, the Statistics Bureau publicly provides population data in 2000 and 2005 and employment data in 2001 and 2006. However, their industrial categories and geographic codes were largely revised between the census year 2000/01 and 2005/06. These revisions complicate any longitudinal analysis. This study, therefore, relies upon the latest population and employment data in 2005/2006. The job market data along the Tokaido Shinkansen Line were extracted from the 2006 Establishment and Enterprise Census of Japan (GOJ, 2010a). In the same way, the labor market data along the Tokaido Shinkansen Line were obtained from the 2005 Population Census of Japan (GOJ, 2010b). These job and labor market data are disaggregated into the 16 major industrial categories on small district scale as defined by the Statistics Bureau, which are fairly comparable to the 2-digit NAICS codes on the census block group scale used in the United States (Table 3).

**Table 3. Industrial Sectors in California and Japan**

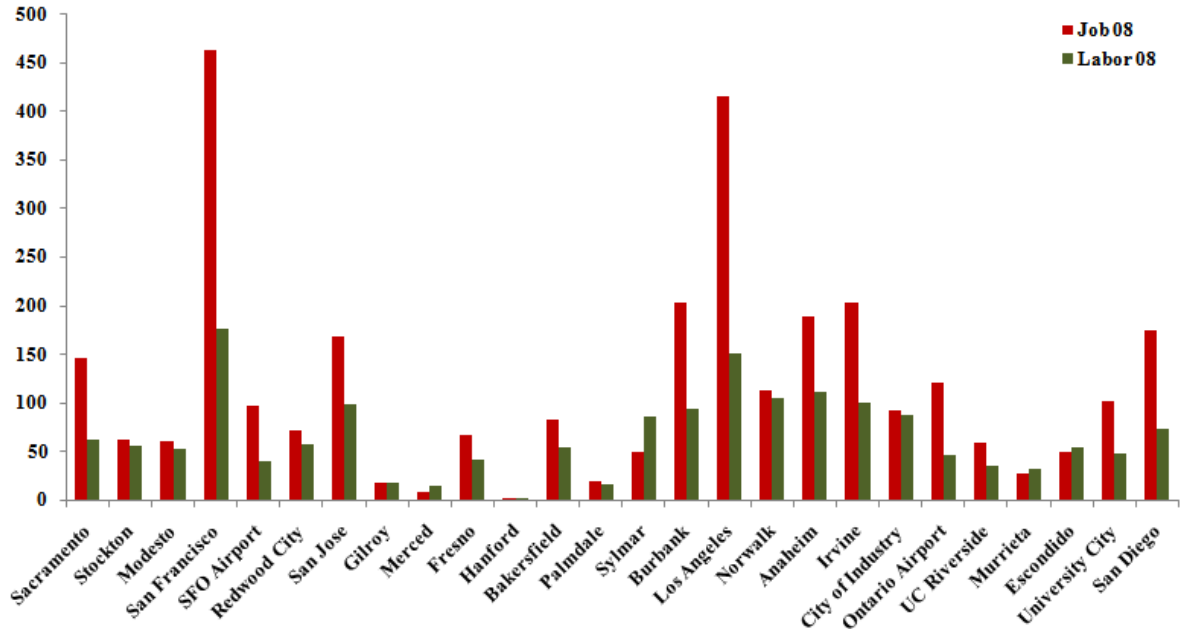
| **California**<br>**20 NAICS Categories (2-Digit Codes)**<br>**2002 & 2008** | **Japan**<br>**16 Major Industrial Categories**<br>**2006/2005** |
|---|---|
| -Agriculture, forestry, fishing & hunting (11) | -Agricultural, forest & fishing |
| -Mining, quarrying, and oil & gas extraction (21) | -Steel |
| -Utilities (22) | -Utility |
| -Construction (23) | -Construction |
| -Manufacturing (31) | -Manufacturing |
| -Wholesale trade (42) | -Wholesale & retail |
| -Retail trade (44) | |
| -Transportation & warehousing (48) | -Transportation |
| -Information (51) | -Information |
| -Finance and insurance (52) | -Finance & insurance |
| -Real estate & rental and leasing (53) | -Real estate |
| -Professional, scientific & technical services (54) | -Multiple service |
| -Management of companies & enterprises (55) | |
| -Administrative & support services (56) | |
| -Educational services (61) | -Educational |
| -Health care & social assistance (62) | -Medical |
| -Arts, entertainment & recreation (71) | |
| -Accommodation & food services (72) | -Restaurant & hotel |
| -Other services (81) | -Other service |
| -Public administration (92) | -Public |

## 4. Empirical Results

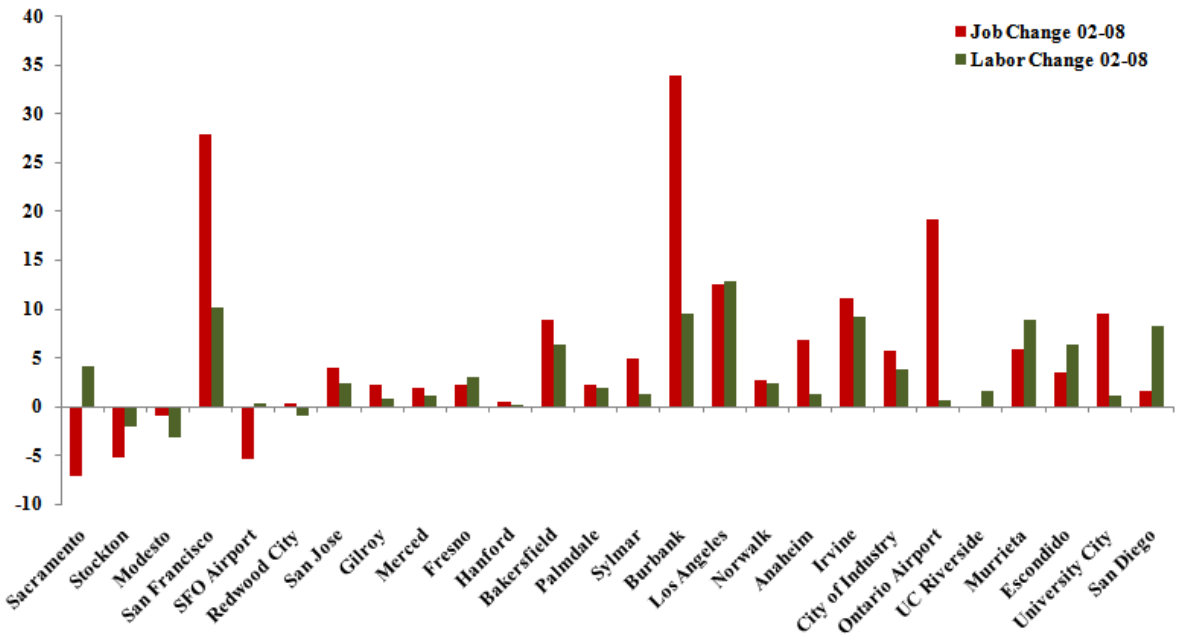
### 4-1. California HSR Project

*(i) Distributions of jobs and workers across the proposed 26 HSR station areas, 2002-2008*

The loci of economic activities in California's planned HSR corridor are unevenly distributed and have markedly shifted over the past decade. The distributions of jobs and workers in 5 km of the proposed 26 HSR stations in 2008 and their changes between 2002 and 2008 are illustrated by two sets of bar charts (Figure 5). The upper figure (a) suggests that the proposed HSR station areas in San Francisco and Los Angeles already formed the two largest employment centers with more than 400,000 jobs, followed by job centers in Burbank, Irvine and Anaheim (vis-à-vis those in San Diego, San Jose and Sacramento). The lower figure (b) shows that between 2002 and 2008, the "primary-city" terminal areas in San Francisco and Los Angeles have attracted a large number of jobs and workers and the new "edge-city" station areas in Southern California have gained more jobs than the traditional "secondary-city" station areas. Notably, Ontario Airport experienced faster job growth than most edge cities in Southern California, while the proposed HSR station areas in Northern California lost a substantial number of jobs over the same period.




(a) # of Jobs and Workers in 5km (1000), 2008




(b) Changes in # of Jobs and Workers in 5km (1000), 2002-2008

**Figure 5. Distributions of Jobs and Workers across the Proposed 26 HSR Stations, 2002-2008**

*(ii) Typologies of job markets, labor force markets and job-labor force balances, 2002 and 2008*

Six typologies are presented in this sections – groupings of planned station areas in terms of job markets, labor force markets, and job-labor force balances in 2002 and 2008. These groupings reveal the nature of recent economic activities along California's planned HSR corridor. Six typology maps, which reveal economic profiles of the 26 proposed stations, are presented in this section. In addition, six typology tables (that show averages of variables on job market, labor force market, and job-labor force balance that were used to form clusters) are presented in Appendix B.

Figure 6 shows the eight types of job markets in 2002 (a) and seven types in 2008 (b). The key features and trends derived from the typology maps are as follows:

- In 2002, San Francisco, Irvine and University City formed a Knowledge-based Business (KB) cluster, while jobs in planned HSR stations in Los Angeles and Sacramento were concentrated mainly in the Public & Finance (PF) sectors.

- By 2008, employment at station-areas in San Francisco and Los Angeles shifted in the direction of Finance + Business Service (FB); on the other hand, Irvine, SFO Airport and Ontario Airport took on the character of Industrial + Business Service (IS) hubs.

- In 2008, University City re-clustered as a Education + Business Service (EB) center, while Sacramento became distinctively more of a Public Service (PS) hub.

- In both 2002 and 2008, many of the proposed HSR station areas were classified as Public Service (PS) hubs. In contrast, two Southern California station areas -- Burbank and Anaheim -- were distinctively characterized as Information + Entertainment (IE) and Leisure Service (LS) centers.

In the same manner, Figure 7 illustrates eight types of labor force markets in 2002 (a) and nine types in 2008 (b). Key features and trends are as follows:

- In 2002, San Francisco, Irvine and University City were again grouped as Knowledge-based + Business Service (KB) and Los Angeles and Sacramento were categorized as Knowledge-based + Public (KP) centers.

- By 2008, San Francisco was solely clustered as Knowledge-based + Business and Other Service (KS) hubs, while Irvine, University City, San Diego and Redwood City were re-clustered as Knowledge-based (KW) centers.

- In 2008, Northern California's Sacramento and SFO Airport station areas were re-grouped as Transportation + Service (TS) hubs; on the other hand, Los Angeles can be classified as a Mixed (MX) hub.

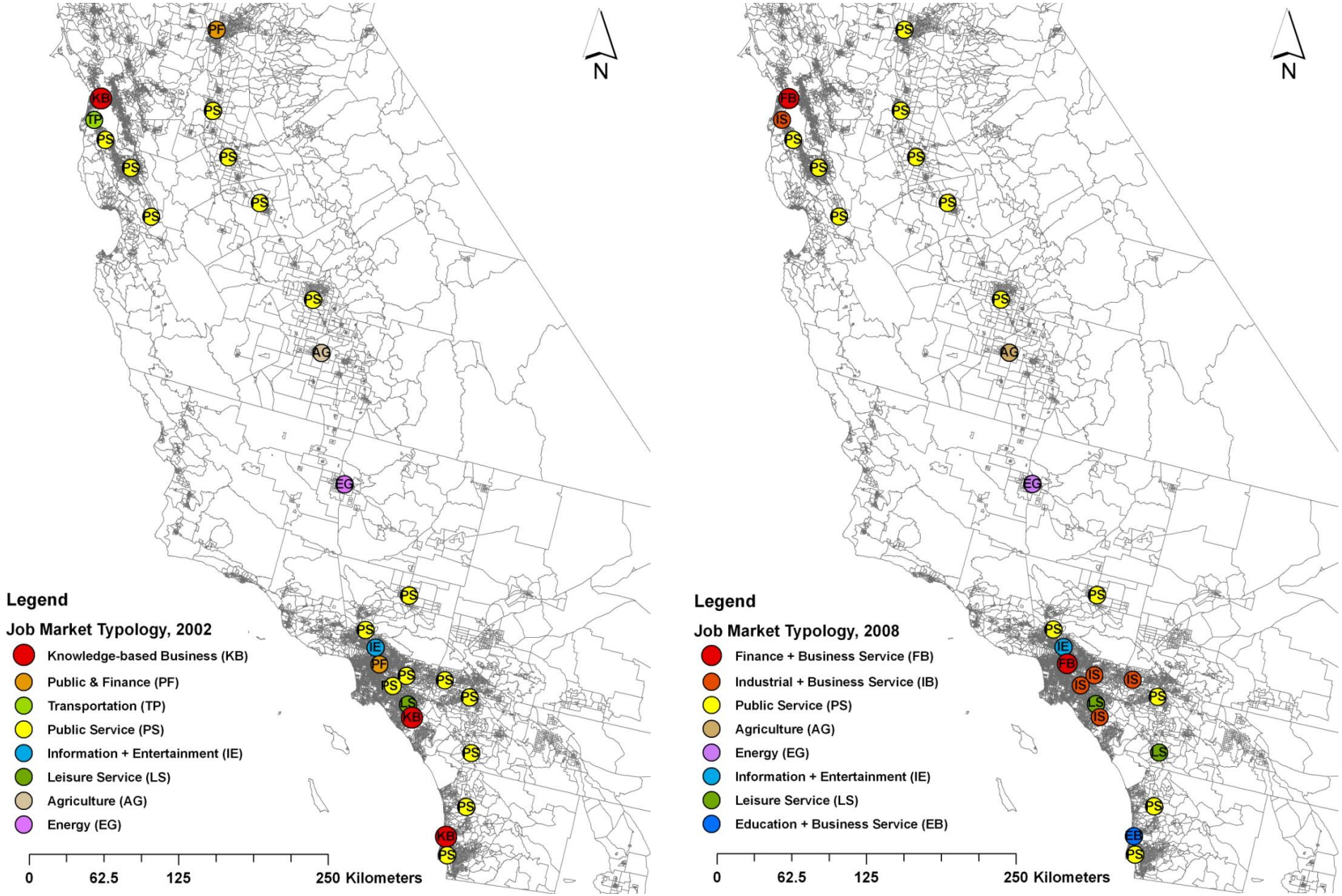
- Between 2002 and 2008, many of the proposed HSR station areas shifted to the Mixed (MX) category; in contrast, Merced and Murrieta took on more the characteristics of Industrial + Entertainment (IE2) and Industrial (ID) centers.

Figure 8 presents seven types of station-area "balance", in terms of ratios on the number of jobs to size of the labor force in 2002 (a) and eight types in 20 are as follows:

- In 2002, having many more jobs than workers, planned station areas in San Francisco, Los Angeles, SFO Airport, Irvine, Ontario Airport, San Diego and Sacramento could be classified as More Regional Jobs (RJ) centers while most other proposed HSR stations could be characterized as More Sub-regional Jobs (SJ) centers.

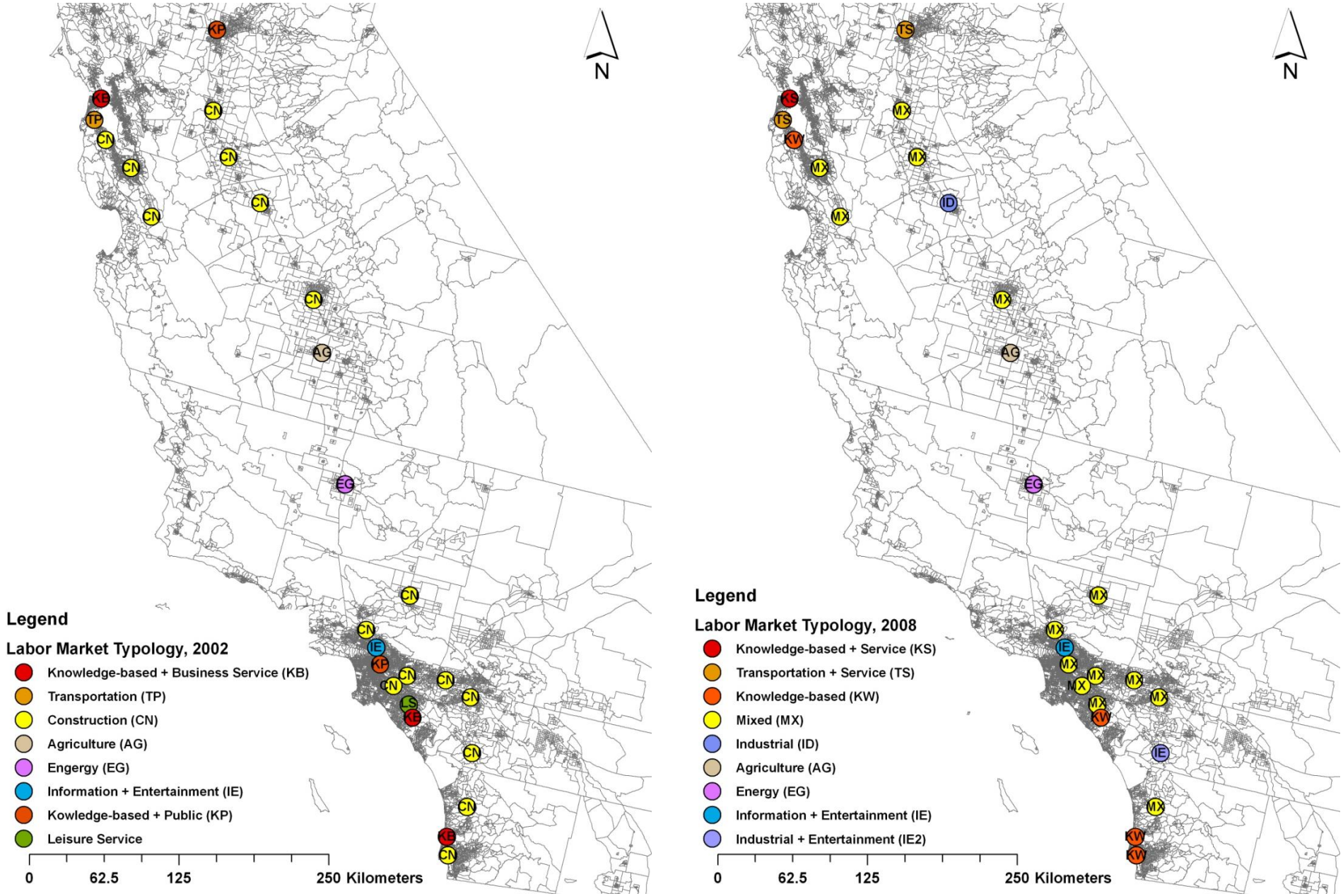
- By 2008, having many more jobs than workers, particularly in the transportation and business service sectors, SFO Airport, Irvine, and Ontario Airport were re-categorized as More Airport-based Jobs (AJ) centers; a number of the other proposed HSR stations were re-characterized from More Sub-regional Jobs (SJ) to More Public Jobs (PJ) centers.

- For more exurban settings between 2002 and 2008, planned station areas in Gilroy, Palmdale, Escondido and Murrieta took on the character of More Balanced (BL) centers, while Merced became a center characterized as More Industrial Workers (IL).



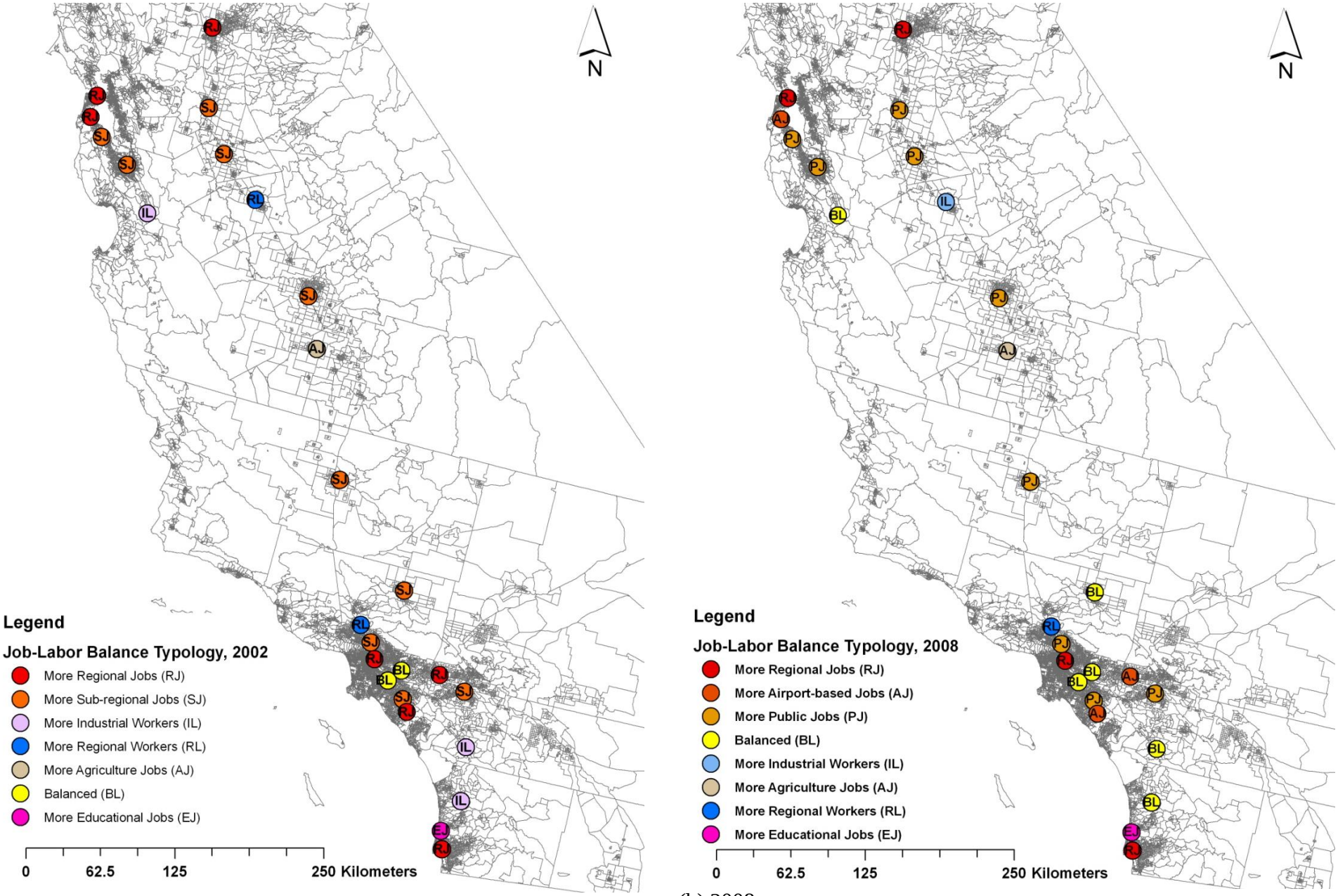

(a) 2002 (b) 2008

**Figure 6. Typologies of Job Markets in 5km of the Proposed 26 California HSR Stations, 2002 and 2008**




(a) 2002 (b) 2008

**Figure 7. Typologies of Labor Force Markets in 5km of the Proposed 26 California HSR Stations, 2002 and 2008**




(a) 2002 (b) 2008

**Figure 8. Typologies of Job-Labor Force Balances in 5km of the Proposed 26 California HSR Stations, 2002 and 2008**

*(iii) Density gradients of job markets within 5 km of the San Francisco Transbay Terminal, 2002 and 2008*

Estimated linear, semi-log, and full-log function models revealed that there was no significant relationship between station proximity and market density within 5 km of the proposed HSR stations in both 2002 and 2008, except San Francisco (Appendix C). This means that no discernible accessibility benefits accrued from being proximate to existing intercity stations and local transit centers around the proposed HSR stations. By comparison, San Francisco shows statistically significant declines in job density as a function of distance from the existing Transbay Terminal (home to the city's plan HSR terminus), particularly in the knowledge-based sectors (Appendix C). In Figure 9, the full-log function models illustrate that the density line for management jobs (NAICS 2-digit code 55) got steeper between 2002 and 2008, whereas the density line for total jobs became slightly flatter in the same period. These empirical results imply that San Francisco's economic advantages have been shifting towards the Transbay Terminal location, wherein advanced service firms could capture the potential accessibility and agglomeration benefits generated by the California HSR project and transit-oriented urban regeneration programs.

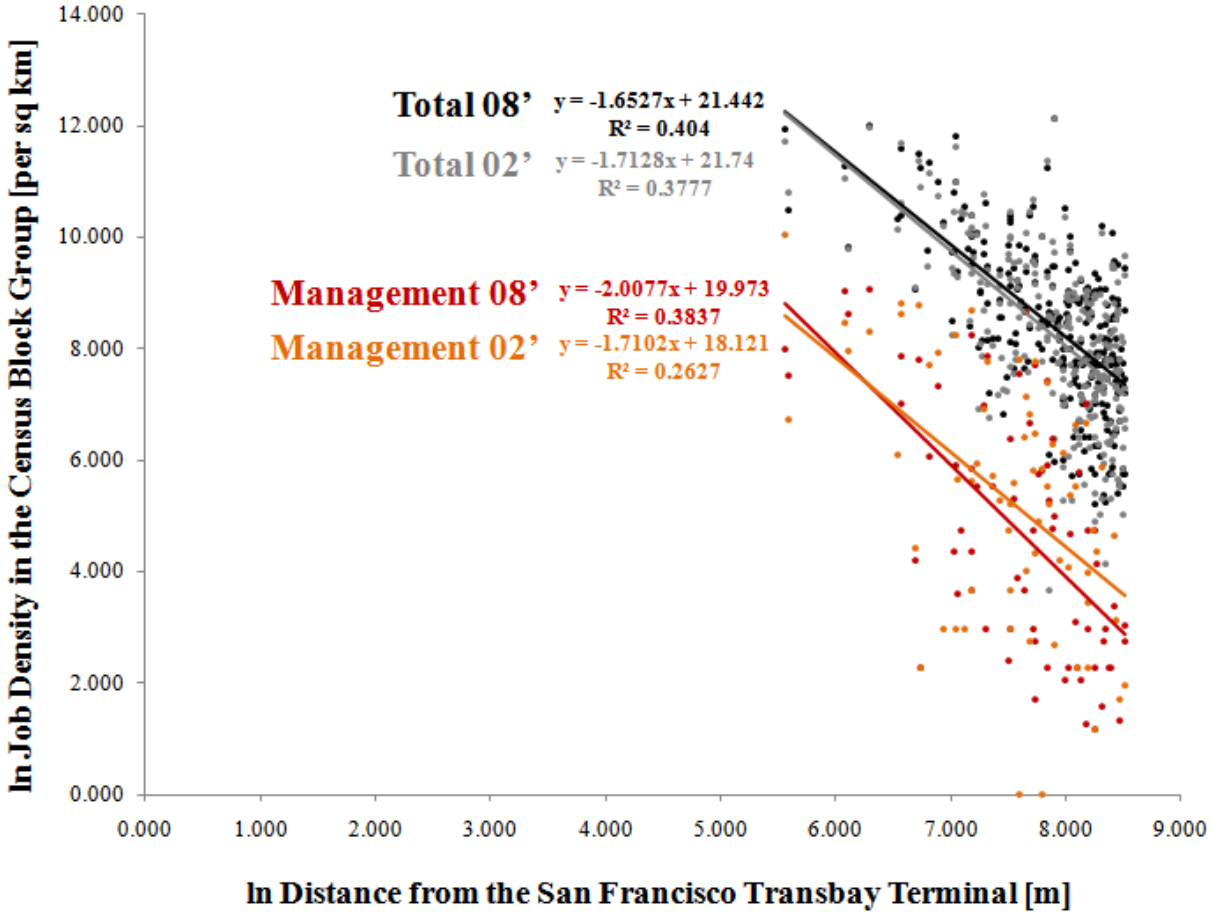



**Figure 9. Density Gradients of Total and Management Job (NAICS 2-digit Code 55) Markets within 5km of the San Francisco Transbay Terminal, 2002 and 2008**

## 4-2. Japanese Tokaido Shinkansen Line

This section carries out a similar analysis for the Shinkansen stations along Japan's Tokaido corridor. Our aim is to contrast trends in California with real-world experiences of arguably the world's most successful HSR system to date.

*(i) Distributions of jobs and workers across the developed 17 Shinkansen station areas, 2006/2005*

As noted earlier, economic activities along Japan's Tokaido Shinkansen Line have been uneven. The distributions of jobs and workers within 5 km of the 17 Shinkansen stations in 2006/2005 are presented in Figure 10. The two Shinkansen station areas in Central Tokyo are regionally and nationally dominant job centers, followed by those in the secondary cities, such as Shin-Osaka, Nagoya and Kyoto. The job and labor markets within 5km of these primary- and secondary-city stations are much larger and denser than those around the proposed HSR stations in San Francisco and Los Angeles. Importantly, the Shin-Yokohama Shinkansen station areas had a relatively sizeable number of jobs and workers on the west edge of Tokyo, compared to other intermediate-city Shinkansen station areas. In particular, the job and labor markets in 5km of the Atami, Kakegawa, Gifu-Hashima and Maibara Shinkansen stations were quite small.

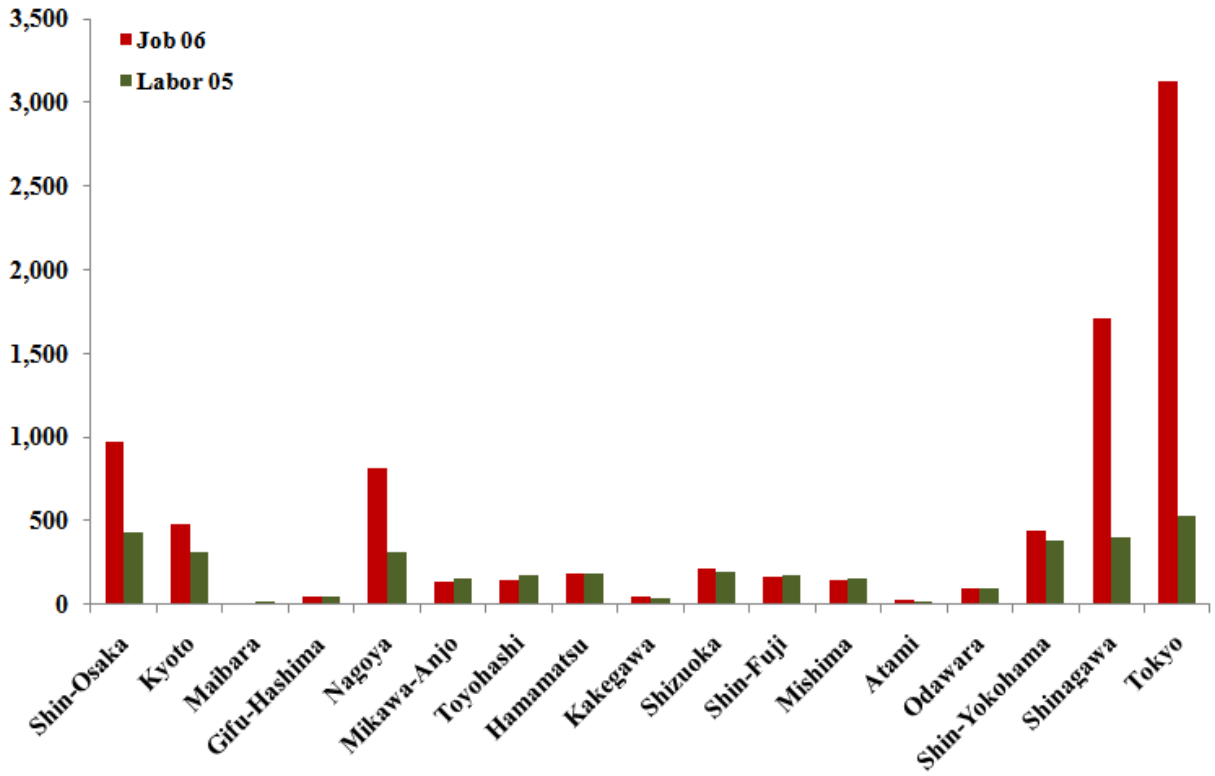



**Figure 10. Distributions of Jobs and Workers across the Developed 17 Shinkansen Stations, 2006/2005**

*(ii) Typologies of job markets, labor markets, and job-labor balances, 2006/2005*

The three typologies for job markets, labor force markets, and job-labor force balances in 2006/2005 capture the regional and local economic geographies across the developed 17 Shinkansen stations the postindustrial period. Three typology maps, which characterize economic agglomerations at the 17 developed Shinkansen stations, are discussed in this section. Three typology tables, summarizing the averages of the job market, labor force market, and job-labor force balance variables used to form clusters, are presented in Appendix B.

Figure11 presents the seven types of job markets along the Tokaido Line in 2006. Key features are as follows:

- Tokyo and Shinagawa were dominant Finance + Business Service (FB) and Information + Business Service (IB) clusters (on the Line's east end), whereas Shin-Osaka and Nagoya formed Regional Business (RB) clusters (on the Line's the west side).

- Most of the intermediate-city stations on the Tokaido Line took on the attributes of either Sub-regional Business (SB) or Industrial (ID) clusters; however, Atami and Maibara were separately categorized into Leisure Service (LS) and Agriculture (AG) centers.

In response to the job market typology in 2006, Figure 12 shows the six types of labor markets in 2005. The key features shown on this typology map are as follows:

- Tokyo, Shinagawa, Shin-Yokohama, Nagoya and Shin-Osaka clustered as Knowledge-based Business (KB) hubs; on the other hand, Kyoto formed a s Leisure + Local Service (LL) cluster.

- Most of the intermediate-city stations on the Tokaido Line were characterized as a Mixed (MX) cluster; however, Atami, Maibara and Mikawa-Anjo were specialized, either as Leisure Service (LS), Agriculture (AG), or Industrial (ID) clusters.

In the same way, Figure 13 illustrates the six types of job-labor force balances in 2006/2005 along the Tokaido Shinkansen Line. The following was found:

- Having much more jobs than workers in almost all the business sectors, Tokyo and Shinagawa were classified as Mega-regional/global Jobs (MJ) clusters, while Shin-Osaka and Nagoya were similarly characterized as Regional Jobs (RJ) centers.

- Containing both jobs and workers in many of the industrial sectors, most of the intermediate-city stations on the Tokaido Line were generally classified into either Sub-regional Jobs (SJ) or Balanced (BL) centers. Kakegawa and Maibara were categorized into Sub-regional Workers (SL) and Agriculture Jobs (AJ) centers.

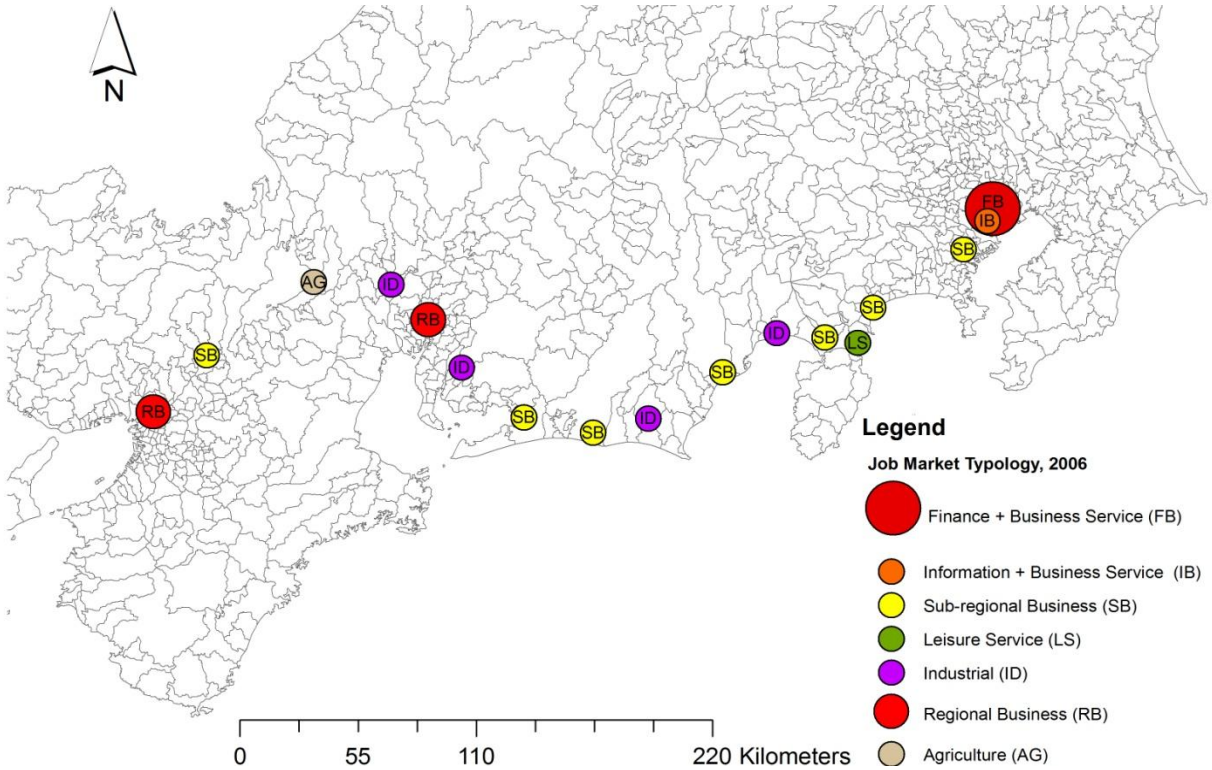



**Figure 11. A Typology of Job Markets in 5km of the 17 Shinkansen Stations, 2006**

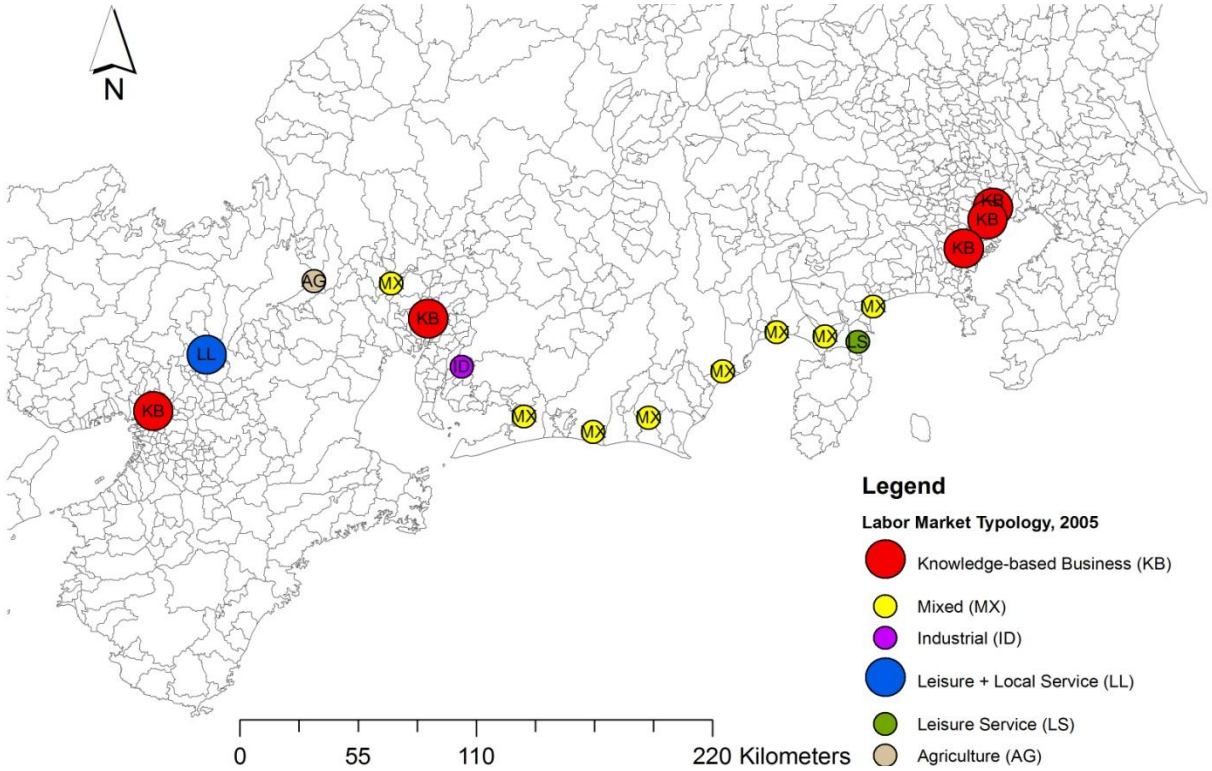



**Figure 12. A Typology of Labor Markets in 5km of the 17 Shinkansen Stations, 2005**

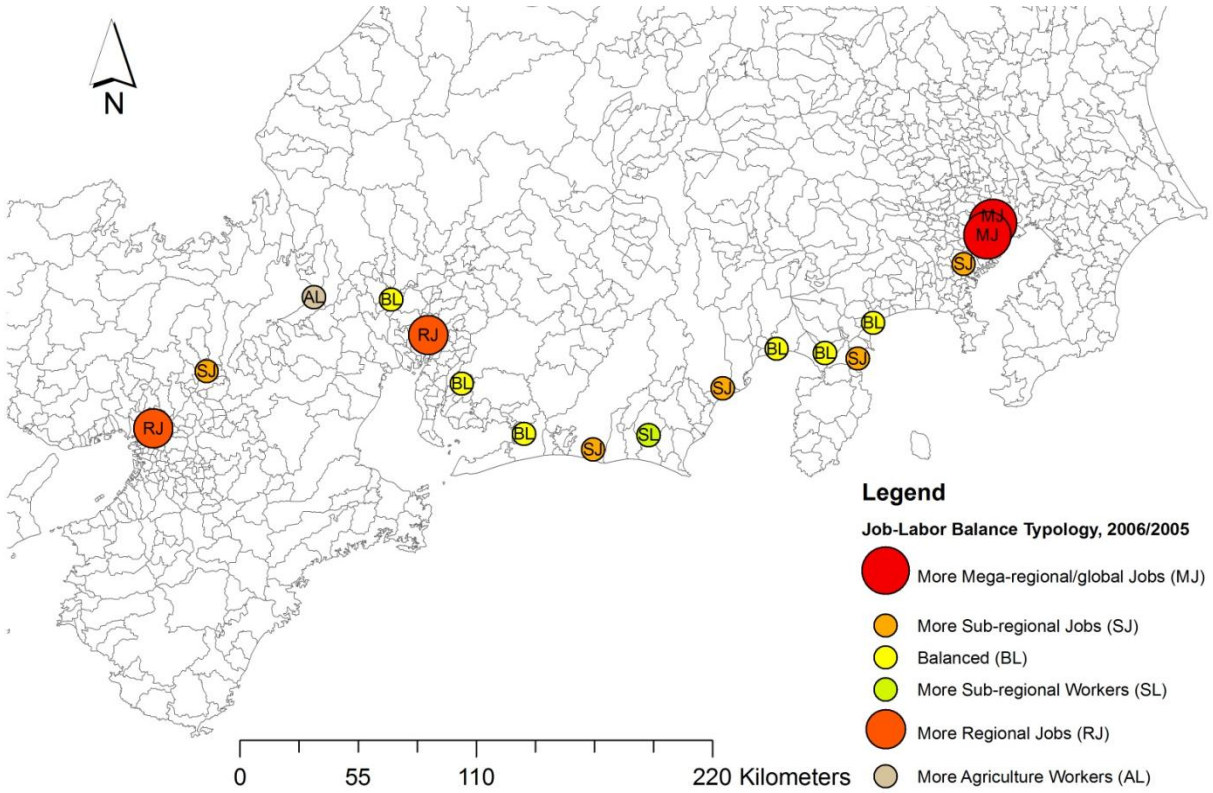



**Figure 13. A Typology of Job-Labor Balances in 5km of the 17 Shinkansen Stations, 2006/2005**

*(iii) Density gradients of job markets within 5 km of the Tokyo station, 2006*

In the case of Japan, the tested linear, semi-log, and full-log function models also revealed little significant relationship between station proximity and market density within 5 km of the developed Tokaido Shinkansen stations in 2006/2005, with the exception of the Tokyo station (Appendix C). This suggests that proximity to a Shinkansen station alone has not powerfully shaped density gradients. Tokyo, however, has statistically significant job density declines from the central terminal station, especially in the knowledge-based business sectors (Appendix). In Figure 14, the full-log function models comparatively shows that the density lines for finance, information and other service job markets were steeper than the density line for total job market in 2006. These empirical figures suggest that Tokyo's high value-added economic activities concentrated around the central terminal station, where financial, informational and business service firms reaped the accessibility and agglomeration benefits conferred by the Shinkansen network (Murakami 2010). These experiences parallel what appears to be unfolding around San Francisco's Transbay Terminal. In the case of Tokyo, public-private sponsored urban regeneration projects implemented over the last decade help leverage high-end growth that took place around Tokyo's HSR station (Murakami 2010). There is no reason that the same outcomes could not be achieved in downtown San Francisco and Los Angeles.

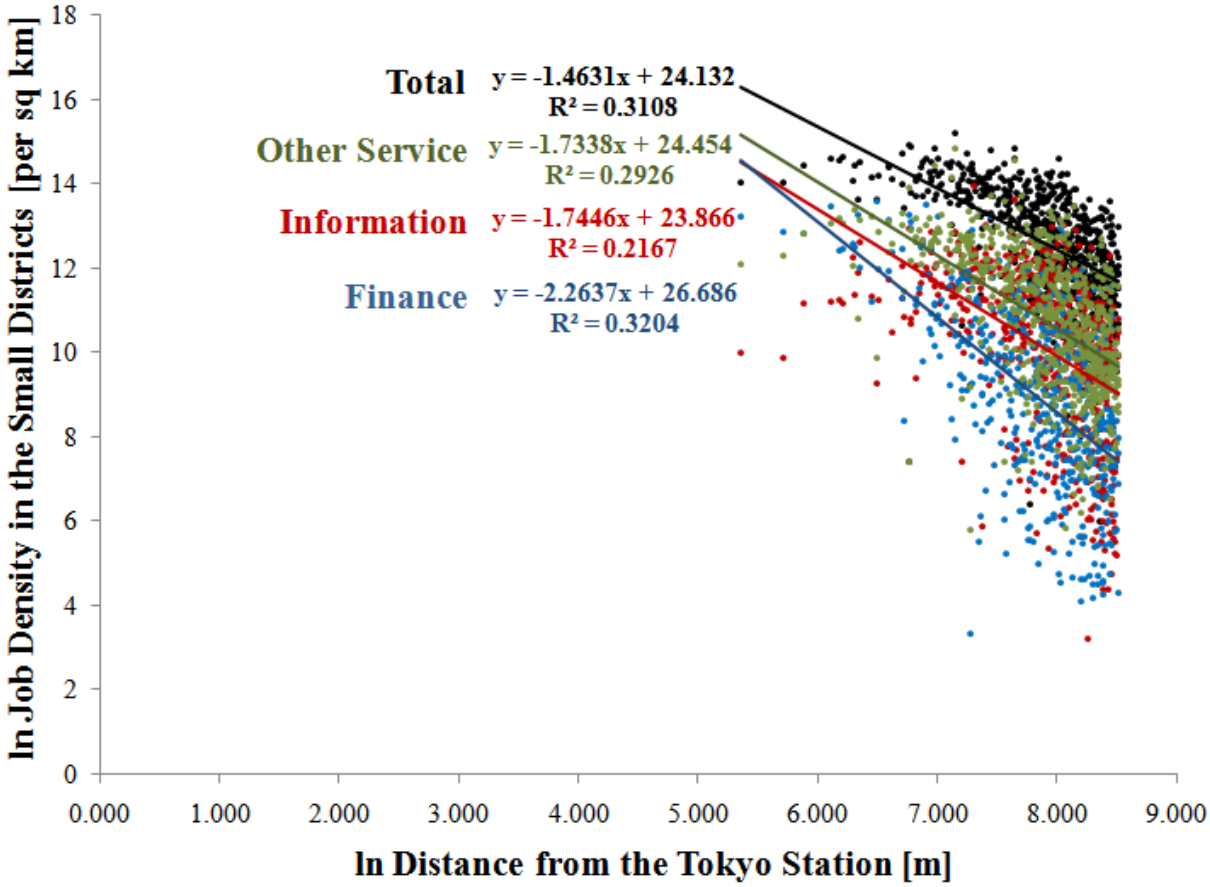



**Figure 14. Density Gradients of Total and Knowledge-based (Finance, Information and Other Service) Job Markets within 5km of the Tokyo Station, 2006**

## 5. Key Findings and Discussion

Based on recent trends and experiences in Japan, California planned HSR investment is likely to have territorially uneven and highly localized economic development impacts. This will be all the more magnified as the state continues to shift toward knowledge- and service-intensive businesses and industries. This section discusses possible shifts in economic activities for four distinct HSR station-area area clusters: "global/regional business centers", "edge cities and aerotropolises", "leisure cities", and "other intermediate cities".

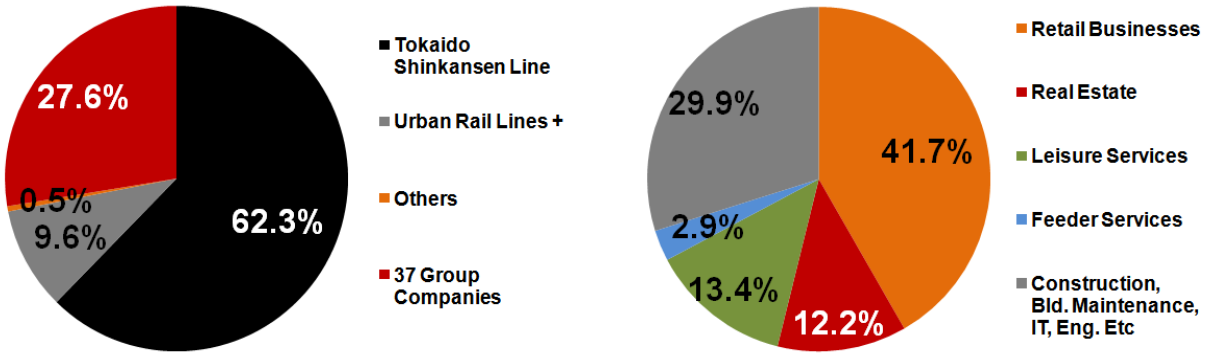
*Global/regional business centers*

Our analysis aligns with that of the existing literature, suggesting that the economic development impacts of a HSR system will likely concentrate in globally connected and regional business centers (i.e., San Francisco and Los Angeles), mimicking Japan's experiences with HSR stations in Tokyo, Shinagawa, Shin-Osaka and Nagoya. This will especially be the case when both public agencies and private entities aggressively embark on large-scale urban-regeneration projects that appeal to high value-added businesses and industries (Murakami, 2010; Curtis,

2009). Around the newly opened Shinagawa Shinkansen station, for example, the Japanese national government, the privatized Central Japan Railway Company, and private real estate developers joined forces to co-develop a prestigious office tower and connected shopping mall. The project featured high-quality public green plazas and well-designed pedestrian circulation systems as a lure to firms and workers that place a premium on livability and are drawn to urban amenities when deciding where to open a business or take on a new job (Figure 15).

**Figure 15. Transit-Joint Redevelopments around the Newly Opened Shinagawa Tokaido Shinkansen Station, 2003**

These transit-joint commercial redevelopment efforts aim not only to increase business passengers on the Tokaido Shinkansen Line but also to raise substantial revenues in the railway agency's non-transportation sectors. Figure 16 shows that the Central Japan Railway Company (a) gained 62.3 % of its total revenues from the Tokaido Shinkansen Line's passenger service operation and 27.6 % of them from the 37 group companies in FY 2006 and (b) generated 12.2 % of the 37 group companies' revenues from real estate businesses. Compared to other private railway corporations' traditional housing co-development models in Tokyo and Osaka (Cervero, 1998), the Central Japan Railway Company's value capture practices and revenues around the Tokaido Shinkansen stations are still new and modest. However, in response to Japan's recent urban regeneration boom, the "privatized" Shinkansen company's real estate revenue streams, mostly from commercial redevelopment packages around the Shinagawa and Nagoya stations, have noticeably increased by 174.5% over the last decade (from JPY24.3 billion in FY1999 to JPY66.7 billion in FY2009; Central Japan Railway Company, 2010).




**US$14.30 Billion** **US$3.94 Billion**

(a) Consolidated (b) 37 Group Companies

Note: US$1 = JPY117 in March 2007 (the end of FY 2006).

Sources: Central Japan Railway Company (2010; 2007).

**Figure 16. Central Japan Railway Company's Operating Revenues, FY2006**

*Edge cities and aerotropolises*

Our results are also consistent with those of researchers, such as Hall (2009) and Kasarda (2010; 2009), who predict that HSR systems will attract knowledge- and service-intensive industries and spur economic activities in large edge cities (e.g., Shin-Yokohama on the west edge of Tokyo; University City on the north edge of San Diego; and Stratford on the east edge of London). HSR investments also hold promise for international and regional airports (e.g., SFO Airport on the south edge of San Francisco; Ontario Airport and Irvine on the east and south edges of Los Angeles; and Satolas Airport on the east edge of Lyon). Some observers question whether automobile-dependent edge cities will be able to sustain dense agglomerations and suburban transit nodes because of high external costs (e.g., traffic congestion, air pollution, airport noise) that are likely to cancel out potential accessibility benefits (Lang, 2003; Tomkins et al., 1998). In lieu of massive roadway and parking infrastructure, HSR could provide a new layer of intercity mobility, relieving suburban gridlock, improving environmental conditions, and strengthening Southern California's polycentric transit-served urban form (as experienced around the Shin-Yokohama Shinkansen station in suburban Tokyo) (Cervero, 2005; 2003; Leinback, 2004; Cervero and Bernick, 1996).

*Leisure cities*

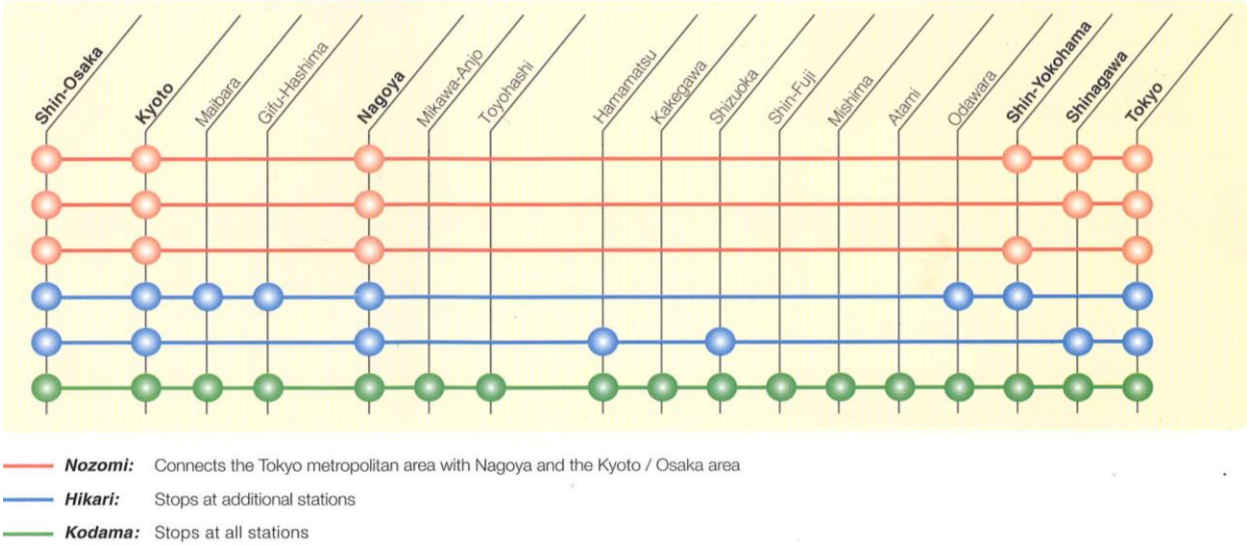
Our findings also suggest that a HSR system might be able to enhance the economic advantages of tourist-oriented clusters in relatively large intermediate cities, such as Kyoto in the west side of Japan and Anaheim in Southern California. As Japan's ancient capital city, Kyoto has witnessed substantial gains in the number of regional businesses, local service-industry workers, and educational institutions within 5 km of the terminal station. It has also become one of Japan's most popular cultural and leisure destinations. Taking advantage of Kyoto's historical resources and central national location, the privatized Central Japan Railway Company designed and aggressively marketed new high-speed "tourists services" that connected greater Tokyo and

Kyoto. Figure 16 shows that the Shinkansen Corporation generated 13.4% of the 37 group companies' revenues from leisure services in FY2006. In a similar manner, Anaheim in Southern California contains a substantial number of entertainment, recreational, hotel, and food-service businesses and workers within 5 km of the proposed HSR station. The city could similarly be promoted as a highly accessible leisure destination for tourist markets in Northern California. However, the proposed siting of Anaheim's HSR station next to the massive SR 57 Freeway interchange could suppressed development activities immediately around the station itself, at least in comparison to what occurred in Kyoto.

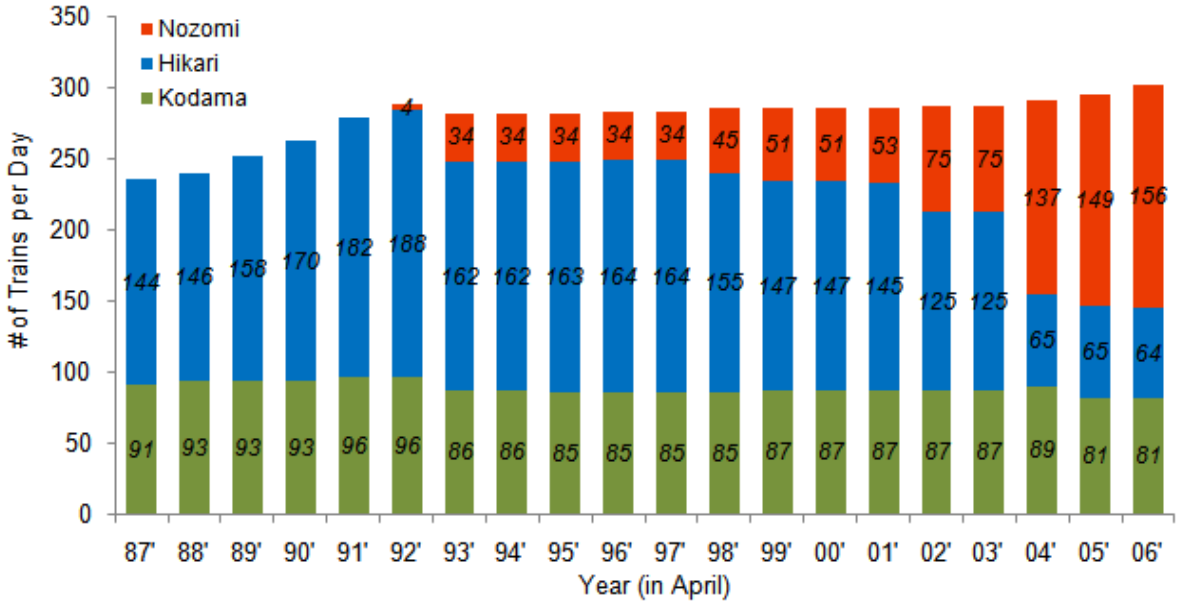
*Other intermediate cities*

A central question remains: does HSR yield regional accessibility and agglomeration benefits that accrue principally to major cities at the expense of smaller ones? Our research suggests that very small and intermediate cities generally lost both manufacturing- and service-based activities within 5km of the proposed HSR stations, while global business centers tend to cluster around the terminal stations. This occurred in Japan and appears to be how employment growth is trending around planned California HSR stations. The causality between HSR service and territorial transformation is always uncertain; however, in the case of Japan, the spatial redistribution of economic activities between major and minor cities on the Tokaido corridor are strongly associated with the Shinkansen Line's intercity service patterns over the last two decades. Figure 17 illustrates that: (a) the privatized Central Japan Railway Company set up the "Nozomi" service patterns that skip through 11 of the 17 Tokaido Shinkansen stations and (b) the Nozomi services have increasingly and importantly replaced the "Hikari" services that were designed to stop by 5 of the 11 intermediate city stations (Odawara, Shizuoka, Hamamatsu, Gifu-Hashima, and Maibara) since 1992. Apparently, these 5 intermediate stops have become less attractive destinations for business passengers and less profitable for the privatized Shinkansen company. New intercity service patterns have been matched by diminishing economic development activities in the minor intermediate cities. For example, Figure 18 shows land use patterns around the Gifu-Hashima Shinkansen station, one of the five intermediate stops skipped by the Nozomi services. A number of surface parking lots dominate the station area; nonetheless, these automobile-dependent facilities have not effectively promoted the Tokaido Shinkansen Line's ridership at the Gifu-Hashima stop.

Public-policy responses could alter market trends. Expanded local bus transit (including the initiation of Bus Rapid Transit) as well as upzoning, for example, could be a lure to new private investments and thus strengthen planned station areas in settings like Stockton, Modesto, Merced, Fresno, and Bakersfield (Cervero and Bernick, 1996). Whether such interventions could reverse market trends, however, remains an open queation. Over the past decade, intermediate cities in California's Central Valley have failed to attract appreciable numbers of knowledge- and service-based firms and workers in comparison to those in Southern California. Their comparative advantage still appears to be in areas like agriculture and traditional manufacturing, the kinds of business that find little value in being near a HSR passenger rail station. Without both clear statewide strategies and strong local efforts, California's proposed HSR system could end up saddling local governments of medium-size cities with high ancillary costs like expanding local bus services and upgrading sewer-water facilities without an expanded tax base from high-value-added industries. State policies should aim to redress such possible inequities.




(a) Service Patterns




(b) Service Changes, 1987-2006

Source: Central Japan Railway Company (2007).

**Figure 17. The Japanese Tokaido Shinkansen Line's Intercity Service Patterns and Changes, 1987-2006**

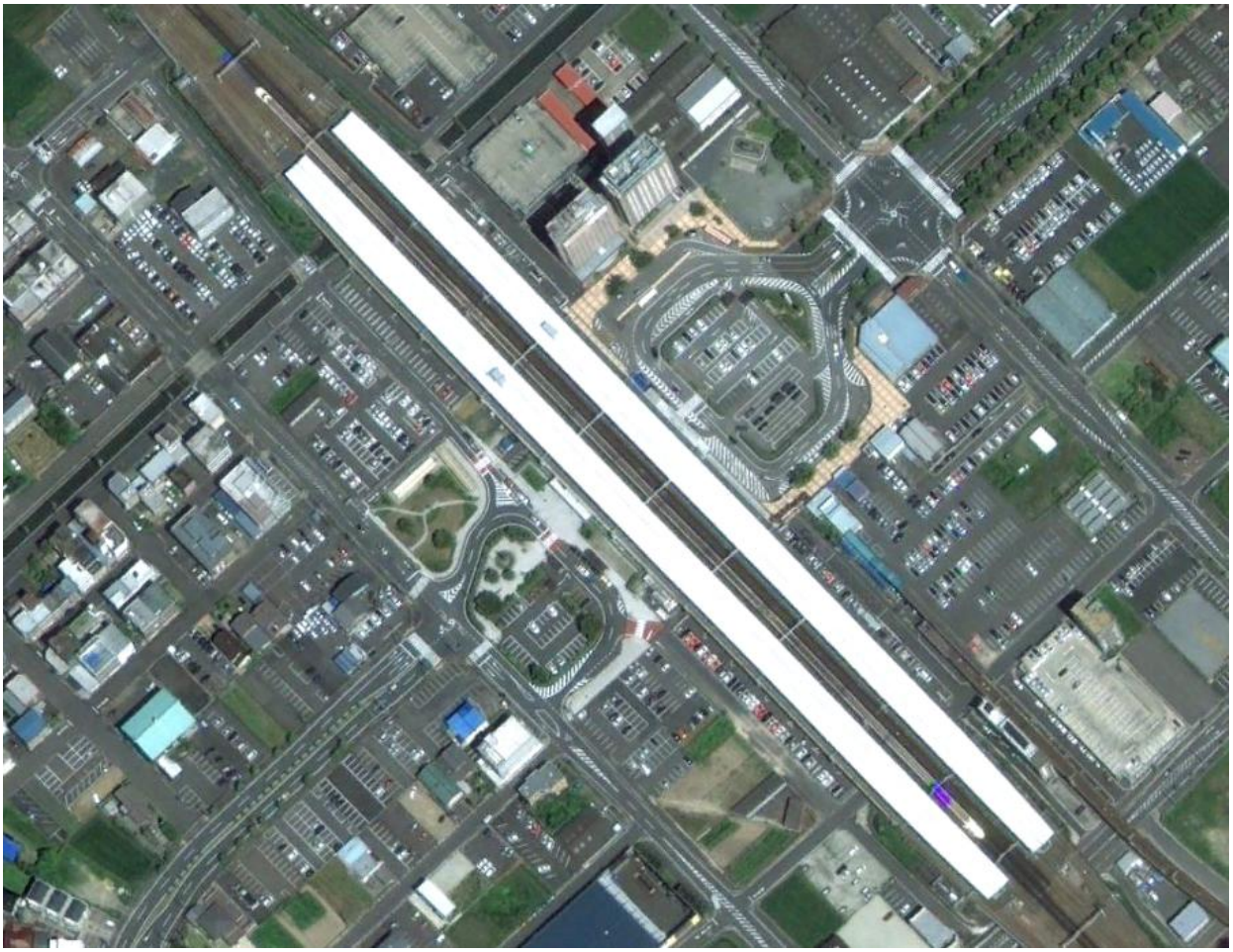


**Figure 18. Land Uses for Automobile Access and Parking around the Gifu-Hashima Tokaido Shinkansen Station: One of the Five Intermediate Cities recently skipped by the "Nozomi" Intercity Services**

## 6. Conclusion and Public Policy Implications

The economic development impacts of the California HSR project are likely to be more redistributive than generative. However, net overall benefits can accrue from spatial redistribution, in the form of strengthening the global competitiveness (and the associated spillover benefits) of the state's two largest urban centers. HSR's business re-location effects in California need not be a simple "zero-sum" game. The knowledge- and service-based firms and workers shifting from somewhere to more accessible, higher density, and high amenity hubs, like downtown Los Angeles and San Francisco, could generate net increases in wealth and economic growth that benefits the state at large (Cervero and Aschauer, 1998; Weisbrod and Weisbrod, 1997).

The direct user benefits of the new HSR and local transit systems alone will unlikely be large enough to cover full investment and operating costs. External agglomeration benefits, if leveraged by pro-active public policies that reward efficiencies and appeal to high value-added industries and labor, could help tilt the benefit-cost equation in HSR's favor. The net economic

impacts of the California HSR project will likely be negative unless public policies (e.g., zoning, supportive infrastructure investments, pro-business governance) pro-actively guide market shifts to station catchments that, based on Japan's experiences, offer comparative economic advantages. Four policy responses are recommended in this regards:

1. **Regional development strategies and flexible funding programs**: State- and corridor-wide policymakers and stakeholders need to form long-term economic-development visions matched by well-articulated mid-term strategies at a regional scale. Such regional development strategies should be tied to a sustainable and flexible funding source that, aided by supportive public policies, allow the accessibility and agglomeration benefits of HSR investments to reveal themselves through traditional market forces.

2. **Joint development and value capture practices in global business centers**: The California HSR Authority and urban redevelopment agencies should take a proactive approach to implementing joint developments to recoup the capital costs of the new HSR and local transit systems from the agglomeration benefits generated in the global business sectors around the proposed HSR terminals in San Francisco and Los Angeles. Value capture practices should promote local land development objectives (e.g., improve livability), discourage excessive levels of rent-seeking investments, and maximize long-term profits.

3. **Local transit-oriented development efforts**: local entities in edge cities and intermediate cities need to pro-actively seize upon opportunities created by HSR investments to leverage private investments around planned HSR rail stations. Under supportive market conditions, investing in high-quality amenities (e.g., streetscape enhancements; public art; cultural and entertainment facilities), supportive infrastructure, and place-making designs could provide a livability premium in the vicinity of HSR stations that help California's major cities recruit, retain, and engage high-skilled knowledge-based workers and industries. With flexible federal and state funding programs, local governments should play a greater role in assembling land parcels, providing development incentives, and minimizing parking facilities around the proposed HSR stations.

4. **Airport connectivity and local access arrangements**: the California HSR and aviation interests should integrate their terminal facilities and intermodal services to offer more advantageous business locations and generate greater agglomeration benefits in edge cities. Having different market profiles and development patterns in the proposed HSR station catchment areas, metropolitan and municipal transportation agencies should aim to enrich local access options, such as the provision of fixed-guideway transit and bus transit systems, paratransit services, and bikeway networks, especially in car-oriented edge cities.

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