Impact of High Speed Rail Stations on Local Development: A Delphi Survey

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High speed rail (HSR) is planned for California and other US states, but there is a significant lack of knowledge regarding the urban development impacts that HSR systems have had in other parts of the world. The study identifies the important preconditions for positive development around HSR stations, the most important positive and negative effects of such development, and extracts lessons for California. From a Delphi survey of twenty-seven experts, we found that the impacts of HSR on the urban development of adjacent station areas differ depending on the context and circumstances. A number of preconditions should be in place for positive development to happen, such as careful choice of station location, an urban design vision for the station area, a transportation plan that links the station to other modes, supportive land-use policies and zoning regulations, and processes that help create broad interest coalitions and elicit community support.

For most of the nineteenth and early twentieth centuries railway systems structured urban geographies. They brought prosperity to the towns they visited and decline to the towns they bypassed. With the proliferation of the automobile in the twentieth century, however, the impact of the railway on urban form waned considerably. In the US, the passing of the Federal Highway Act of 1956 initiated the building of the modern interstate highway system. In the subsequent decades, more than 43,000 miles (69,200 km) of highways were superimposed on the American landscape connecting remote villages and towns. The highway epitomized modernity, as it shrank distances and moved people and goods efficiently and at high speeds. During that time, railway transit infrastructure in the US quickly became obsolete. As the modal share of railway trips dramatically declined over the second part of the twentieth century (Congressional Budget Office, 2003) thanks to increased automobile ownership and the proliferation of air travel, so did the impact of the railway on the urbanization patterns of communities.

At the dawn of the twenty-first century, something close to a 'second railway revolution' (Hall and Banister, 1994) has emerged in some regions of the world, as high speed rail (HSR) systems, first implemented in Japan, now crisscross Western and Northern Europe, and are under construction in Korea and China. Most recently, the HSR fever has reached the US. In 2009, the Obama administration envisioning environmentally friendly HSR corridors across the country, committed $8 billion for thirteen such corridors across thirty-one US states. With $3.48 billion allocated to California, the state is the largest beneficiary of the HSR federal funds (CHSRA, 2011).

Four sets of expectations accompany the proliferation of HSR systems: 1. transportation goals; 2. environmental goals; 3. economic development goals; and 4. urban development/spatial restructuring goals. With serious congestion often clogging the highways, 'bullet trains' travelling on dedicated right-of-way corridors in excess of 220 km per hour are seen by their proponents as improving the mobility of citizens and the connectivity and accessibility of the places they pass through. HSR advocates also expect that proliferation of such systems would entail environmental benefits, namely offsetting increases in automobile and air travel and reducing roadway congestion, fuel consumption, and greenhouse gas (GHG) emissions. Municipal and state governments are often simultaneously harbouring economic development expectations, hoping that HSR systems can rejuvenate local or regional economies, increase a city's primacy (for first-tier cities) or visibility (for second-tier or more peripheral cities), generate jobs and tourism. Lastly, HSR stations are expected to act as catalysts for desirable patterns of development and growth in station-adjacent neighbourhoods.

Opponents, on the other hand, point to the often enormous construction and significant operational costs of HSR projects, their noise and visual intrusion to adjacent communities, and their adverse impacts on agriculture and wildlife. For the proposed HSR systems in the US, some are also sceptical if they would be able to gain considerable market share from other transportation modes and capture adequate ridership to meet their operating costs. Sceptics assert that if the share of all trips captured by HSR remains small in the US, reductions in CO_2 emissions and other GHGs will be minimal and, hence, any environmental benefits would be insignificant (Kosinski *et al*., 2010). Critics also argue that HSR, rather than generating new economic growth, is mostly redistributing it (Levinson *et al*., 1997; 1999), creating winners and losers. Large and central (first-tier) cities are seen as more capable of reaping economic benefits from HSR than smaller and more peripheral (second-tier) cities on the network (Vickerman, 1997). Cities without HSR stations are mostly left out of the picture (Gutierrez *et al*., 1996).

Proponents and opponents of HSR systems may debate their merits, but despite an emerging literature on HSR development and its associated opportunities and challenges, there is little systematic evidence as to which factors lead to positive and desirable development patterns around HSR stations, or which spatial planning strategies lead to positive local outcomes. Peter Hall (2009, p. 68) argues that 'HSR will be the maker of some cities but the breaker of others', but what are the preconditions that lead to positive development patterns? What potential negative impacts can be mitigated through urban planning? What should municipal governments interested in spurring development around new HSR stations know from the experiences of other cities with HSR networks? Such questions become particularly critical for some California municipalities which are now embarking on planning for the accommodation of HSR facilities.

To address these questions, we will first review the existing literature and also report on a Delphi survey of knowledgeable HSR planning experts, which we conducted in 2010. The purpose of the survey was to draw from the experiences of other HSR systems around the world in order to identify:

- the positive and negative impacts of HSR stations at a local level;
- the prerequisite economic, real estate, policy, transportation, urban development, and municipal behaviour variables that must be in place for desirable development to take place around HSR stations; and
- lessons drawn from international case studies that may be applicable to the California context.

Impacts of High Speed Rail: A Literature Review

A number of studies in the last decade have sought to evaluate how HSR meets different expectations. Most of these studies focus on the transportation, environmental, and economic development impacts of HSR. A markedly slimmer body of work examines its spatial development impacts. To date, many of the variables that influence urban change and spatial restructuring in the context of high speed rail remain largely unmeasured, including economic, urban design, real estate, and municipal behaviour factors. This is particularly true of HSR's long-term effects, which require study over two or more decades.

The bulk of research on high speed rail has so far focused on three areas: 1. cost-benefit analyses of proposed and, to a far lesser extent, realized projects, 2. estimates of the demand for high speed transit and the potential for capturing travel demand served by other modes; 3. economic development impacts of HSR on cities along its network. A number of studies have focused on developing 'complete' accounting methods of the costs and benefits of high speed rail projects (e.g. Brand *et al*., 2001; Priemus, 2007; Nash, 2010) and the policy environments they seek to affect (see Schweiterman and Scheidt (2007) for an analysis of the situation in the United States, and Thompson (1993) for an investigation of the French case). *Ex ante* cost benefit analyses exist for the proposed systems in California (Levinson *et al*., 1997; 1999; Taylor *et al*., 1997) and proposals in Greece (Tsamboulas *et al*., 1992); the Netherlands (Froidh, 2008); Spain (Coto-Millán *et al*., 2007; de Rus and Nombela, 2007; Coto-Millán and Inglada, 2004); Switzerland (Nash *et al*., 2007) and Turkey (Akgungor and Demirel, 2007). Emerging is a set of *ex post* cost-benefit analyses of realized projects, the earliest of which is by de Rus and Inglada (1997).

Researchers have also undertaken estimation of potential demand for HSR services in various contexts: Henscher (1997) for Australia; Martin and Nombela (2007), de Rus and Roman (2006), and Guirao (2006) for Spain; Lee and Chang (2006) and Suh and Yang (2005) for South Korea. Similar research has estimated the potential capture from competing modes. These include studies by Clever and Hansen (2008), Gonzalez-Savignat (2004*a*), Lopez-Pita and Robuste (2004) for mode shift from air travel; Givoni (2006) for conventional passenger rail; and Gonzalez-Savignat (2004*b*) for personal vehicles.

Researchers have sought to examine the economic development impacts of HSR even though how much development is directly attributable to a line is often difficult to quantify (Givoni, 2006). A number of factors intervene and affect the type of economic impacts that accompany the construction and operation of an HSR corridor. These include the size of a city and its status in the urban hierarchy, its distance to other major cities on the network, the extent of other present modal links and transportation networks (Garmendia *et al*., 2008), pre-existing economic and land market conditions, and the type of anticipatory planning and policy intervention that is put in place to leverage the coming of the HSR (Vickerman, 1997). It comes as no surprise that the economic development impacts of HSR appear to be quite varied and mixed.

For instance, Cervero and Bernick (1996) found that by the early 1990s the Shinkansen line in Japan did not generate significant shifts of population or employment along its corridor, and it strengthened the economic role and primacy of Tokyo and Osaka at the expense of intermediate cities. In a later study, Banister and Berechman (2000) found that the line had both local and regional economic development impacts on Japan's employment growth patterns, and resulted in increased land values around station areas in intermediate cities.

Many scholars argue that most growth and economic benefits from HSR accrue to

the first-tier cities of the network, where firms are better positioned to expand their reach in secondary markets and smaller cities (Hall, 2009; Murakami and Cervero, 2010). This leads some to argue that HSR facilitates the territorial polarization between large and central (first-tier) and peripheral and smaller (second-tier) cities (Guttierez *et al*., 1996). Nevertheless, examples of HSR-induced economic development in small and intermediate cities are also observed. For example, in France, the TGV HSR network has had catalytic effects on the growth and development of second-tier cities such as Lyon and Lille (Greengauge 21, 2006). In Germany, Ahlfeldt and Fedderson (2009) found that small cities along the Koln-Frankfurt HSR corridor saw substantial increases in their GDP compared to other local towns. In Spain, small cities on the HSR network, less than one hour away from major metropolitan centres, were found to accrue economic development benefits thanks to their integration into the larger metropolitan network which helped them attract new economic activities and housing investments (Garmendia *et al*., 2008). Some of the benefits of HSR for small and peripheral cities may also relate to a revamped and more 'modern' image and the increased visibility that this new transportation mode helps them acquire (Bertolini and Spit, 1998). Some have also argued that HSR may extend the spatial reach and economic role of exurban 'edge' cities, particularly where it combines with airport facilities (Hall, 2009; Kasarda, 2010).

Despite the above examples, substantial positive impacts are by no means universal among cities on HSR networks. As noted above, some have witnessed adverse economic effects (Bonnafous, 1987). The literature indicates that the economic and development effects of HSR are interlinked over the long run, but these effects may be unevenly distributed among cities. As a result, scholars continue to debate whether or not HSR truly generates economic development or whether it merely redistributes economic activity, moving it from locations bypassed by the rail (those that have experienced relative reduction in accessibility) to locations made more accessible because of HSR service (Murakami and Cervero, 2010).[1]

Spatial Restructuring and Urban Development Impacts

A smaller number of studies has examined the impacts of HSR on urban form. These include studies that investigate the macro effects of HSR on spatial restructuring and the relative position of cities within the urban hierarchy, as well as studies examining the micro effects of stations on the urban development patterns of adjacent neighbourhoods.

A series of exploratory and conjectural studies has inquired about the macro impacts of HSR, anticipating the possibility of a broad transformation of the regional territory because of increased access and mobility. A principal proponent of this hypothesis has been Peter Hall (1997), who has considered the space-time convergence created by high speed rail among the principal forces re-shaping spatial structure and the city-system in Europe and leading to its internationalization, 'informationalization', and decentralization. Others, notably Garmendia *et al*. (2008), Horner (2000), Blum *et al*. (1997), and Sasaki *et al*. (1997) have echoed Hall's assertion that high speed travel lessens the friction of distance, upending to some extent traditional theories of location and economic agglomeration. Blum *et al*. (1997), for instance, project the advent of corridor regions with integrated but dispersed labour and consumption markets. Sasaki *et al*. (1997) have modelled the potential for spatial dispersion of economic activities among Japanese high speed rail cities, and Garmendia *et al*. (2008) have hypothesized the integration of smaller cities into the metropolitan region, encouraging the further development of polycentric urban forms. Bruinsma and Rietveld (1993), on the

other hand, have argued that an increased inequality between location and increased centralization will emerge as a result of the differential increase in accessibility that accompanies high speed rail. Knowles (2006) argues that telecommunications and roadway improvements could have much greater 'shrinkage effects' than high speed rail, given the relatively small portion of the population that can access the HSR network. His assessment, however, is less true for densely populated European regions, where large portions of the population can access HSR systems. Indeed, the literature so far has not given a definitive answer whether HSR facilitates decentralization and sprawl from metropolitan centres or concentration to them, and outcomes seem to depend on particular contexts and circumstances, and key variables such as station centrality, intermodality, city size, and extent of the HSR network, among others.

Studies examining the micro impacts of HSR on the urban development patterns of local and station-adjacent areas are very few. Many local municipalities are interested in attracting an HSR network because as Ureña *et al*. (2009, p. 269) explain:

> There are 3 reasons why HSR is often seen at the local level as an opportunity to transform the structure of the city center and also to change the overall city image by developing new urban projects and attracting high quality spaces: 1) local communities have become the real entrepreneurs behind attracting investment; … Cities step up their efforts to attract investors, production activities and professional services; 2) HSR projects a high quality image and is often used in city marketing campaigns; 3) railway sites are generally large, centrally located and underused, so HSR provides an excellent opportunity to exploit the availability of such extensive and relatively vacant plots to develop the urban center.

To these factors triggering planning for station area development, Bertolini and Spit (1998, p. 35) add

> … the ongoing privatization process or at least the shift towards greater market-orientation of transportation, and most notably railway companies. Transportation infrastructure and service providers are increasingly seeking ways to recapture the accessibility premium they help to create. This implies the development of commercial activities within stations and redevelopment of land above or around stations.

Examples from Europe show that HSR stations have indeed acted as catalysts for urban development in some cities. For example, extensive redevelopment projects causing a considerable economic spin-off have appeared around HSR stations in first-tier cities such as Amsterdam (Zuidas), Brussels (Midi), Madrid (Prolongacionde la Castellana), London (King's Cross-St Pancras), and in second-tier cities such as Lille (Euralille), Rotterdam (Centraal), Zaragoza (Digital Mile), and Ciudad Real, among others. In other cities, however, the building of an HSR station has not brought about any catalytic effects and was not accompanied by new development. Thus, Berlin is still awaiting redevelopment around its Central Station (Hauptbahnhof) (Peters, 2009); the HSR station in Tours did little to regenerate the area around it (Greengauge 21, 2006); the Ashford station at Kent, UK shows at present little evidence of positive development [Vickerman, in response to survey], while the Ebbsfleet International HSR station, 10 miles (16 km) outside London, has so far only witnessed the building of a park-and-ride facility (Hall, 2009).

The accommodation and smooth integration of transport and urban development is not a simple undertaking. Bertolini and Spit (1998) attribute this to the dual nature of station areas which need to act as *nodes* accommodating both transport and non-transport networks, and as *places* hosting a variety of diverse uses. This generates a series of dilemmas: 1. a *spatial dilemma* because of the compressed nature of most sites which, nevertheless, should accommodate both passengers and local residents and businesses; 2. a *temporal dilemma* because transport investments do not necessarily have the same time horizons as redevelopment

plans; 3. a *functional dilemma* entailed in the requirement of achieving a multi-functional environment; 4. a *financial dilemma* because of the high cost of addressing technical difficulties and accommodating conflicting requirements; and lastly 5. a *management dilemma* which is inherent in the mix of public and private investments and properties, and the heterogeneity of different actors and stakeholders (Bertolini, 1998).

The Delphi Survey Process

The review of the literature shows clearly that the development of an HSR station may have varied impacts on local contexts. Positive local impacts will not happen by the mere presence of a station but require systematic thinking and planning and supportive policies, which should be informed by the experiences of HSR implemented systems in other parts of the world. To identify the 'collective wisdom' from such previous experiences, we compiled a group of HSR experts and conducted a Delphi survey.

The Delphi survey, which was developed in the early 1950s by Norman Dalkey and Olaf Helmer of the Rand Corporation, is a technique to reach a systematic group judgment (Rawitz, 1981). It is described as 'a method of structuring a group communication process so that the process is effective in allowing a group of individuals, as a whole, to deal with a complex problem' (Linstone and Turoff, 1975, p. 3). The technique is particularly useful in decision- and policy-making situations (Cavalli-Sforza *et al*., 1982). The goal of a Delphi survey is to achieve informed consensus or at least to delineate, clarify, and define existing opinions and views (Herrick Cramer, 1991). This is achieved by an iterative process in the form of three rounds of questions.[2] The goal of the iterative process is: 'to obtain a convergence of responses to each question. Such convergence would be indicated by the decrease in the measures of dispersion for the responses and by the stability of the distribution of the responses to each question' (Cavalli-Sforza *et al*., 1982, p. 12).

For the Delphi panel, we recruited twenty-seven individuals with significant expertise in high speed rail research and evaluation.[3] Panel members were identified by means of the following criteria:

1. Position at university or think tank with research and publications on HSR evaluation (twenty participants)[4];

2. Leading position in a public sector agency involved in HSR design, development, or evaluation (three participants);

3. Position in a private sector company involved as consultant, urban designer, or developer of HSR stations (four participants).

While the great majority of panel participants (22/27) had an academic affiliation, many of them (9/22) had also served as consultants to public and private sector companies involved in high speed rail development. The twenty-seven panel members were from ten different countries: US (five), the Netherlands (four), Spain (three), UK (three), France (two), Germany (two), Sweden (two), Italy (two), Japan (two), China/Hong Kong (one), and Australia (one). Nineteen of the respondents were male and eight were female. We identified the members of the Delphi panel through their publications but also from references from knowledgeable sources.[5]

During the first round of the Delphi process we asked participants the following four questions:

1. Referring to an existing HSR system with which you are familiar, please describe the positive effects this system has had on the urban development of station-adjacent communities.

2. In your view, which were the most important preconditions for the generation

of the positive effects you have outlined in the first question?

3. Please describe some of the negative effects that this system has had on the urban development of station-adjacent communities and what may have precipitated them.

4. Regarding the California context,[6] what should municipalities do to bring about positive changes in the areas adjacent to HSR?

Additionally, we asked respondents to identify successful examples of station-adjacent development that we could study as models in a later stage of our research.

During the first round (summarized in table 1, opposite), the survey asked respondents to identify the local effects of HSR on cities and communities. As one Delphi respondent underlined: 'On a local scale the impacts seem to be generative; however, on a regional or national scale the impacts might be distributive' [Bruinsma]. Additionally, and as one respondent cautioned, the 'effects of HSR service areas are embedded in complex processes of long-term spatial development. Thus, they are rarely isolated and even less measurable' [Klein]. With these caveats in mind, respondents identified two major types of positive effects in some HSR adjacent areas: development related effects and economic/market related effects. In regards to development effects, respondents referred to HSR stations bringing about urban regeneration and acting as catalysts for new residential and commercial developments. These included:

1. New or revitalized neighbourhoods around station areas 'with activities such as trade, socio-cultural facilities, and new residences, and green areas which improve the quality of the urban district such as in Amsterdam Zuidas (figure 1) or Lisbon East (figure 2), as well as new neighbourhood services and creation or reclaiming of public spaces such as in Madrid Atocha and Métropont of Lausanne' [Pucci].

2. New city cores and commercial centres such as at Lyon-Part Dieu, at Shin-Osaka, Shin-Yokohoma, and Saku-Daira Station in Hokuriku-Shinkansen;

3. Regeneration and revitalization of formerly derelict city areas such as in Lille (Euralille; see figure 3), Nantes, Brussels,

Figure 1. HSR station in Zuidas district of Amsterdam.

Figure 2. Oriente HSR Station in East Lisbon.

Figure 3. The Mall in Euralille HSR station development.

Table 1. Results of Round 1: responses.

Question 1 *Positive Effects*	*Question 2* *Preconditions*	*Question 3* *Negative Effects*	*Question 4* *Lessons for California*
Development Effects -Urban regeneration -Catalyst for new development -New commercial development -New residential development -New major buildings (e.g. convention centre, shopping centre, entertainment centre) -Infill development -Brownfield development -New developable land -New architectural landmarks -New services (e.g. neighbourhood retail, convenience stores)	*Physical/Environmental* -Central station location -Mixture of uses around station - Integration of station w. surrounding area -High quality architecture - Adequate parking - Significant station area improvements - Vertical integration of multi-modal facilities	*Physical/Environmental* -Tearing down existing buildings -Sea of parking around station -"Barrier effect" (i.e. lack of integration between station and surrounding area) -Buildings of inappropriate scale -Unattractive node not conducive to residential development - Reduction of land-use mix and variety -Noise - Dangers, nuisances (e.g. pollution, odours) - Decreased safety in station areas - Traffic congestion -Empty land	*Physical/Environmental* -Increase allowable densities in HSR station area - Provide high quality architecture -Provide high quality public space -Stimulate housing and mixed-use projects -Designate special development zones around stations -Create nodes of services -Ban single-family zoning in station areas -Provide diversity of housing options -Stimulate office/commercial projects -Plan station as a lively node with mix of activities -Develop good urban design plan of station area -Locate stations centrally -Minimize negative externalities (noise, congestion)
Economic/Market Effects -Increased public sector investment -Increased land values -Increased rents -Increased per capita income -Increased tourism -New employment centres -Increased regional significance -Attraction of special events (e.g. business conventions, conferences	*Economic/Market* -Significant public funding -Active real estate market -Public sector land ownership -Strength of existing area prior to HSR *Transportation* -Location at a transportation node - Highway access to station - Good public transportation connections - Competitive HSR fares -Good and frequent HSR service *Process/Planning* -Existence of strategy to benefit from HSR station -Multi-functional plan (ensuring mix of activities and versatility of spaces -Plan tailored to local conditions -Coordination between public-private sectors -Joint development activities -Supportive state policies -One agency coordinating development -Cooperation of local stakeholders -Strong political will/vision	*Economic/Market* -Significant investment costs -Land speculation -Decreased housing affordability -Lowering of housing values -Weakening of other city areas -Regional imbalance (strengthening of metro areas at the expense of secondary areas or strengthening of cities with HSR stations at the expense of those bypassed by the train-Increased competition among jurisdictions *Social/Political* -Gentrification/displacement -Loss of public good will for other infrastructure projects -Loss of political capital for HSR supporters	*Economic/Market* -Develop marketing/promotion strategies -Develop incentives for affordable housing around stations **Institutional/Regulatory** -Encourage public/private partnerships -Develop cooperative planning tools -Provide incentives for desirable development -Reduce planning/zoning regulations -Combine HSR development with other local assets -Encourage community involvement/participation -Develop distinct policies for central vs. peripheral cities -Develop regulations to prevent land use speculation *Transportation* -Plan station as an intermodal node -Connect station to local airports via transit -Connect with intra-urban transit system -Provide good HSR service -Good integration of regional and local transportation services

Rotterdam, Arnhem, and Torino, and redevelopment of formerly brownfield sites and railway properties such as at Kings Cross, Stratford, and Ebbsfleet.[7]

4. New architectural landmarks and new attractive major buildings combining convention centres, retail, and entertainment facilities (e.g. in Lille, Lisbon, Berlin, and Kyoto).

Identified positive economic effects include: 1. increased public sector investment, especially from the part of national governments, which typically accompanies the development of HSR stations and can give an economic boost to local areas; 2. depending on station location, increased land values and rents (though this may bring along the negative by-product of gentrification [Hall, Wright]);[8] 3. increased productivity 'measured in per capita income' [Ahlfeldt]; 4. creation of new employment centres; 5. increased regional significance of formerly remote cities; 6. increased tourism or at least opportunities for development of tourism and the attraction of special events such as business conventions and conferences in peripheral cities, which experience an increase in their accessibility.

As one respondent stressed, however, 'The HSR cannot produce development by itself but can act as catalyst when other conditions are present' [Bertolini]. Delphi participants listed an array of preconditions that should be in place for positive development to occur in local areas. These included physical/environmental factors (central station location, station integration with surrounding area, high quality architecture and station design which accommodates multimodal facilities, adequate parking, and mix of other uses, station area improvements, etc.), economic/market-related factors (significant public funding, active real estate market; area vitality prior to HSR development, public sector land ownership), transportation factors (location at a transportation node, good highway access and public transportation connections, competitive HSR fares, and good and frequent HSR service), and factors related to the political context and planning process (e.g. strong political will and vision, pre-planning for HSR, adjustment of plans to local conditions, coordination between public and private sectors with one public agency taking the lead, joint development activities, cooperation of local stakeholders, supportive state or national policies). The long list of responses to this question indicates that a number of items should be in place for positive development to happen.

HSR development is not only associated with positive effects. Respondents listed a variety of negative physical, economic, and social outcomes that may also accompany HSR. Physical adverse effects in some areas included the tearing down of historic buildings to make room for expanded railway tracks, the creation of 'a sea of parking lots' around the station, and the negative externalities of noise, toxic pollution, odours, and traffic congestion around station areas. Many also mentioned the 'barrier effect' often created when railway infrastructure, parking lots, and bulky station buildings drastically segregate the station from adjacent neighbourhoods. As one respondent also noted, too often HSR stations become 'complex logistical nodes that are not conducive to residential development and not attractive as destinations in and of themselves' [Cervero]. Here again, we might conclude that the urban form could be planned more effectively to mitigate these negative conditions.

Negative economic effects listed by respondents include the significant public expenditure of building and operating an HSR network, which often leads to increased government subsidies, and the opportunity cost 'because of other foregone services caused by the enormous public expenditure' [Ponti]. Some respondents also listed certain political costs such as the possible loss of 'public good will' and political capital for the development of other infrastructure projects.

Some pointed to the possible regional and economic imbalance that may accompany the building of an HSR network if the first-tier cities are strengthened at the expense of second-tier cities or cities bypassed by the train [Peters]. Local negative economic impacts listed by respondents included land speculation and decreased housing affordability, though some argued that housing values may decrease in station-adjacent areas. These seemingly contradictory responses pinpoint the need for more research to understand the differential effects of HSR on land and housing values in HSR station-adjacent areas.

An adverse, and for some inevitable, social impact is the displacement resulting from gentrification [Hall], which has been observed around HSR station neighbourhoods in Shin-Osaka and Brussels Midi. According to one respondent, development at King's Cross in London has led to the displacement of a number of disadvantaged ethnic minorities, who have found it impossible to bid for space in the new developments [Wright].

The first round of the Delphi survey did not involve any prioritization of responses. However, in the second round, the panel was asked to select and rank the ten items they felt were the most important per question. The ranked responses were sent one last time (third round) to the panel, who were then asked to select and rank the five most important responses to each question. As shown in tables 2 and 3 (which summarize the results and rankings of rounds two and three respectively), this iterative process led to a considerable convergence of responses.

During the first round, respondents' comments made clear that impacts were substantially different for central versus peripheral cities. Therefore, in the subsequent rounds, we requested that the panel addresses each question separately for central and peripheral cities. Additionally, we asked respondents a series of follow-up clarifying questions.

Positive and Negative Effects on Local Development

For both central and peripheral cities the most positive (or second most positive) effect of HSR, as seen by the panel, is its potential for urban regeneration of station-adjacent areas. Responding to a follow-up question, 47 per cent of respondents felt that regeneration will *only* take place, in the presence of a robust economy and property market. Others disagreed stressing that urban regeneration projects often take place with significant public funding, and such funding can override weak market conditions [Willigers, Pucci]. One respondent clarified that commercial and residential development would require a buoyant real estate market, while construction of civic buildings (government offices, convention centres, schools, etc.), which are also part of urban regeneration, would not [Trip].

Under certain preconditions, which will be discussed below, respondents argued that the HSR station may act as a catalyst for additional development, giving momentum to pre-existing urban dynamics or spurring new commercial development and major buildings in central cities as well as brownfield redevelopment in peripheral cities. Respondents saw differences in the types of development which would be likely to be attracted in central versus peripheral cities. Most respondents (63 per cent) believed that since peripheral cities have fewer economic resources, they will see significantly fewer architectural landmarks and new public spaces developed around their stations. In follow-up questions, most respondents (55 per cent) agreed that peripheral cities are most likely to attract residential uses around their stations, though one respondent argued that 'with robust policies in place, non-residential uses can also be developed' [Vickerman]. One respondent also cautioned that the HSR station may act as catalyst for the wrong type of development, such as the sprawling array of warehouses

Table 2. Results of Round 2: priority ratings (scoring range: 0–10): central cities.

	Question 1 *Most important positive effects*			*Question 2* *Most important preconditions*			*Question 3* *Most important negative effects*			*Question 4* *Most important lessons for California*	
Rank	Responses	Score	Rank	Responses	Scores	Rank	Responses	Score	Rank	Responses	Scores
1	Urban regeneration	6.53	1	Central station location	6.59	1	Barrier effect between station and adjacent area	5.82	1	Provide good connection to intra-urban transport systems	4.29
2	Catalyst for additional development	5.41	2	Integration of station with surroundings	5.53	2	Significant cost	4.18	2	Locate stations centrally	2.65
3	New commercial Development	4.82	3	Location at a transportation node	5.29	3	Traffic congestion	3.00	3	Plan station as intermodal node	2.47
4	New major buildings	4.65	4	Good public transit connections	4.29	4	Gentrification/ displacement	2.41	4	Increase allowable densities	2.35
5	New architectural landmarks	4.00	5	Good and frequent HSR service	3.65	5	Land speculation	2.29	5	Good integration of regional and local transportation systems	2.18
6	Increased land values	3.94	6	Strong political will/ vision	3.24	6	Weakening of other city areas	2.18	6	Connect stations to local airports through transit	1.88
7	Increased public investment	3.35	7	Multi-functional plan with mix of activities	3.18	7	Noise	1.47	7	Develop good urban design plan for station	1.82
8	New public spaces	3.00	8	Strategy to benefit from HSR station	2.94	7*	Tearing down of existing buildings	1.47	7*	Plan station as lively node with mix of activities	1.82
9	New residential development	2.94	9	Mixed-use concept	2.71	9	Loss of public good will for other infrastructure	1.17	9	Design high quality public spaces around station	1.53
9*	Increased rents	2.94	10	High quality architecture	2.53	10	Decreased housing affordability	1.00	10	Stimulate office and commercial projects	1.41

Table 2. Results of Round 2: priority ratings (scoring range: 0–10): peripheral cities.

	Question 1 *Most important positive effects*			*Question 2* *Most important preconditions*			*Question 3* *Most important negative effects*			*Question 4* *Most important lessons for California*	
Rank	Responses	Score	Rank	Responses	Scores	Rank	Responses	Score	Rank	Responses	Scores
1	Catalyst for additional development	6.65	1	Location at a transportation centre	6.00	1	Significant cost	4.29	1	Provide good connection to intra-urban transport systems	5.53
2	Increased public sector investment	3.82	2	Integration of station with surroundings	5.06	2	Barrier effect between station and surrounding area	4.00	2	Good integration of regional and local transportation systems	4.65
3	Urban Regeneration	3.76	3	Good public transit connections	4.65	3	Land speculation	2.65	3	Plan station as intermodal mode	4.53
4	Brownfield redevelopment	3.65	4	Central station location	3.94	4	Sea of parking lots	2.47	4	Increase allowable densities	3.29
5	New residential development	3.59	5	Good and frequent HSR service	3.59	5	Unattractive node not conducive to residential development	2.35	5	Locate stations in central areas	2.65
6	New employment centres	3.53	5*	Strong political will/ vision	3.59	6	Noise	1.88	6	Plan station as lively node with mix of activities	2.47
7	New commercial development	3.29	7	Strategy to benefit from HSR station	3.53	7	Sprawl in outlying areas	1.82	7	Provide good HSR service	2.41
8	Increased land values	2.94	8	Station area plan tailored to local conditions	3.41	8	Decreased housing affordability	1.53	8	Stimulate housing and mixed-use projects	2.35
8*	Increased tourism	2.94	9	Co-ordination between public–private sectors	3.18	9	Gentrification/ displacement	1.41	9	Design high quality public spaces around station	2.06
10	Increased regional significance	2.71	10	Multi-functional plan with a mix of activities	2.53	10	Weakening of other acity areas	1.23	10	Develop good urban design plan for station	2.00

Table 3. Results of Round 23: priority ratings for the five most important issues (scoring range: 0–5).

	Question 1 Most important positive effects			*Question 2 Most important preconditions*			*Question 3 Most important negative effects*			*Question 4 Most important lessons for California*	
Rank	Responses	Score	Rank	Responses	Scores	Rank	Responses	Score	Rank	Responses	Scores
					CENTRAL CITIES						
1	Urban regeneration	4.30	1	Central station location	2.85	1	Barrier effect between station and adjacent area	4.15	1	Provide good connection with intra-urban transport systems	3.60
2	Catalyst for additional development	3.25	1*	Integration of station with surroundings	2.85	2	Significant cost	3.50	2	Locate stations in central area	2.60
3	New commercial Development	2.15	3	Station located at transportation node	2.70	3	Traffic congestion	1.75	3	Plan station as intermodal mode	2.10
4	New major buildings	1.60	4	Strong political will/ vision	1.65	4	Gentrification/ displacement	1.40	4	Increase allowable densities in HSR station	1.70
5	Increased public sector investment	1.30	5	Good and frequent HSR service	1.60	5	Land speculation	1.30	5	Develop good urban design plan for station	1.10
									5*	Plan station as a lively node with mix of activities	1.10
					PERIPHERAL CITIES						
1	Catalyst for additional development	4.05	1	Station located at transportation node	3.45	1	Significant cost	3.45	1	Provide good connection with intra-urban transport systems	3.20
2	Urban regeneration	1.90	2	Strong connection to surrounding area through public transit	2.30	2	Barrier effect between station and adjacent area	3.25	2	Good integration of regional and local transportation systems	2.75
2*	Brownfield redevelopment	1.90	3	Integration of station with surroundings	2.25	3	Sea of parking lots around station	2.95	3	Plan station as intermodal mode	1.95
4	Public sector investment	1.85	4	Good and frequent HSR service	1.70	4	Land speculation	1.50	4	Increase allowable densities in HSR station	1.70
5	Increased regional significance	1.30	5	Strong political will/ vision	1.65	5	Unattractive node not conducive to residential development	1.30	5	Locate station in central areas	1.55

and storage facilities often encountered around major airport or bus terminals in the US [Deakin].

Respondents, while agreeing that early signs of development were positive, had mixed reactions to a follow-up question asking them about the time-horizon of new development around station areas.

> It depends; it can be less or more than 20 years. [Bertolini]

> Residential activities may happen within 5 years (or even in advance of the project), employment development may take longer. If no actions are undertaken within 10 years, I expect nothing will happen anymore! [Bruinsma]

> If no development is seen after 5 or 10 years, it's less likely that there will be significant effects after 20 years due to the HSR alone. [Willigers]

The increased public sector investment typically accompanying HSR construction was also ranked among the five most positive effects of HSR on local development. Indeed, the majority of respondents (69 per cent) disagreed with the argument that HSR networks use significant public funds that could be better used on other infrastructural projects.

> I don't know that the funds would have been made available for other infrastructure projects. [Deakin]

> If the alternative is more highways, which it often is, I do disagree [that HSR systems use public funds that could be better used on other infrastructural projects]. The problem is not just the public funds. In the case of legally privatized yet still publicly owned railway companies, like the German railways, the problem is that high speed rail funding takes away from investment in the wider railway network. [Peters]

> I agree or disagree depending on the city system that exists in every country. I agree [that investment on HSR is not economically sound] in a dispersed and not dense city system, but I disagree [that it is not economically sound] in a dense and compact city system with big cities at 400 to 700 km distance. [de Ureña]

The high cost of investment was, nevertheless, listed as the most important and second most important negative effect of HSR for peripheral and central cities respectively. A second negative impact that HSR can have in both central and peripheral cities, according to the panel, is the 'barrier effect' that often develops between railway stations and their adjacent areas. This same issue was addressed by Trip (2004, p. 6) when he referred to 'the risk of urban fragmentation of the station developing into a separate "island", distinctive from the surrounding area in terms of spatial and functional development, ownership, control, scale, and architecture'. According to the panel, peripheral cities, in particular, where land is cheaper than in central cities, run the risk of acquiring a sea of parking lots, and their station developing into an unattractive node not conducive to residential development. As explained by one respondent:

> The sea of parking lots will be a US problem which is not so apparent in most of Europe. And the rail lines themselves, well, so much of station renovation and upgrading in Europe is all about putting them underground or building over them [Peters].

Land speculation, accompanied by gentrification and displacement of some residents in central cities, was listed among the five most significant adverse effects of HSR stations. Other negative effects that made it to the 'top ten' but not the 'top five' list included noise, and for central cities, the possible tearing down of existing historic buildings to make room for new development, as well as the weakening of other city areas (table 2). For peripheral cities, there was a concern that the HSR may entice sprawl in outlying areas, because of increasing rents and housing prices.

Important Pre-conditions

The *location* of a station appears to be the most important precondition for subsequent development, according to the panel (table 3). It is important that the location is situated close to a city's central core to take advantage of pre-existing complementary development

and services. Responding to a follow-up question, the majority of the Delphi participants agreed that new construction is less likely to occur around HSR stations located at the edge of first-tier cities.

Connectivity with other transportation modes appears to be equally important for creating vibrant, transit-supportive density nodes around stations. The siting of the station at a *transportation node* with strong connections to other regional and interregional networks was listed as the most important prerequisite for its future development at peripheral cities, and the third most important precondition for central cities. As argued by Bertolini and Spit (1998, p. 31) in an earlier publication:

> A railway station's essential feature appears to be its function as an intermodal interchange, rather than a place where trains arrive and depart. The railway station is to be seen as 'an urban exchange complex'… The railway system has to offer full connectivity in both the hard sense – the infrastructure – and the soft sense – the services… In the process the railway station turns into 'a place to be', not just a 'place to pass through'.

This observation underscores the importance of a station being both a place and a node.

In a follow-up question, 65 per cent of respondents agreed that in peripheral cities, HSR stations will only act as catalysts for additional development if linked with other means of mass transit (railway, buses, airplanes). Interestingly, proximity of the HSR station to highways was deemed less important, but this is a likely outcome given the significant European representation in the panel (eighteen of the twenty-seven participants were from Europe).

According to the panel, an additional very important prerequisite for development appears to be the HSR station's good integration with its surroundings, what Trip (2004, p. 6) calls 'the embeddedness' of the station area in spatial, visual, and psychological dimensions. Here good urban and architectural design are essential to make the station accessible to the city, give the travellers a good sense of orientation, and provide bridges (literally and metaphorically) to the surroundings. In a follow-up question, 84 per cent of respondents agreed that high quality of station design and public spaces is likely to act as an important catalyst for additional development. As one respondent further explained:

> Attempts to integrate railway infrastructure into an urban environment can include 'soft' solutions (treatment of borders, increasing permeability, constructions of different types of railway crossing, adapting to specific topographic site conditions) and 'hard' solutions (covering sections of the rail tracks or constructing rail bypasses)… The restructuring of the railway system offers the opportunity to improve the integration of rail space within the urban fabric and thereby palliate the barrier effect that railway installations traditionally create. [Tiry]

Respondents also noted that a strong political will and vision is required for successful development around HSR stations. Some argued that these should be combined with station area plans tailored to local conditions, a strategy of how the city could benefit from the HSR, and good coordination between public and private sectors. According to the panel, development will not happen in a vacuum but will require careful planning and policy intervention (see also Nuworsoo and Deakin, 2009). As argued by Vickerman (1997, p. 36), 'only those stations which are prepared to support HSR with complementary investment will stand to gain'.

Importantly, the quality and frequency of the HSR service is an important precondition for ridership and was consequently listed by respondents among the top five preconditions for station-area development.

Lessons for California

The introduction of high speed rail in California is no longer a hypothetical issue. In November 2008, Californians voted to pass Proposition 1A – the Safe, Reliable High Speed Passenger Train Bond Act for

the twenty-first century – approving the issuance of $9.95 billion of general obligation bonds to partially fund the construction of a $40 billion,[9] 800 mile (1,300 km) high speed railway between Northern and Southern California. In 2009, the Federal government allocated $2.34 billion for HSR in California, as part of the Federal stimulus package, which was augmented in December 2010 by another $624 million. With matching state funds, California had in August 2011 a total of $6.3 billion to initiate construction of HSR's first leg in the area of Fresno to Bakersfield (High Speed Rail Authority Press Release, 8 August 2011).

Significant debates are looming in political and academic circles about the costs and benefits of HSR for the state, as well as the accuracy of ridership and cost projections. While these are important issues, they are beyond the scope of this study, which asks a different question: how should California municipalities prepare for HSR? Moreover, if HSR is to be implemented, can benefits be included that do not increase costs?

It should be noted that in California, the imposition of new rail systems has not necessarily been positive for the surrounding areas. This is clearly demonstrated in Southern California, where poor choice of station locations and lack of pre-planning have confounded efforts to attract projects near many heavy rail commuter and light rail stations (Loukaitou-Sideris and Banerjee, 2000). In January 2009, Tom Adams, California League of Conservation Voters Board President, described the vicinities around many of the region's Metrolink commuter stations – another significant investment in rail transit – as wastelands. Many of these stations are surrounded by vast plains of parking which, while providing enhanced access to commuters living at the fringe of the metropolitan area, repel the kind of local accessibility to goods and services espoused by TOD (transit oriented development) advocates. But as the transit advocacy coalition TransForm notes, '… good land use does not automatically follow new transit; policies must be in place to link investments in the high speed train with supportive land use' (http://transformca.org).

To utilize the collective wisdom of the Delphi process, we asked our respondents to outline the most important lessons that California can draw from the experiences of other countries.

Certainly, there are considerable differences between California cities and cities along HSR networks in Europe. For one, planning is much more *ad hoc* and decentralized in California cities, and development is primarily driven by the private sector. In contrast, many of the European cities that host HSR networks have benefited from deliberative master plans put together by powerful public sector agencies. Second, the urban form of European cities is typically more compact, dense, and walkable than their California counterparts. While parts of the Bay Area, Los Angeles and San Diego are quite dense, they are primarily designed for the automobile. In contrast, many European cities provide a more walkable, bikable, and transit-friendly environment. Third, European cities have higher levels of intermodality than California cities, which are primarily built around the automobile. Thus, the HSR network in Europe is not a 'stand-alone' system, but is rather intricately linked with other transportation networks and modes. Typically, European HSR stations do not only accommodate high speed trains, but are hubs of local transport. To these differences one should add that California residents are more 'married to their cars' than Europeans. They have higher rates of automobile ownership and more automobile miles travelled per capita.

Respondents were well aware of the aforementioned differences. It is for this reason that most emphasized the need to make the HSR station a well connected and central node within the city. They argued that the most important lesson for California municipalities is that they

should provide good connections of the new HSR system with other intra-urban and regional transportation systems (including local airports), and plan the station as an intermodal node. Station location (which was also described as the most important precondition for desirable development) should be chosen carefully to maximize opportunities for desirable development. Panellists argued that in both first- and second-tier cities, the HSR station should be centrally located rather than at the edge of the city to take advantage of the centre's good accessibility and connectivity with outlying areas, as well as existing buzz and activities.

Pre-planning in anticipation of the rail and the preparation of station urban design plans was stressed as important to avoid the barrier effect, create a lively node with a mix of activities, and high-quality public spaces. Complementary land-use regulations such as the increase of allowable densities in the HSR station area can help stimulate housing, mixed use, and commercial projects. Transportation planning of the station area should have the objective of enhancing its connectivity to different transportation modes, while careful attention should be given to the amount and siting of parking facilities so that they do not create a barrier that separates the station from its adjacent area.

In the end, the biggest lesson from the successes and failures of HSR systems around the world to catalyze further development is that growth and development around station areas will not happen by the mere presence of the HSR network. A number of conditions should be in place, which at a minimum should entail a careful choice of station location, an urban design vision for the station area, a transportation plan that links the station to other modes, supportive land-use policies and zoning regulations, and processes that help create broad interest coalitions, and elicit community support through transparent meetings and hearings. It seems that how such preconditions are fulfilled by municipalities and transportation agencies will determine whether the HSR becomes a catalyst for positive development.

NOTES

1. The following outcomes are presented in different HSR studies: 1. net growth occurs primarily in large cities on the network; 2. net growth occurs in large and small cities on the network; 3. there is no net growth and central cities on the HSR network benefit only from the redistribution of economic activity from both the smaller cities on the network and the cities off the network; 4. there is no net growth and central and peripheral cities benefit from the redistribution of economic activity away from cities bypassed by the network.

2. In the first round, the panel responds to the questions posed by the researchers, who in turn, use simple statistics to summarize the panel's responses. The summaries are sent back to the panel for a second and a third round. In these rounds, the experts are asked to reconsider and rank their responses based on the information provided to them by the results of the previous round.

3. Twenty-seven experts participated in the first round of the Delphi survey but a few of them dropped out in the next two rounds because of time constraints. Twenty-three of the original participants participated in the second round, while twenty of the original participants participated in the third and last round of the Delphi survey.

4. We solicited the most authoritative academic voices on high speed rail research and evaluation, asking people who have published extensively on the subject to participate on the Delphi panel of experts.

5. One of auxiliary questions of the first round was 'Could you recommend and provide us with contacts of other individuals that we should invite to participate in this survey?'.

6. To inform the Delphi respondents about the California station-area context, we provided a brief description of the particular population and density characteristics and type of settlement (e.g. urban, suburban, exurban/rural) for different California stations.

7. There are plans for residential and some commercial development at former derelict quarry

sites at Ebbsfleet in the Thames Gateway, but these plans have not been implemented yet.

8. It should be noted that a few effects such as higher land values, rents, or station-gentrification that were identified as 'positive' by some Delphi participants were identified as 'negative' by others.

9. The original cost estimate of $40 billion for the California HSR has been recently expanded to $98.1 billion.

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