Freeway Expansion and Land Development: An Empirical Analysis of Transportation Corridors

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1. Introduction

Road transport infrastructure can, together with other factors, influence location choices and decisions involving residential, commercial, and industrial development The network of roads and highways provides a means for access for workers and materials as well as a way for distributing products and services Greater access lowers the costs of transportation and therefore increases the supply of many resources, including land, labor, and materials An investment in highway infrastructure can have a variety of land use impacts, depending upon which of the above factors have been affected and how important they are The impact also depends on the nature of the investment For example, the effect of building a new freeway is likely to differ from that of expanding the capacity of an existing one The impacts of enhancements to radial and circumferential routes may also differ

There is a sizable literature concerning the impact of road investments on land use, land values, development activity, social and community variables, and local and regional economies The studies have been carried out in a number of different communities in the U S and have used a variety of research methods, from case studies to large-scale regional models. There is, however, a paucity of empirical work that attempts to isolate the impact of transportation investments in a statistically rigorous way Much of the literature uses a case study approach that is highly descriptive and yields anecdotal information (1-5) Such studies are often inconclusive concerning the existence of linkages, and invariably so with regard to their magnitude. Other studies, while more quantitative, rely on complex models that are virtually impossible to validate (6-8)

In this study we employ econometric techniques to study land use impacts of highway capacity expansion projects in several corridors, all located in California's four largest urban areas Our analysis is intended to measure the effect of the expansions upon land use in the areas served by the expanded roadway, after controlling for other factors Section 2 overviews our research approach, while section 3 describes our data set Section 4 presents an exploratory analysis of development impacts from road capacity expansion, based on simple graphical techniques, and argues that this indicates the need for more rigorous statistical analysis Section 5 documents the procedure for this analysis, and Section 6 discusses its results A summary and conclusion are offered in Section 7

2. Approach

Our objective is to statistically evaluate the land use impacts of highway capacity expansion projects. To do so, we develop a data set based on a "panel" of corridors in which highway capacity expansions have occurred The corridors in the panel are located in large urban regions in the state of California The "panel" includes a number of corridors with a large number of years of information for each This enables us to make statistically robust estimates of the land use changes that result from expanding the capacity of nearby roads Furthermore, by having a number of different projects from across the state included in the data, we can be fairly confident that our results are broadly representative of conditions within California's large urban areas

Different types of land use changes, including residential. commercial, and industrial development, are considered Much of the previous literature has focused upon one type of land use when examining the outcome of a new highway facility or a capacity enhancement project We want to ascertain whether one type of land use is affected more than, or in a different way from, another

In order to empirically investigate the land use consequences of a capacity enhancement project, a broad set of data is needed First, an accurate representation of the land development activity before and after the project is necessary Second, we require demographic, socio-economic, and financial variables that can affect land use, so we can be confident that any measured impact of a capacity expansion is not in fact capturing the influence of other, excluded, variables

Development activity in an urban region is subject to both local and regional influences For example, growth in single family homes in the Bay Area's Contra Costa county may result from housing demand associated with economic activity in downtown San Francisco, rather than a recently completed capacity enhancement project in a corridor in Contra Costa Therefore, the information contained in corridor data is partly reflecting what is occurring at the broader regional level and partly due to what is happening in the corridor It is thus important to distinguish and control for these broader regional influences by normalizing the variables used in the empirical examination This is explained in greater detail below

3. Data Description: Variables and Geographic Study Areas

Our analysis is based on a set of corridors located in the four largest urban areas in California There were many capacity enhancement projects in these regions in the past two decades. Projects are selected from reference 9, an annual publication from California Department of Transportation, which provided the size, cost, and date of completion of highway construction projects The single most important criterion in selecting a project for inclusion in the data set is that it be a capacity enhancement of a controlled access radial freeway, completed between 1970 and 1988 These years are selected so that information covering a sufficient period on either side of the project completion date is available. Once the projects are chosen, the communities most directly impacted by them are identified Any community located in the affected corridor, and whose route to the central city of the region would normally include the expanded road section, is chosen

All corridors are located in one four major metropolitan regions of California the San Francisco Bay Area (9 counties), Sacramento (6 counties); Los Angeles-Long Beach (3 counties); and San Diego (1 county) Over the past three decades all of these areas have experienced high rates of growth, and had a significant amount of investment in highway infrastructure. Three of the corridors are in the Bay Area, one in Sacramento, and two each in Los Angeles and San Diego The corridors are identified and described in Table 1 Note that in four of the eight cases more than one capacity expansion occurred over the study period This complicates the analysis, since for years after the second expansion the impacts of both expansions must be considered Our procedure for doing this is discussed below

Four dependent variables are used as to explore the impact of capacity enhancements on land use All are based on building permit activity, data for which are available at the city level from the U S Census Residential permit activity is measured in terms of the number of housing units for which permits were granted Commercial and industrial permit activity is quantified based on cost of permitted construction Note that these variables are all flow variables that measure the rate of development For example, one dependent variable employed in the analysis is the growth in single family homes as measured by the number of such units for which building permits issued in a given year This variable measures the addition to the existing stock of single family homes each year rather than the total number of such homes To normalize for regional trends, permit activity in the affected corridor is divided by regional permit activity. For example, in the case of single family homes, the dependent variable is the annual permits issued for single family units in the corridor divided by the annual permits issued for single family units in the region

The set of independent variables form several groups One group consists of socioeconomic variables It includes population (obtained from the California Statistical Abstract), total personal income (from the U.S. Census Current Population Reports), gasoline price index (from the California Statistical Abstract), construction cost index (from the Engineering News Record), and the "available population capacity" as measured by the difference in the population predicted by planners (obtained from the various regional planning agencies) for the region for the year 2001 and the population in the year of the observation Where appropriate the corridor variables are normalized by regional variables

A second group consists of transportation variables. A transit expenditure variable, defined as the sum of local transportation fund (TDA), federal, state, and local capital grants and non-governmental donations, controls for the impact of these expenditures on land use changes, but is found to be statistically insignificant The other transportation variables – which are the focus of our investigation – are functions of the time since completion of a capacity expansion project These include dummy variables used to identify when a project was completed that is, a variable is set to 1 for the year after a project was completed and for each subsequent year, while for all other years it has the value 0. We also include a time variable equal to 0 in the year the project was complete (and all preceding years) and incremented by 1 in each subsequent year Thus, a project completed in 1985 would have a value for this variable of 0 in 1985 and before, 1 in 1986, 2 in 1987, and so on When warranted, the square of the time variable is also included Together, the expansion completion dummy and the time variable(s) define a first or second order polynomial in time since project completion designed to capture the dynamics of the land development response to a road capacity increase.

The use of project completion date as the key milestone for the analysis may be questioned A capacity expansion could influence land use decisions well before it comes on-line, so long as decision makers are confident that it will occur It is difficult, however, to relate the knowledge and beliefs of decision makers to project milestones that can be objectively ascertained The project completion date is employed in this study because it is a well-defined time by which it can be safely assumed that all key actors know about the expansion We leave the possibility of using other project milestones as a topic for future research

Because of gaps in the data and changes in the composition of some of the urban corridors area over the period of analysis, various dummy variables are included in the model Two of these variables indicate cases in which a new city was incorporated in a corridor sometime during the analysis period Corrections are necessary in these cases because permit data for unincorporated areas are available only at the county level, so that permits in unincorporated areas affected by the capacity expansion cannot be counted.

Two additional dummy variables are used only for the I-580 corridor (Corridor 1 in Table 1) The City of Pleasanton placed a freeze on land development in 1972, because of inadequate sewage treatment capacity This event is reflected in the one dummy variable In 1976 Pleasanton received federal financial assistance for new sewage treatment facilities, and the city terminated the freeze but placed a 2 per cent limit on growth of residential projects that is still in effect The years during which the limit was in effect are indicated by a second dummy

4. Graphical Analysis of Capacity Expansion Land Use Impacts

Before undertaking any regressions. we explore the data graphically. Observing land use variables over time and juxtaposing them to the year of completion of a capacity enhancement project provides a first pass at determining if there are any impacts Results for two of the eight corridors contained in the panel are presented below to illustrate the approach

Figures 1 and 2 present single family housing permit activity for the two example corridors and their associated urban regions Figure 1 plots these data for I-580 in eastern Alameda county (part of the San Francisco Bay Area) while Figure 2 does so for I-5 in the San Diego area In the case of I-580, there is a discernible acceleration in single family housing construction after the completion of the capacity enhancement project However, this acceleration also coincides roughly with the lifting of the development freeze in this corridor in 1976 Thus the graph sheds little light on the individual contributions of these two events For I-5, the behavior in the corridor parallels that of the region with no apparent impact from completion of the capacity enhancement project

Figures 3 and 4 show similar plots for multi-family housing As in the single family case, there is a surge in corridor permit activity after completion of the I-580 capacity expansion, while the I-5 data suggest, if anything, the opposite effect Figure 5 depicts a very sharp increase in commercial permit activity (measured in dollar valuation rather than physical units) after the I-580 expansion, while Figure 6 offers evidence of a short period of accelerated commercial development a short time after I-5 was expanded. The contrast of Figures 5 and 6 illustrates how the dynamics of the (apparent) response of development to a road improvement can vary--a point that is addressed in the statistical model presented below

Scanning Figures 1-6 it becomes evident that they do not support definitive conclusions as to whether a capacity enhancement project has an impact on land development The figures suggest impacts in some instances but not in others Furthermore, even when a capacity expansion appears to have an impact, the net contribution of this event relative to other factors cannot be readily discerned For example, development constraints resulting from lack of sewage capacity may have influenced activity on the I-580 corridor as much or more than the highway expansion did. It is, therefore, necessary to utilize a more powerful statistical technique that allows us to consider all the influences simultaneously and will yield test statistics that measure the significance of the influences

5. Statistical Analysis of Land Use Impacts: Procedure

Regressions are estimated using ordinary least squares (OLS) for each of the dependent variables described earlier A number of different models and functional relationships are investigated and their statistical performance compared All models are estimated on the data described above, which are organized into a "panel" -- a combination of cross-sectional and time series data The panel is created by stacking the data by region so the variables vary across regions as well as over time Models could be estimated separately for each region, but our focus is on relationships that hold across the full sample of expansion projects Therefore, the empirical investigation concentrates on the entire set of data, using dummy variables to control for persistent differences between corridors

Several different functional forms, including linear and log-linear models, and combinations of variables are investigated Statistical testing clearly shows that the log-linear model is superior for all dependent variables The preferred log-linear model has the form

$$\ln(L_{ikt}) = \lambda_i + \alpha_{ik} + \sum_j \beta_{ij} \ln(X_{jkt}) + \sum_l \delta_{il} D_{lkt} + \sum_{m=1}^{2} \sum_{n=0}^{N} \gamma_{imn} \Delta t_{mkt}^{n} + \varepsilon_{ikt} \qquad (1)$$

where.

L_{ikt}	is the normalized permit variable for land use i in corridor k in year t (i=1 for single family housing, i=2 for multi-family housing, i=3 for commercial development, and i=4 for industrial development),
X_{jkt}	are continuous independent variables;
D_{lkt}	are dummy variables;
Δt_{mkt}	is the maximum of the number of years since completion of capacity expansion m and 0,
$\lambda_0, \lambda_i, \alpha_{ik}, \beta_{ij}, \delta_{il}, \gamma_{imn}$	are parameters to be estimated,
ε_{ikt}	is an error term assumed to be normally, identically, and independently distributed.

The coefficients of primary interest in the model are the γ_{imn}. These coefficients specify a polynomial of degree N in Δt that characterizes the impact of the mth (m=1 or 2) capacity expansion in a corridor on the ith type of land use (i=1,2,3, or 4) Consider, for example, the coefficient γ_{110}. This coefficient pertains to the impact of an initial capacity expansion (m=1) on single family housing (i=1) Furthermore, since n=0, the coefficient measures a shift in permit activity that occurs just after the expansion occurs and remains constant through time Similarly, the coefficient γ_{211} pertains to the impact of an initial capacity expansion (m=1) on family housing development (i=2). In this case, n=1, so the impact is one whose magnitude (whether positive or negative) increases linearly with time since completion of the expansion project (Δt). In theory, a polynomial of sufficient order can closely approximate any "well-behaved" dynamic response of a land use variable to a capacity expansion In practice, we found statistically significant coefficients only for n=0,1, and (in the case of commercial development only) 2 This does not mean that responses are in fact characterized by first (or second) order polynomials, but rather that our data set can support only a first (or second) order approximation of the "true" response

Our use of the m index reflects the expectation that capacity is added to a corridor more than once, the effects of the latter expansions may differ from those of the initial one. The data contain only four corridors where two expansions occurred, but in two cases the later expansion occurs near the end of the time series (see Table 1). The results for the second capacity expansion are thus based considerable fewer data, and should be considered more tentative than those for the initial (m=1) expansion

A number of the independent variables in our model are highly correlated Rather than run many regressions with different combinations of variables and select the "best" one in some ad hoc way, we use principal components analysis to select the subset of variables to be included in the regressions Principal components is a multivariate statistical technique that analyzes intercorrelations among variables, how variables jointly "hang together" The goal of principal components is to summarize a multivariate data set in a small number of components thereby eliminating variables whose contribution to the explanation of the variation is negligible This proved to be a useful technique for screening our initial set of independent variables and choosing a subset for the subsequent regressions

6. Statistical Analysis of Land Use Impacts: Results

The results of four regressions--one for each of the four land use types--are reported below in Tables 2 through 5 Table 2 contains the results for single family housing permits (i=1). The regression equation fits well, in a statistical sense, explaining 81 per cent of the variation in the dependent variable based on the adjusted R^2 statistic As in most of the models, the response is approximated by a first order polynomial in Δt -- higher order terms are statistically insignificant.

For the single family housing model, three of the four capacity enhancement variables are statistically significant at the 5 per cent level, and the remaining one -- γ_{121} -- is significant at the 10 per cent level The estimates for γ_{110} and γ_{120} positive and of the same magnitude The positive value indicates that capacity enhancement leads to an initial upward shift in the corridor share of single family home permit approvals The estimates of γ_{111} and γ_{121} are also significant but of opposite sign, the former being negative while the latter is positive As explained above, the former estimate is the more meaningful one since it pertains to the "first" capacity expansion in a corridor Its negative sign implies that after the initial capacity increase and consequent upward shift in the corridor share of single family housing development, this share decreases with time However, if there is a subsequent capacity expansion, it causes not only an upward shift in the corridor share of single family housing development (since γ_{120} is positive) but also an upward trend in this share (since γ_{121} positive)

Table 3 contains the estimates for multi-family housing (i=2) model The important results are, as before, the γ estimates The constant response coefficient for the first capacity enhancement, γ_{210}, is positive, significant, and of similar magnitude as that in the single family housing model (γ_{110}) This implies that the first capacity enhancement on a corridor stimulates multi-family permit activity Unlike the single family case, however, the estimate for γ_{220} is not statistically significant, implying that a second capacity expansion does not immediately stimulate family housing development The first order coefficients, γ_{211} and γ_{221}, are again of opposite sign, with the more meaningful γ_{211} estimate implying that the initial surge in multi-family housing development attenuates over time γ_{211} is estimated to be about 60 per cent greater than γ_{111}, suggesting that the pace of multi-family housing development diminishes more rapidly than that of single family home construction

Our regression results for the corridor share of commercial permit activity are contained in Table 4 They imply that an initial capacity enhancement has a statistically significant, positive, and immediate, impact on the corridor share of new commercial construction (based on the estimate for γ_{310}) Furthermore, the effect rises over time as the γ_{311} is positive and significant, but it does so at a decreasing rate, since γ_{312} is negative If there is a second enhancement project on the same corridor, its initial impact is negative, but statistically insignificant. The subsequent evolution is similar to that of the first project: growing more positive, but at a decreasing rate

Finally, the results for industrial permit activity appear in Table 5 The completion of an initial capacity enhancement project has no immediate effect on the pace of land development for industrial use, since the γ_{410} estimate is statistically insignificant. The capacity increase does, however, spur an upward trend in the corridor share of industrial development, since the γ_{411} estimate is positive and significant The estimated impacts of a second expansion, if one occurs, parallel those of the first. γ_{420} is not significant, implying that there is not an immediate upward shift, but γ_{421} is (marginally) significant, suggesting that the corridor share of industrial permit activity begins to trend upward after the expansion is completed

7. Summary and Conclusions

Our research has investigated, using a panel of data, the impact of highway capacity expansion in a number of corridors located in major urban areas of California. The data set contained variation across corridors as well as time and represents as careful an attempt as possible to test land use impact hypotheses in a rigorous statistical way. Four dependent variables are considered, based on construction permits for single and multi-family housing units, for commercial construction, and for industrial development A number of additional variables are introduced in an attempt to distinguish the impact of a highway capacity increase from land use changes resulting from other factors

We have found that highway capacity expansion has a strong and statistically significant effect on both residential and non-residential land use We found that capacity enhancement has the effect of increasing the number of single family housing permits in the affected corridor relative to the level in the region If a second expansion occurs on the same corridor, its impact is similar to the first. In either case, after an initial upward "shift" in single family home permits in the corridor relative to the region, the share gradually declines. This suggests that development moves forward in time but may not increase in the aggregate The results for multi-family housing permits are similar Again, there is a significant upward shift in corridor permit shares that dissipates over time In the case of multi-family housing, however, a second capacity expansion on the same corridor appears to yield a different impact

Non-residential land use changes are examined using estimated cost of permitted commercial and industrial construction The results for these two types of development contrast Capacity enhancement is found to have an immediate positive impact on commercial but not on industrial land use For both forms of development, the initial capacity increase is found to trigger an upward trend in the corridor share of permit activity In the case of commercial development, there is evidence that this trend diminishes over time

By necessity, our analysis has depicted the land use impacts of highway capacity expansion in considerable detail We have differentiated among development types, between initial and subsequent capacity expansions. and between impacts that take the form of abrupt shifts and those that evolve over time. Our results suggest that these distinctions are important· highway capacity expansions have different impacts on different types of development, impacts of initial and subsequent expansions differ, and impacts may include both sudden shifts and more gradual trends However, we also recognize that the statistical analyses on which our findings are subject to uncertainty, and that some of our more detailed findings, particularly those pertaining to second capacity expansions, rest on small numbers of observations While we acknowledge uncertainty over these details, our results offer strong support for one overriding conclusion: highway capacity expansion stimulates development activity, both residential and non-residential, in the corridors served by the expanded facilities The impacts will vary, and the results presented here cannot supplant the detailed analysis required to assess the consequences of individual projects. They do, however, point to the need to consider land use impacts carefully and thoroughly whenever capacity enhancement projects are being contemplated.

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ABSTRACT

We report on an econometric analysis of building activity in corridors located in California urban areas where freeway capacity expansions have occurred over the last two decades Four different permit types, single family housing, multi-family housing, commercial development, and industrial development are considered We estimate models relating the corridor share of regional permit activity to several independent variables, including whether the expansion had occurred and, if so, the time since the expansion The model was estimated on a panel consisting of eight corridors, so that results effect the composite impacts over the set, rather than what occurred in any specific corridor We find that single family residential development increases sharply immediately after capacity expansions, but the impact attenuates with time The initial impact of multi-family activity is similar, decays more rapidly Commercial development also accelerates after a capacity expansion, continuing to do so for a period of several years, albeit at a declining rate Industrial development is not immediately affected by an expansion, but does appear to trend upward in the years following Overall, these results imply that expanding highway capacity results in increased traffic-generating activities along the adjacent corridor

Table 1.
Corridors and Projects Included in Data Set

No	Route	Improved Stretch	Region	Cities Affected	Year Completed
1	I-580	Dublin to San Leandro	Bay area	Castro-Valley, Dublin, Livermore, Pleasanton & San-Leandro	1978 & 1988
2	I-680	Walnut Creek to San-Ramon	Bay area	Walnut Creek	1974
3	SH-101	GG Bridge to Richardson Bridge	Bay area	Mill Valley, Larkspur & Corte Madera	1975
4	I-80	Auburn to Roseville	Sacramento area	Auburn, Loomis, Rocklin & Roseville	1977
5	SH-101	Oxnard to Thousand Oaks	LA area	Camarillo, Oxnard, Port Hueneme, Thousand Oaks & Ventura	1975 & 1988
6	I-5	San-Juan-Capistrano to San-Clemente	LA area	San-Juan-Capistrano & San-Clemente	1973 & 1982
7	I-15	San Marcos to Miramar	San Diego area	Escondido, Poway & San-Marcos	1977 & 1982
8	I-5	Chula-Vista to Imperial-Beach	San Diego area	Chula-Vista, National-City & Imperial-City	1973

Table 2
Dependent Variable Corridor Share of Single Family Housing Permits (Housing Units)

PARAMETER	ESTIMATE	STD ERROR	T-STATISTIC	PARAMETER DEFINITION
λ_1	-6.60	2.84	-2.32	Constant for single family housing
α_{11}	0.51	0.32	1.61	Corridor 1 fixed effect
α_{12}	-0.74	0.42	-1.76	Corridor 2 fixed effect
α_{13}	-1.88	0.56	-3.35	Corridor 3 fixed effect
α_{14}	-0.36	0.43	-0.85	Corridor 4 fixed effect
α_{15}	-0.33	0.52	-0.63	Corridor 5 fixed effect
α_{16}	-1.49	0.45	-3.34	Corridor 6 fixed effect
α_{17}	-0.45	0.25	-1.78	Corridor 7 fixed effect
α_{18}	0	--	--	Corridor 8 fixed effect (forced to zero)
δ_{11}	0.84	0.21	3.90	Dummy variable for entry of a city in time period
δ_{12}	0.03	0.21	0.14	Dummy variable for entry of a second city in time period
δ_{13}	-0.94	0.26	-3.56	Dummy variable set equal to 1 for years in which there was a land development freeze in the I-580 Corridor, 0 otherwise
δ_{14}	-0.80	0.29	-2.75	Dummy variable equal to 1 for years land development was frozen due to inadequate sewage capacity, 0 otherwise
β_{11}	0.33	0.24	1.34	Available population capacity of corridor
β_{12}	-0.52	0.26	-2.04	Gasoline price (constant $)
β_{13}	0.19	0.15	1.26	Income in corridor/Income in region
λ_{110}	0.40	0.14	2.83	Years after completion of first expansion project =1, otherwise 0
λ_{111}	-0.04	0.02	-2.54	Time since completion of first expansion project, completion year =0
λ_{120}	0.40	0.20	1.98	Years after completion of second expansion project =1, otherwise 0
λ_{121}	0.05	0.03	1.68	Time since completion of second expansion project, completion year =0

Number of Observations 192
Adjusted $R^2 = 0.81$
Standard Error = 0.54

Table 3
Dependent Vanable Corndor Share of Regional Multi-family Housing Permits (Housing Units)

PARAMETER	ESTIMATE	STD ERROR	T-STATISTIC	PARAMETER DEFINITION
λ_2	-6 15	4 08	-1 51	Constant for multi-famıly housıng
α_{21}	-1 02	0 45	-2 25	Corridor 1 fixed effect
α_{22}	-0 50	0 61	0 83	Corridor 2 fixed effect
α_{23}	-1 70	0 80	-2 11	Corridor 3 fixed effect
α_{24}	-1 60	0 62	-2 58	Corridor 4 fixed effect
α_{25}	-1 49	0 75	-1 98	Corridor 5 fixed effect
α_{26}	-3 30	0 64	-5 17	Corridor 6 fixed effect
α_{27}	-0 86	0 36	-2 38	Corridor 7 fixed effect
α_{28}	0	--	--	Corridor 8 fixed effect (forced to zero)
δ_{21}	0 79	0 31	2 57	Dummy variable for entry of a city in time period
δ_{22}	-0 06	0 30	-0 21	Dummy variable for entry of a second city in time period
δ_{23}	0 12	0 38	0 31	Dummy variable set equal to 1 for years in which there was a land development freeze in the I-580 Corridor, 0 otherwise
δ_{24}	-0 33	0 42	-0 78	Dummy variable equal to 1 for years land development was frozen due to inadequate sewage capacity, 0 otherwise
β_{21}	0 32	0 35	0 92	Available population capacity of corridor
β_{22}	-0 83	0 37	-2 25	Gasoline price (constant $)
β_{23}	0 07	0 22	0 34	Income in corridor/Income in region
λ_{210}	0 45	0 20	2 21	Years after completion of first expansion project =1, otherwise 0
λ_{211}	-0 08	0 02	-3 17	Time since completion of first expansion project, completion year =0
λ_{220}	0 09	0 29	0 30	Years after completion of second expansion project =1, otherwise 0
λ_{221}	0 17	0 04	3 79	Time since completion of second expansion project, completion year =0

Number of Observations: 192
Adjusted $R^2 = 0\ 67$
Standard Error = 0 74

Table 4

Dependent Variable: Corridor Share of Regional Commercial Building Permits (Dollar Value of Construction)

PARAMETER	ESTIMATE	STD ERROR	T-STATISTIC	PARAMETER DEFINITION
λ_3	-4 09	4 50	-0 91	Constant for commercial development
α_{31}	-1 34	0 52	-2 58	Corridor 1 fixed effect
α_{32}	-1 69	0 60	-2 81	Corridor 2 fixed effect
α_{33}	-2 55	0 78	-3 23	Corridor 3 fixed effect
α_{34}	-0 91	0 63	-1 45	Corridor 4 fixed effect
α_{35}	-1 46	0 77	-1 88	Corridor 5 fixed effect
α_{36}	-3 93	0 74	-5 30	Corridor 6 fixed effect
α_{37}	-0 12	0 51	-0 23	Corridor 7 fixed effect
α_{38}	0	--	--	Corridor 8 fixed effect (forced to zero)
δ_{31}	0 58	0 46	1 23	Dummy variable for entry of a city in time period
δ_{32}	-0 33	0 31	-1 05	Dummy variable for entry of a second city in time period
δ_{23}	0 96	0 45	2 11	Dummy variable set equal to 1 for years in which there was a land development freeze in the I-580 Corridor, 0 otherwise
δ_{34}	0 46	0 44	1 04	Dummy variable equal to 1 for years land development was frozen due to inadequate sewage capacity, 0 otherwise
β_{31}	-0 02	0 38	-0 05	Available population capacity of corridor
β_{32}	-0 04	0 41	-0 10	Gasoline price (constant $)
β_{33}	-0 11	0 22	-0 51	Income in corridor/Income in region
λ_{310}	0 59	0 22	2 70	Years after completion of first expansion project=1, otherwise 0
λ_{311}	0 15	0 06	2 52	Time since completion of first expansion project, completion year =0
λ_{312}	-0 01	0 003	-2 31	Time since completion of first expansion project, completion year =0, squared
λ_{320}	-0 45	0 33	-1 35	Years after completion of second expansion project=1, otherwise 0
λ_{321}	0 26	0 11	2 11	Time since completion of second expansion project, completion year =0
λ_{322}	-0 01	0 009	-1 26	Time since completion of second expansion project, completion year =0, squared

Number of Observations 168

Adjusted R^2 = 0 74

Standard Error = 0 74

Table 5
Dependent Variable Corridor Share of Industrial Building Permits (Dollar Value of Construction)

PARAMETER	ESTIMATE	STD ERROR	T-STATISTIC	PARAMETER DEFINITION
λ_4	-4.75	6.72	-0.71	Constant for industrial development
α_{41}	0.29	0.73	0.40	Corridor 1 fixed effect
α_{42}	-4.51	0.98	-4.57	Corridor 2 fixed effect
α_{43}	-3.71	1.17	-3.17	Corridor 3 fixed effect
α_{44}	-1.42	0.89	-1.59	Corridor 4 fixed effect
α_{45}	-0.14	1.07	-0.12	Corridor 5 fixed effect
α_{46}	-3.20	1.01	-3.20	Corridor 6 fixed effect
α_{47}	1.82	0.69	2.64	Corridor 7 fixed effect
α_{48}	0	--	--	Corridor 8 fixed effect (forced to zero)
δ_{41}	-0.66	0.59	-1.09	Dummy variable for entry of a city in time period
δ_{42}	0.67	0.42	1.58	Dummy variable for entry of a second city in time period
δ_{43}	0.23	0.61	0.37	Dummy variable set equal to 1 for years in which there was a land development freeze in the I-580 Corridor, 0 otherwise
δ_{44}	-0.48	0.61	-0.78	Dummy variable equal to 1 for years land development was frozen due to inadequate sewage capacity, 0 otherwise
β_{41}	0.06	0.57	0.11	Available population capacity of corridor
β_{42}	-0.25	0.57	-0.04	Gasoline price (constant $)
β_{43}	-0.09	0.29	-0.32	Income in corridor/Income in region
λ_{410}	-0.09	0.31	-0.29	Years after completion of first expansion project=1, otherwise 0
λ_{411}	0.09	0.04	2.19	Time since completion of first expansion project, completion year =0
λ_{420}	0.53	0.44	1.21	Years after completion of second expansion project=1, otherwise 0
λ_{421}	0.13	0.06	1.87	Time since completion of second expansion project, completion year =0

Number of Observations 135
Adjusted R^2 = 0.76
Standard Error = 0.97

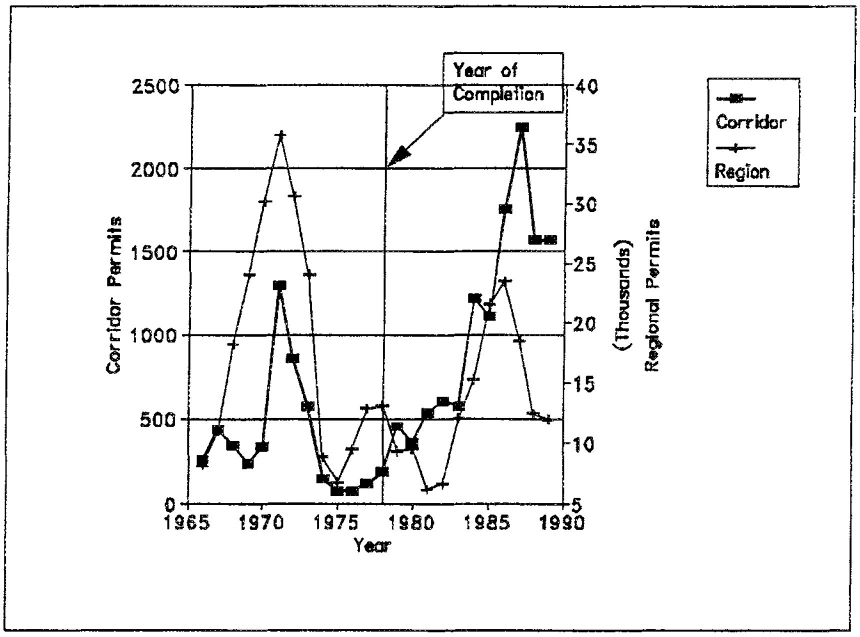

Figure 1 Annual Permits
Single Family Housing Units, I-580 Corridor

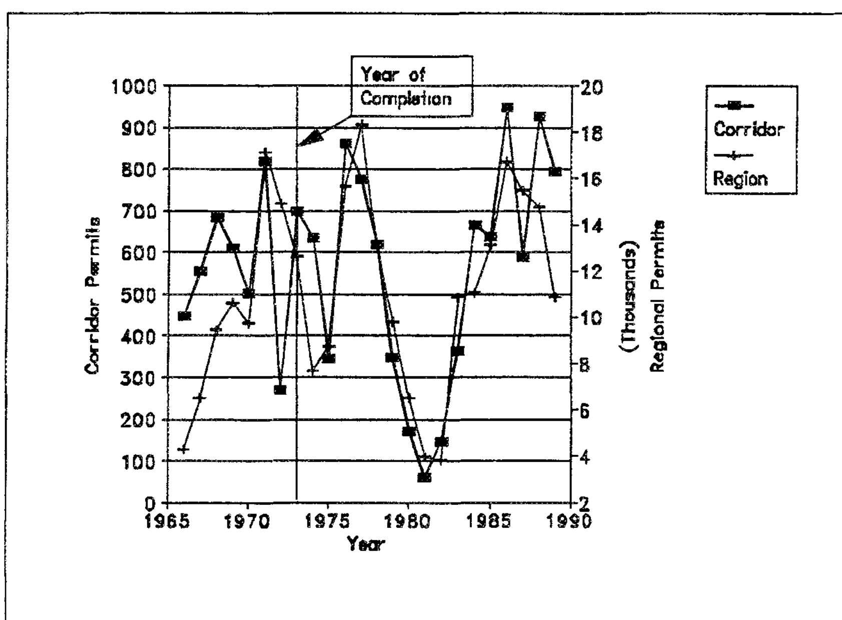

Figure 2. Annual Permits
Single Family Housing Units, I-5 Corridor

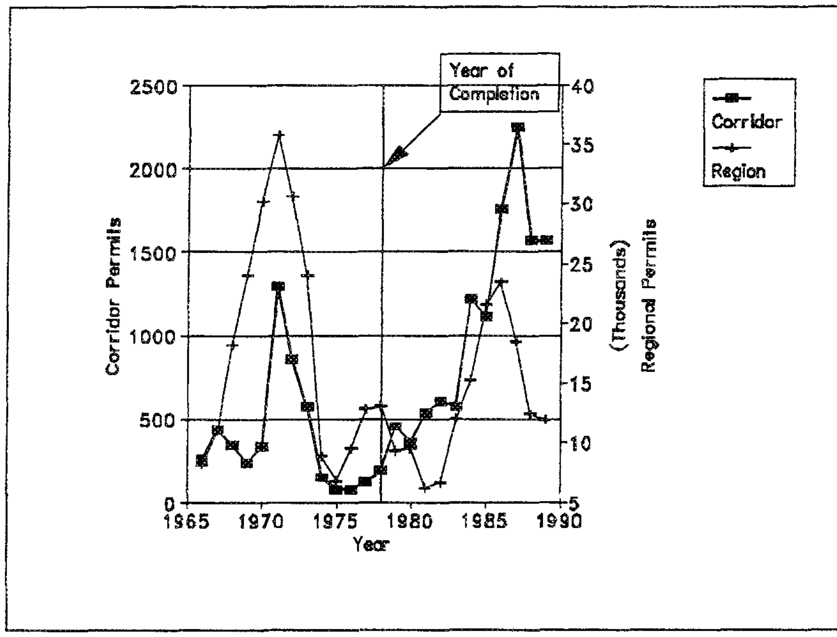

Figure 3 Annual Permits
Multi-family Housing Units, I-580 Corridor

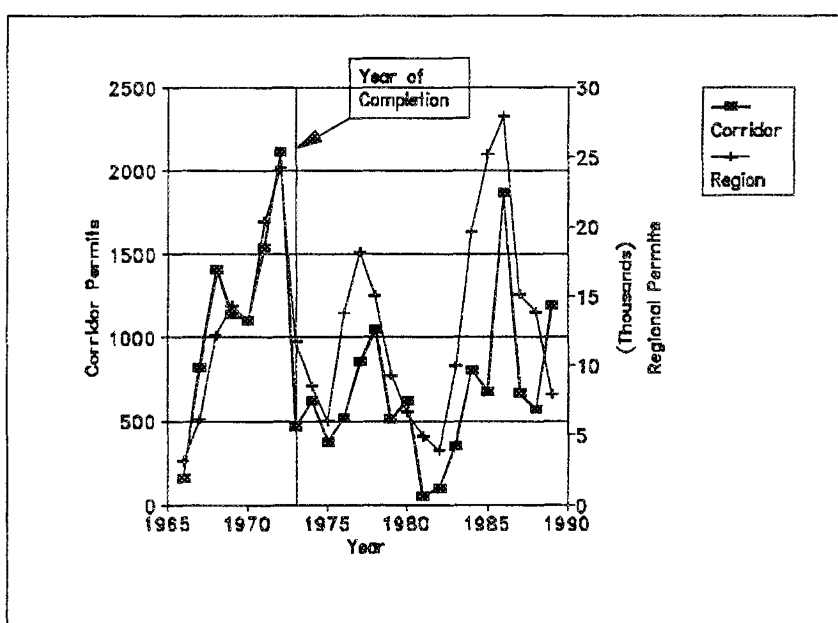

Figure 4 Annual Permits
Multi-family Housing Units, I-5 Corridor

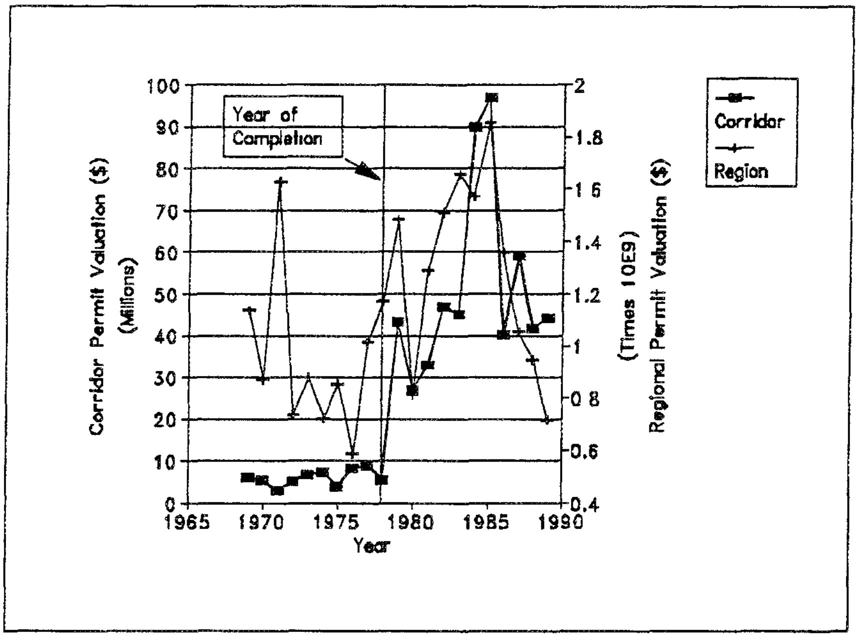

Figure 5. Annual Permit Valuation
Commercial Construction, I-580 Corridor

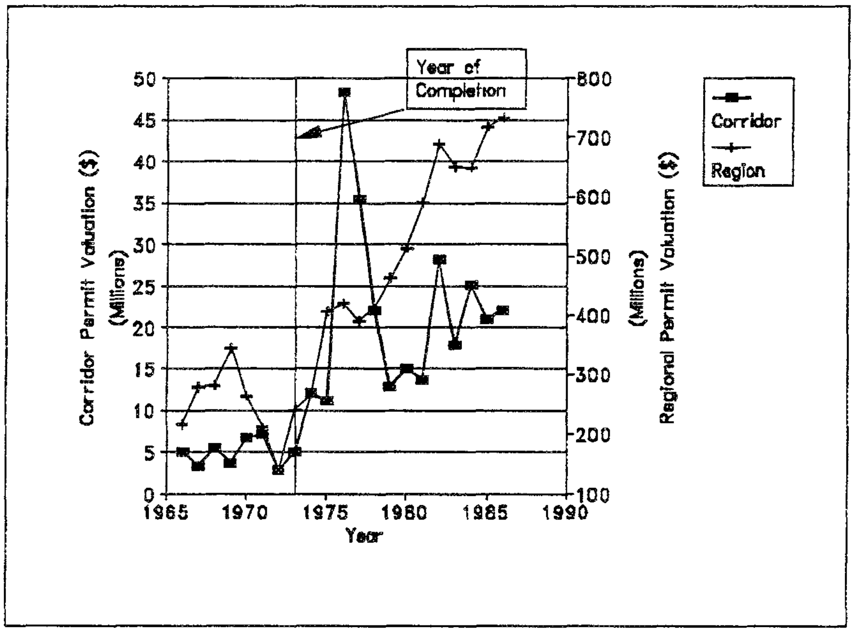

Figure 6 Annual Permit Valuation
Commercial Construction, I-5 Corridor