M. Cullo

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GENERAL PLANNING CONSULTANT

TECHNICAL MEMORANDUM 88.4.5 (REVISED):

METRO RAIL BEFORE-AND-AFTER STUDY: RESEARCH DESIGN, METHODOLOGY, VARIABLES AND DATA COLLECTION PLAN

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Prepared for:

Southern California Rapid Transit District

Prepared by:

Schimpeler Corradino Associates
Cordoba Corporation
Myra L. Frank & Associates

in association with

The Planning Group, Inc.

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ACKNOWLEDGMENT

The General Planning Consultant wishes to acknowledge the contributions of Dr. Shant Agajanian in the development of the study methodology and techniques described in this document. As an independent consultant to the GPC on this project, Dr. Agajanian played a lead role in articulating the research problem and creating the research design and methodology for isolating Metro Rail impact on property value using predictive regression models and residuals analysis.

1.0 INTRODUCTION

The purpose of the Los Angeles Metro Rail Before-and-After Study is to examine the monetary benefits which accrue over time to property located in the vicinity of Metro Rail stations and to isolate the benefits which are directly attributable to the Metro Rail system. The study is further intended to identify benefits which may be linked to particular events associated with the development of the rail system (e.g., commencement of construction, commencement of operations, etc.). The study will attempt to advance the state of the art in benefit measurement through the scientific analysis of benefits that occur over time in the vicinity of Metro Rail stations. This knowledge will be useful in understanding the process by which benefits are derived and will advance knowledge of the methodology to evaluate land use impacts of transit systems in the United States.

The following tasks constitute the Before-and-After Study:

1) Identify Indicators of Benefit and Determine Area of Coverage
2) Identify Potential Sources of Data
3) Evaluate Useability of Data
4) Refine Indicators and Areas of Coverage
5) Design Data Base and Analysis Methodologies
6) Compile Data Base and Establish Update Procedures
7) Analyze Data and Develop Prototypical Case Studies

Tasks 1, 2 and 3 of the Study have been accomplished prior to the development of this Technical Memorandum. The results are contained in Technical Memorandum 88.4.1, Metro Rail Before-and-After Study: Analysis of Potential Monetary Benefit Indicators, Identification of Potential Data Sources and Evaluation of Data Useability.

This Technical Memorandum presents the findings of Tasks 4 and 5 of the Before-and-After study. The purpose of Tasks 4 and 5 is to develop the research questions, research design, methodology, data requirements and collection plan, basic data base design and software to be used in the Study. Detailed data base design will be undertaken in Task 6.

Several studies have attempted to examine the effect of transit systems located throughout the United States on property values, with mixed results. The BART Impact Program conducted multiple regression analysis on 12 BART station areas and found some small, but measurable effects on property value attributable to the BART system (MTC, 1978). The methodology used in this study is examined in this Technical Memorandum. The Atlanta Regional Commission issued several reports concerning property sales prices and numbers of sales in MARTA station areas, but did not attempt to separate the impact of the MARTA system from other factors influencing property values (Atlanta Regional Commission, 1978). The Washington Metropolitan Council of Governments examined commercial development activity (Cardwell, 1982) and employment activity (Cater, 1984) in Metro station areas as compared to the remainder of the Washington, DC region, but did not directly measure the influence of Metro on property value.

This study builds on this previous work and refines and expands the techniques available to isolate the impact of the transit system on changing property values from the many other factors which influence property value. The basic approach of this study is to:

1) Examine the factors which currently influence property values for different land uses and subareas of the Metro Rail station areas. This is done by developing pre-Metro Rail equations which reflect observed factors and patterns of influence on property values in station areas. These equations will be developed by observing property sales in a time frame during which Metro Rail would not be expected to influence property value. As such, these equations can be used to predict future sale prices as if Metro Rail had not occurred;

2) Obtain actual post-Metro Rail sales prices for parcels in the station areas. The study will predict prices for these parcels as if Metro Rail had not occurred using the equations above and compare the actual sales prices to the predicted prices. The difference between the actual and predicted sales prices is termed the "residual" change in property value.

3) Estimate the portion of the residual change in property value that is due to the influence of the property's distance to the Metro Rail station. This analysis will directly provide the magnitude of the change in property value due to Metro Rail.

The estimated amount of property value attributable to Metro Rail influence at that time can be quantified to assess the amount of direct monetary benefits received and can be analyzed spatially to assess the distribution of the impact within the MOS-1 study area. Steps two and three can be replicated for any post-Metro Rail period to allow for tracking impact over time.

The sections which follow examine in detail: 1) the research problem, research design and methodology to be used to address the research problem; 2) data requirements and data collection plan; and 3) basic data base design and software to be used to implement the methodology.

2.0 RESEARCH PROBLEM, RESEARCH DESIGN AND METHODOLOGY

This section examines the basic research problem posed by the study of transit-related monetary benefits and presents a research design and methodology to enhance the effectiveness of the analysis in isolating the influence of Metro Rail on the value of properties located in station areas.

2.1 RESEARCH PROBLEM

The ability to confidently and accurately estimate the direct monetary benefits of transit stations upon local properties has proven elusive. Property values in transit station areas are influenced by many economic factors, including the transit system. Conventional real estate appraisal techniques acknowledge other influential factors including: directional growth patterns, location, utility (or capacity to produce), size, corner influence, shape, thoroughfare conditions, exposure, character of business climate, plottage or assemblage, topography, obsolescence, and building restrictions and zones (California Department of Real Estate, 1987). Past studies have attempted to isolate and quantify direct and indirect benefits of transit stations upon local property values but have suffered from such problems as:

1) unscientific methods of investigation;
2) research design problems inherent in Before/After studies;
3) limits on time, resources and information.

Among these problems, the need to improve upon research design is most acute. Before/After studies of transit station impacts upon property values present particular methodological problems including:

1) Difficulty in introducing experimental or quasi-experimental research design due to the absence of suitably comparable exogenous control areas. This is due to the influence of location as a major determinant of property value and the unique attributes of location which are often unreplicable in any given urban area. If they could be used, control areas would allow for the identification and isolation of non-transit related factors on property value. However, as long as this problem of comparability exists, the insights to be gained from observation of control areas are limited. Because of the uniqueness of different areas in the city, the researcher could never be sure whether observations in the control area were reflective of similar conditions in the experimental area.

   At the same time, it is clearly necessary for the researcher to be able to determine the effects of these non-transit related factors in the station areas in order to confidently conclude that certain observed effects are related to the transit system, and not to other factors. This is the most perplexing problem associated with developing a study design for a research problem of this nature. The methodology described in this document is acutely aware of this problem and is designed to ensure that these factors are properly accounted for.

2) The effects of a transit improvement may be comparatively small in relation to other factors which influence property values.

3) The effects of a transit improvement may vary year-to-year in response to specific events associated with the development of the transit system and may result in a shift in trend rate and direction over the long-term.

The latter two effects were evidenced in the findings of the BART Impact Program which examined the effect of BART on property prices and rents (MTC, 1978). This study examined sale prices of properties in BART station areas in three time frames: before the BART construction period, during BART construction and after BART construction was completed. The study examined properties which sold during any two of these time frames (Before/During, During/After or Before/After). Regression analyses were performed on the ratios of the first and second sale prices to determine the factors which were influencing the total price differential between the two time frames in which the property sold. In the process, a number of problems were encountered, including:

1) The impacts of BART (where found) were small and their significance was easily lost in the error shadow of the most influential variables (location, market, etc.) (MTC, 1978).

2) The study was not longitudinal in that it only examined three general time periods (Before, During and After). It is possible that the effects of BART on property value may have occurred in smaller discrete time frames (e.g., immediately following system announcement, immediately following system funding, etc.). If this were the case, these effects would have been indistinguishable or undetectable using the BART methodology.

3) It was necessary to wait until several years after BART had begun operation before any results could be obtained. This time frame was required to identify sufficient numbers of parcels with sales in linked time periods to obtain sufficient statistical significance.

These research problems need to be overcome, to the extent possible, if the current research effort is to advance transit benefit impact methodology. The research design described in the following section is designed to build on the impact studies conducted elsewhere in the nation.

2.2 RESEARCH DESIGN

The proposed research design is aimed at providing accurate estimates of Metro Rail impacts on property value. Three characteristics of the proposed research design are especially critical to the goal of advancing transit benefit measurement methodology. First, the research design avoids the need for exogenous control areas by providing internal control for all exogenous factors. Second, it isolates Metro Rail impacts from other impacting variables for closer and more detailed examination. Finally, it allows for annual post-Metro Rail impact analysis in order to discern the time-critical dimension of Metro Rail impact. The null hypothesis throughout the research is that Metro Rail will have no significant effect upon changes in the value of properties in Metro Rail station areas.

The area to be studied will encompass the properties located within the benefit assessment districts established for the Minimum Operable Segment-1 (MOS-1) portion of the Metro Rail project. The 4.4-mile MOS-1 runs from Union Station to the Wilshire/Alvarado station. In 1985, under enabling authority granted by

the California state legislature, the Board of Directors of the Southern California Rapid Transit District established benefit assessment districts designed to finance approximately 10% of the cost of constructing the first segment of Metro Rail. Two districts were established, one for the four downtown Los Angeles stations (Union Station, Civic Center, 5th/Hill, 7th/Flower) and one at the Wilshire/Alvarado station.

Because the study methodology directly accounts for the factors which are influencing the value of property in the station areas (both Metro Rail-related and non-Metro Rail related), the use of control areas in this research design is not indicated and therefore not proposed.

The research design approaches the Before/After methodology differently from previous before/after studies of transit station impacts by attempting to isolate those impacts directly associated with development of the transit system. Earlier studies attempted to investigate impacts by simply comparing "before" and "after" conditions. The BART study analyzed the ratio between the sales prices for property which sold in two of three defined time frames: before, during and after BART construction (see Figure 1). The proposed Metro Rail approach investigates impacts by comparing two different conditions: (1) "after with Metro Rail" (actual sales prices) and (2) "after as if Metro Rail had not occurred" (predicted sales prices using equations developed for pre-Metro Rail sales). This approach does not require both before and after "linked" sales. With the ability to predict "after as if Metro Rail had not occurred" property values, the methodology can approximate the amount of post-Metro Rail property sale value which is due to the continuation of pre-Metro Rail trends and factors for any property. The difference between this predicted value and the actual post-Metro Rail property sales value is termed the "residual" impact value.

The proposed research design encompasses the following steps:

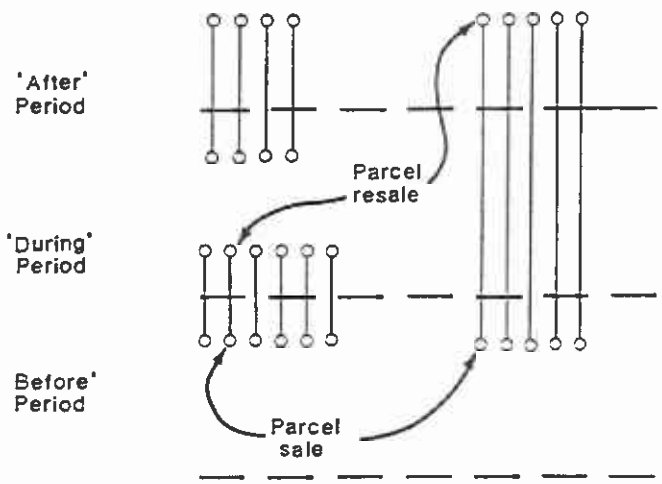
1) A set of multiple regression equations will be developed to estimate property value based upon pre-Metro Rail property sales. Separate pre-Metro Rail baseline predictive equations will be formulated for major land uses and geographic subareas, as appropriate. For instance, attempts will be made to develop separate equations for office, industrial and unimproved property in different locations in the study area, such as the Financial District, Chinatown, Central City East. Using these two key parameters (land use and geographic subarea) in combination will yield a matrix of potential scenarios for which predictive equations can be developed (e.g., office property in the Financial District, industrial property in the Union Station area, etc.). These equations will be developed in the smallest geographic area possible which will yield statistically significant results. This is expected to yield equations which reflect the greatest predictive accuracy. A prime concern in this analysis is that there be enough cases for each set of parameters to ensure confidence in the results obtained. If the initial set of geographic subareas does not contain enough cases to provide statistical significance, these subareas can be aggregated into larger geographic delineations (e.g., Financial District plus Civic Center, Chinatown plus Little Tokyo) until the required significance is achieved. As the geographic area increases in size, it can be expected that the predictive accuracy of the equations will decline, because of the increased complexity and diversity of factors introduced to the process. As a result,

FIGURE 1

DATA COLLECTION & PROCESSING

PHASE I: BART

for each BART station examined



Cases are linked pairs.

3 Periods- anticipatory

immediate

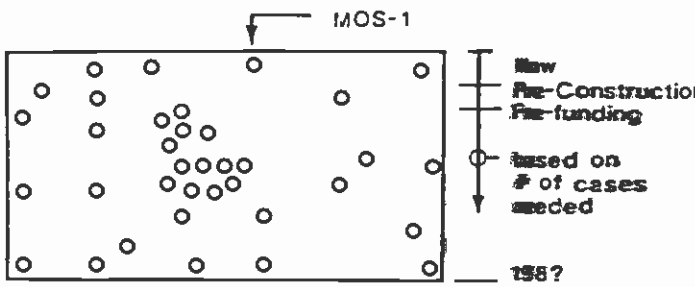
long term

Array of descriptive variables for each linked case

Unit of Analysis = $ increase at resale or derivitive thereof

PHASE I: METRO

A DATA



Cases: each non-exempt property sale

array of descriptive variables for each sale

Unit of Analysis = Sale Value

B PREDICTIVE EQUATION

-multiple regression technique

longitudinal variable values to produce annualized predictions based on trends through last year

Sale Value of Parcel in Year x = f (site characteristics) • f (locational characteristics) • f (market characteristics) • f (policy characteristics) f (year of sale)

these aggregations will need to be considered carefully to reflect, as practicable, similarities in location and market characteristics. This will work to maximize the predictive power of the equations which are ultimately developed.

The resulting equation(s) will capture, to the extent possible, significant pre-Metro Rail trends and factors which influence property value. The definition of the pre-Metro Rail time frame is central to this analysis. It is imperative that the pre-Metro Rail time frame be defined such that the property sales data for that time frame be free of the influence of Metro Rail, including speculative influence. This issue is discussed in further detail in section 2.3.1.2. Because they are designed to reflect no Metro Rail influence, the predictive equations developed in this step can be used to estimate the future price of properties in the station areas "as if Metro Rail had not occurred".

2) Data will be collected on actual property sales in station areas during the time frame following the defined pre-Metro Rail time frame. This data will provide the "after with Metro Rail" condition for the property.

3) The difference between the estimated price of properties "as if Metro Rail had not occurred" and the actual sales price "with Metro Rail" will be determined. This difference is referred to as the "residual" difference.

4) A second analysis will be conducted on this "residual" difference. Because of the manner in which the predictive equations were developed in Step 1, this residual value may contain any or all of three possible factors:

   a) Changes due to the introduction of Metro Rail. Because the predictive equation for property value "as if Metro Rail had not occurred" does not contain the Metro Rail influence on property value, the complete influence of Metro Rail on property value would be expected to be contained in the residual. This is critical to the analysis which is conducted in this phase.
   b) Changes due to new trends and factors not included in the pre-Metro Rail baseline predictive equation.
   c) Error in estimation of the pre-Metro Rail baseline predictive equation caused by changes in the influence of the variables contained in the equation.

This methodology is illustrated in Figure 2. It differs from the methodology used in the BART impact study in that it examines the difference between the actual and predicted property value (the "residual" difference in property value) while the BART impact study examined the total difference in the before and after property value (and found that the influence of BART on this total difference was small compared to the influence of other variables). In the Metro Rail methodology, much of the influence of these other variables will be accounted for and contained in the predicted property value and will thus never need to enter into the residual value analysis. With this methodology, the impacts of Metro Rail are expected to be considerably more discernible.

The focus of the residual impact analysis is the influence of Metro Rail on property value, item a) above. This research will examine the relationship between the residual value and distance from individual properties to the

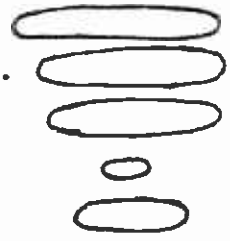
FIGURE 2

ANALYSIS

PHASE II: BART

MULTIPLE REGRESSION relative influence

Change in $ value of parcel = f (site) • f (location) • f (market) • f (BART) • f (other 'E')



Conclusion: IF f (BART), distance to station

IS POSITIVE, coeffecient value

AND SIGNIFICANT, good F ratio

THEN BART HAD SOME IMPACT

FOR THAT PERIOD

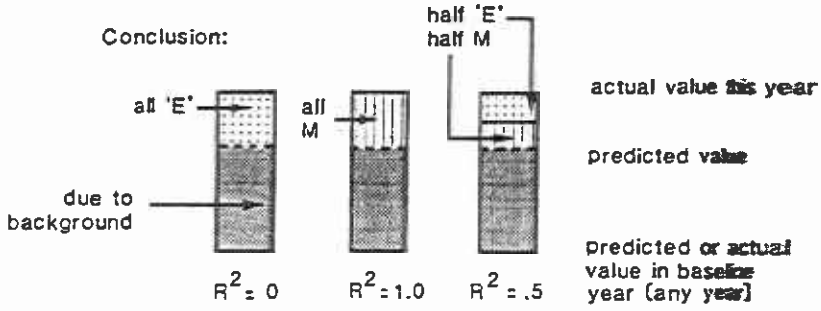
PHASE II: METRO

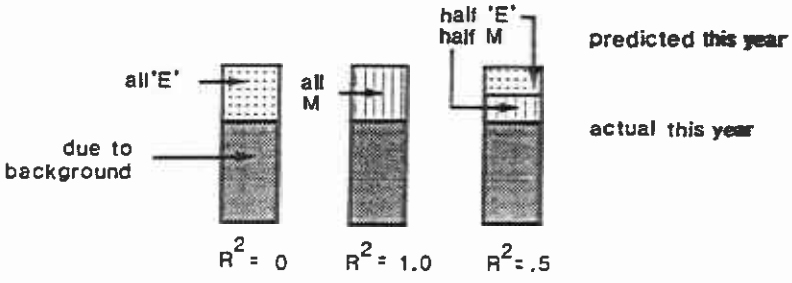
'RESIDUAL' IMPACT ANALYSIS

Bivariate Analysis

difference between actual and predicted parcel value this year = f (METRO) • f (other 'E')

Conclusion:





nearest Metro Rail station through the use of a bivariate analysis with the residual value as the dependent variable and distance from Metro Rail as the independent variable. Initially, walking distance from the nearest Metro Rail station will be used, under the hypothesis that benefit to property is related to the distance patrons are willing to walk to and from a transit station. Alternative behavioral explanations of proximity to Metro Rail (e.g., travel time savings) may also be developed and used as the independent variable in the analysis of residual values. As an economic representation of the impact of Metro Rail, this perceptual "distance" may prove to be a more accurate explanation of the influence of Metro Rail on property value than measured distance alone.

Existence of a correlation between residual value and distance from the Metro Rail station (either physical distance or other behavioral representation of distance) will be considered to be indicative of a Metro Rail impact. This is because only Metro Rail-related influences would be expected to demonstrate this relationship. Non-Metro Rail factors would be expected to be more randomly distributed throughout the study area. Should the relationship between residual value and distance to Metro Rail be significant, the research may conclude that the degree of residual property value explained by the distance to Metro Rail reflects the amount of direct monetary benefits received by property owners due to the location and operation of Metro Rail.

This approach provides specific benefits:

1) It emphasizes the impact of Metro Rail on property value by isolating those impacts in the residual value. Because the residual value is smaller than the total change in property value (the subject of the BART analysis), analysis of the residual value serves to highlight the influence Metro Rail may have and precludes the "swamping" effect of other variables which was experienced by the BART study.

2) Once the pre-Metro Rail equations are formulated to approximate post-Metro Rail sale prices "as if Metro Rail had not occurred," they will serve as a control to estimate most of the underlying non-Metro Rail influences affecting changes in actual property sales values. Essentially, by using the pre-Metro Rail equations to represent the property sales price "as if Metro Rail had not occurred", the predicted sales price will continue to reflect the non-Metro Rail factors which were influencing property values in the pre-Metro Rail period. To the extent that the same factors are contributing to property value in the post-Metro Rail period, those factors will be reflected directly in the predicted sales price. In the event that other factors (including Metro Rail) begin to influence property value in the post-Metro Rail period, the accuracy of the predictive equations will decline, but the difference in property sales price between what would have been expected based on past trends and what actually occurs based on the influence of new factors will be accounted for in the residual value. Then, in the analysis of residual value, the Metro Rail influence will be separated from the other non-Metro Rail related factors which are contained in the residual value.

   For instance, it can be hypothesized that property value may be a function of mortgage interest rates in the Los Angeles region. In the development of the pre-Metro Rail predictive equations, the importance of this factor in

influencing property value will be determined. Assuming that it is found to be a statistically significant determinant of property value, it will be contained in the pre-Metro Rail predictive equation. A predicted sales price (as if Metro Rail had not occurred) from this predictive equation will reflect the same degree of influence of mortgage interest rates on property value. If the relative influence of mortgage interest rates on property value does not change over time, the predicted sales price will reflect the total influence of mortgage interest rates. If, at the time for which a sales price is predicted, mortgage interest rates are influencing property to a greater or lesser degree, that difference will be reflected in the residual value. If the influence of mortgage interest rates was not statistically significant in the pre-Metro Rail period, but is significant in the post-Metro Rail period, then it will be reflected in the residual value, rather than the predicted sales price.

In any event, in the research design discussed in this paper, all factors which are influencing property value in the post-Metro Rail period will be accounted for, either in the predicted value (for factors which do not change over time in the way they affect property value) or in the residual value (for new factors such as Metro Rail, or changes in the manner in which the pre-Metro Rail factors affect property value). This is an important consideration because it is necessary to ensure that all factors which are influencing a property's value are accounted for in order to isolate the impact of Metro Rail from the influence of non-Metro Rail related factors. Most importantly, the methodology will reflect the actual factors at work in the area where benefits are being measured, thus eliminating the doubts which may arise if non-Metro Rail influences were estimated by observing an exogenous control area where the same forces may or may not be influential in the same way and to the same degree. Because this is the case, this approach eliminates the need for exogenous control areas since non-Metro Rail property value influences will have been accounted for.

3) With the pre-Metro Rail equations, the impacts of Metro Rail can be recalculated for any post-Metro Rail calendar year, enabling the tracking of impacts over time and allowing for analysis of correlations between Metro Rail-related changes in property value and events associated with the development of the Metro Rail system.

2.3 METHODOLOGY FOR RESIDUAL IMPACT ANALYSIS

The following sections describe the specific methodology to be used to implement the research design described above.

2.3.1 Phase I: Formulate Baseline Pre-Metro Rail Value Estimation Equations (One-Time)

The purpose of this phase is to develop a set of equations reflecting the factors currently influencing property values in Metro Rail station areas. These equations will model pre-Metro Rail property values and will be able to predict post-Metro Rail property values "as if Metro Rail had not occurred." These equations will be developed for differing land uses and different geographic subareas within the MOS-1 benefit assessment districts, as

appropriate. Recognizing the likely trade-off between the accuracy of the predictive equations and the size of the geographic area for which the equations are developed, the objective of this phase will be to model accurately, and with statistical significance, property values for all land uses and geographic subareas, using the minimum possible number of equations.

2.3.1.1 Unit of Analysis

The unit of analysis will be individual parcels within the MOS-1 benefit assessment districts which are not used for residential, government or non-profit purposes and which have a recorded sale during the pre-Metro Rail and/or post-Metro Rail time frames (see following section). Each parcel will be categorized by land use type (office, industrial, other commercial) and by subarea (e.g., east side industrial, Chinatown, Wilshire/Alvarado). Each parcel which has a recorded sale within the area will become a case. Only pre-Metro Rail cases will be used to formulate the baseline equations.

2.3.1.2 Analysis Timeframe

The analysis timeframe will be divided into five stages:

a) pre-Metro Rail (baseline): before announcement of route (1976-1983)
b) pre-funding: before announcement of financing (1984-1985)
c) pre-construction: before commencement of construction (1986)
d) construction: before station operation (1986-1992)
e) post-Metro Rail: after station operation (post 1992).

These time frames are considered appropriate in light of the events associated with planning and construction of MOS-1. The initial stages of developing a rail transit program for Los Angeles County began in 1974 with the passage of Proposition 5, which provided that a portion of state gasoline taxes be used for development of rail transit. Planning for a regional rail transit program in Los Angeles County began in the mid-1970's and the federal environmental alternatives analysis program for rail transit was begun in 1977. A preferred alternative of heavy rail transit from downtown to the San Fernando Valley was selected in 1978 and preliminary engineering commenced in 1979. The second phase of alternatives analysis and route finalization was held in 1981 and 1982 and the final system definition was completed in May, 1983. Later that year, the first funds were appropriated for construction of the MOS-1 segment.

The influence of the transit system on property sales and value is hypothesized to begin when the final route is selected. Prior to this time, it is considered likely that the uncertainty associated with the planning and alternatives analysis processes would preclude significant investment or speculation by the real estate market. For this reason, the final route and funding decisions made in 1983 are considered to provide the best benchmark for delineating the pre-Metro Rail time frame. The pre-Metro Rail predictive equations will be developed using property sales in 1983 and earlier. Preliminary analysis of sales data availability suggests that valid sales data points are available from the year 1976.

In 1984 and 1985, the final financing plan for MOS-1 was developed with the federal government. The establishment of the MOS-1 benefit assessment districts was also accomplished during this time frame. This period is considered to be the pre-funding time frame. In 1986, the funding plan for MOS-1 was completed and construction of MOS-1 commenced. The year 1986, therefore, is considered the pre-construction period for MOS-1. Construction is scheduled to be completed and operations are expected to commence in 1993.

An analysis of Metro Rail benefit will be conducted for each stage based upon the calendar year in which it occurs. Property sales data will be collected for each year and actual sales prices compared to prices predicted for that year using the pre-Metro Rail predictive equations. Thus, impacts resulting from the announcement, funding and construction will also be able to be estimated. Pre-funding, pre-construction and construction impacts will also be able to be estimated to improve the techniques for estimating post-Metro Rail impacts.

2.3.1.3 Predictive Equations

A set of predictive equations will be formulated to estimate property value for any calendar year by each land use and for each subarea. As noted earlier; aggregation of geographic subareas may be necessary to yield predictive equations with adequate statistical significance. Property sales value data from 1976 to 1983 will be used to develop the equations. The equations will be derived as follows:

a) use of multiple-regression technique
b) use of "property sale value" as the dependent variable
c) use of "year of sale" as a control independent variable
d) use of the site, locational; market and policy characteristics as independent variables (see Chapter 3 for complete listing of items)

This would produce a multiple regression equation which can be specified as:

Sale Price of Case = f (year of sale) + f (site features) + f (locational features) + f (market features) + f (policy features)

This standard equation, which is used widely for mass appraisals (Mark and Goldberg, 1988), can be specified as:

$$Y = B_0 + B_1 X_1 + B_2 X_2 + \ldots + B_n X_n + u$$

where Y = Sale price
X = a variable
B = coefficient to be estimated
n = the number of variables contained in the equation
u = the error term.

The specific independent variables selected are expected to vary by land use and subarea. To identify the variables best able to predict sales price, a factor analysis of the pre-Metro Rail cases would be undertaken by land use and subarea. The technique of combining factor analysis and regression analysis has been found to be useful in reducing the problems associated with

multicollinearity among the many variables to be examined in the course of this analysis. The factor analysis is designed to group highly related variables in a data matrix and thereby reduce a large number of variables, which may be highly correlated, into a smaller number of underlying factors (Morton, 1977).

A full cross correlation matrix will be developed to display the relationships between all independent variables. Where a number of variables are found to be related, only one would be used in the equation to eliminate multicollinearity among the independent variables in the equation. Multicollinearity occurs when two independent variables in the equation affect the dependent variable in essentially the same manner. For instance, the height of a building and the square footage of the building may both serve to impact the property value in the same way. If two multicollinear variables are contained in the same equation, the regression equation obtained may contain nonsense coefficients that differ significantly in size and direction (sign) than would be expected. Subsequent refinement of the equations will be conducted using curve fitting techniques to improve the R^2 statistic to the highest significant level.

Where necessary, the use of dummy variables to represent qualitative property conditions at the time of sale will be explored. Although less desirable than quantitative data because of the discrete, rather than continuous, nature of these variables, dummy variables will be included in the equations to the extent that they improve the R^2 for the equation. Dummy variables to be included in the predictive equations will be determined as the equations are developed.

Internal control checks will be conducted to assure significant coefficient values, avoid problems of multicollinearity, heteroschedasticity and avoid other problems associated with the multiple-regression technique. These checks will include Analysis of Variance (ANOVA) and F-test to determine the significance of the regression, T-tests to determine the significance of the computed coefficients in the regression equation and analysis of residuals for normal distribution and random variance to satisfy the assumptions of regression analysis. If enough cases are available, the data base will be randomly split into two parts and tests performed to ascertain that the two parts are statistically similar. Qualitative checks of the data will be made in conjunction with the analysis of outliers as the equations are developed. Because using ratios, percentages and actual values in the same regression equation can cause distortion, ratio values (e.g., FAR) are not proposed to be used in the analysis.

2.3.1.4 Use of Equation

The formulation of the predictive equation will be based upon sales cases preceding the announcement of the Metro Rail alignment (1976-1983). These cases will produce a "baseline" equation which reflects property value determinants in the pre-Metro Rail period. Use of these equations to project property values for a subsequent period will be considered to be an indication of change in property value "as if Metro Rail did not occur". This key output in the form of a pre-Metro Rail predictive equation for each use by each sub-area is central to the research design.

2.3.2 Phase II: Estimate Impacts of Metro Rail (Repeated Process)

The purpose of this phase is to systematically assess the full impact of Metro Rail upon property values. This phase can be repeated for every calendar year in the post-Metro Rail period. Presented below is an annual iteration. The analysis described below can be performed for every property which is sold during the post-Metro Rail period.

2.3.2.1 Calculation of "Residual" Value

It will be necessary to develop an estimate of residual property value for each case with a recorded sale in the post-Metro Rail calendar year of analysis. To obtain this estimate, the following steps will be employed:

a) list the "actual" sale price for each case which sold in the calendar year.

b) estimate the calendar year sales price "as if Metro Rail had not occurred" using the pre-Metro Rail estimation equation obtained as described above.

c) subtract the actual sales price from the estimated sales price to obtain the "residual" change in property value.

d) do this for each case and each land use for each subarea.

Calendar year periods can be combined if more cases are needed to obtain statistically significant residual impact results.

2.3.2.2 Residual Impact Analysis

Once the array of residual property values are determined, a bivariate analysis will be conducted to regress the residual value against distance to Metro Rail (either walking distance or a behavioral representation of distance to Metro Rail, as discussed earlier). This analysis will reveal the strength of association between a parcel's residual property value and its proximity to the nearest Metro Rail station.

2.3.2.3 Interpretation of Results

The R^2 statistic from the simple bivarate regression will indicate the amount of contribution that proximity to the station has upon residual values of MOS-1 properties. For instance, if the R^2 for this equation is 50%, it can be concluded that 50% of the residual value is caused by Metro Rail. By extension, it can be concluded that the direct monetary benefit to local property resulting from Metro Rail is the amount equivalent to the proportion of the residual value explained by the independent variable (distance to Metro Rail station). This estimated amount will be considered the rise in property values within the benefit assessment district attributable directly to Metro Rail location and operation.

This interpretation also implies that any influence other than Metro Rail upon the residual will appear in the error term of the bivariate equation. This will reflect either error in the equation used to predict value "as if Metro Rail had not occurred" or new trends and conditions not associated with distance to Metro Rail that have emerged in the post-Metro Rail period.

2.3.2.4 Controls

The above interpretations are correct only if no multicollinearity among variables exists. There are two areas in which multicollinearity could conceivably impact upon the conclusions drawn as a result of the analysis: (1) in the development of the pre-Metro Rail predictive equations or (2) in the bivariate analysis of residual value.

In the case of the development of pre-Metro Rail predictive equations, it is safe to assume that the entire influence of Metro Rail is contained in the residual value of the property as long as there is no variable in the pre-Metro Rail predictive equation which influences property value in the same manner as Metro Rail. If such a variable were to be contained in the predictive equation, it is possible that the predictive equation would reflect some influence of Metro Rail in the estimation of property value "as if Metro Rail had not occurred" and the residual value of the property would be understated.

In the case of the bivariate analysis of residual value, it is safe to assume that the amount of residual value which correlates with distance from Metro Rail is the result of Metro Rail <u>if</u> no other variables in the residual analysis are influencing property value in a manner similar to Metro Rail.

A control test will be undertaken which will examine property value as a function of distance to the Metro Rail station in the pre-Metro Rail period and compare it to the residual analysis in the post-Metro Rail period to determine whether they are derived from the same source. The methodology to be used is as follows: The null hypothesis will be that the two analyses are measuring the same phenomenon (i.e., a Metro Rail influence is occurring in both the pre- and post-Metro Rail periods). Since the influence in the pre-Metro Rail period is most likely not Metro Rail (because of the manner in which the pre-Metro Rail period was defined), it must be another factor which is acting in the same manner as Metro Rail. Two regression equations will be developed, one for each of the pre-Metro Rail and post-Metro Rail conditions. Confidence interval regression coefficients will be established to test whether the two equations are statistically different. If either falls within the range of the confidence interval, the null hypothesis will be rejected and the correlation between residual value and distance to Metro Rail will be presumed to be reflective of the influence of Metro Rail on property value.

2.3.2.5 Plotting Metro Rail Impacts on Property Values

Once satisfied that the attributed values to Metro Rail impact are significant and credible, the impact values can be plotted to spatially display the impact gradient for the given calendar year by land use and compute the benefits in aggregate for all non-exempt properties.

3.0 DATA REQUIREMENTS AND COLLECTION PLAN

In order to conduct the analysis using the methodologies described above, it is necessary to first identify the dependent and independent variables in the equations to be developed. In Technical Memorandum 88.4.1, both dependent and independent variables were grouped together under the term "indicator." For the sake of clarity, this term will be supplanted by the terms "dependent" and "independent" variables. The predictive equations to be developed will take the general form as indicated in Figure 3.

3.1 DEPENDENT VARIABLES

The purpose of the research design and methodology presented in the preceding sections is to determine the effect of Metro Rail on property values. Therefore, property value is the primary dependent variable to be used in the predictive equations to be developed. Reported property sales in the pre- and post-Metro Rail time periods in the study area will constitute the statistical universe for this analysis.

Lease rates, capitalized to property value, may be used as a potential surrogate for property value in cases where infrequency of property sales does not provide enough cases to ensure reasonable confidence in the predictive equations and residual values calculated. It is not expected that this will be required. However, should it become necessary, standard appraisal techniques for estimating the value of a property based on the income generated by the property will be used for this calculation. These steps include:

1) The potential gross income from the property will be estimated based on the square footage of the building and the annual lease rate per square foot.

2) The gross income will be adjusted for the estimated vacancy rate and estimated operating expenses. This provides the net annual income for the property.

3) The net annual income is divided by a capitalization rate to determine the value of the property. The capitalization rate is the rate of return on investment which investors demand before actually investing in a project. Should use of lease rates as a surrogate for property value become necessary, real estate industry sources (brokers, mortgage lenders, etc.) will be consulted to determine the appropriate capitalization rate to be used.

3.2 INDEPENDENT VARIABLES

The list of independent variables to be potentially included in the pre-Metro Rail predictive equation must be sufficiently inclusive to ensure that the major factors which could affect property value are considered. At this point in time, it is uncertain which of the factors contained in the lists which follow will be found to be most influential on property value. This will be determined in the Analysis phase, Task 7, of the Before-and-After Study.

Property values are influenced by many factors. However, these factors can be grouped into four broad categories:

BASIC STRUCTURE OF MULTIPLE REGRESSION EQUATIONS

VALUE OF DEPENDENT VARIABLE	IS A FUNCTION OF INDEPENDENT VARIABLES			
	SITE CHARACTERISTICS	LOCATION CHARACTERISTICS	MARKET CHARACTERISTICS	POLICY CHARACTERISTICS
o PROPERTY VALUE/SALES PRICE-DAMAR o LEASE RATES-BOMA GUIDE	o PARCEL SIZE-BADD o IMPROVEMENT o SIZE-BADD o AGE-DAMAR o YEAR REHABILITATED-DAMAR o CONDITION-DAMAR (Bldg.Class) o USE-BADD o PARKING SPACES-DAMAR/CRA o HEIGHT-BOMA GUIDE/DAMAR	o ACCESS TO PROPERTY o DISTANCE FROM METRO-CALCULATED o BUS USAGE-RTD o STREET FRONTAGE-COUNTY ASSESSOR o DISTANCE FROM FREEWAY-CALCULATED o SURROUNDING AMENITIES o SURROUNDING LAND USE o SURROUNDING PARKING AGGREGATE LAND USES IN SURROUNDING BLOCKS AND ASSIGN TO PARCELS o CRIMES IN AREA-LAPD	o REGIONAL & NATIONAL MARKET CONDITIONS-US GOVT, SCAG, WALL STREET JOURNAL, STATE DEPT. OF FINANCE o GNP o PRIME INTEREST RATE o CPI FOR LA o CONSTRUCTION COST INDEX o FOREIGN EXCHANGE INDEX o REGIONAL UNEMPLOYMENT RATE o EMPLOYMENT CALIFORNIA STATE EMPLOYMENT DEVELOPMENT DEPT o POPULATION-STATE DEPT. OF FINANCE (LA COUNTY DEPT OF REGIONAL PLANNING) o BACKGROUND PARKING COST-CRA o OFFICE VACANCY RATE-COLDWELL BANKER	o REDEVELOPMENT AREA/SUBAREA-CRA MAPS o ZONING-BADD/DAMAR o CRA INVESTMENT BY SUBAREA-CRA o PROVISION OF PARKING-ZONING CODE/CRA o SPECIFIC PLAN DESIGNATED LAND USE/DENSITY-LADOP o GENERAL PLAN DESIGNATED LAND USE/DENSITY-LADOP o PROPOSITION U AFFECTED-ZONING CLASSIFICATION

BADD- BENEFIT ASSESSMENT DATA BASE
CRA- LOS ANGELES COMMUNITY REDEVELOPMENT AGENCY
LADOP-CITY OF LOS ANGELES DEPARTMENT OF PLANNING

FIGURE 3

1) Site Characteristics
2) Location Characteristics
3) Market Characteristics
4) Policy Characteristics

Each of these factors are discussed in the following sections in greater detail, including the components of the factors and the hypothesized effect of each factor on property value. In the process of developing the predictive equations for land uses and subareas, the actual importance of each factor and component in predicting property value will be ascertained and only the most important factors will be included in the final predictive equations which are developed.

3.2.1 Site Characteristics

Site characteristics are the characteristics of the individual properties within the benefit assessment districts. The components of site characteristics which may be included in the pre-Metro Rail predictive equation are:

1) Parcel Size - the value of the property may clearly be related to the size of the parcel. The larger the parcel, the higher the property value.
2) Improvement Characteristics - the value of the property may be related to whether or not the property is improved and the characteristics of the improvements located on the property, including:
   a) Size - the larger the improvement, the higher the property value.
   b) Age - the newer the improvement, the higher the property value. This may also be true for rehabilitated improvements, which may have higher property value than similar improvements which have not been rehabilitated. A formula for weighting the impact of improvements on property value may be developed if necessary to increase the accuracy of the predictive equations.
   c) Condition - if the improvement is deteriorated, the property value may be lower than a property containing an improvement in good condition.
   d) Use - the property value may relate to the use(s) of the property and the income generated by those uses.
   e) Number of Parking Spaces - the number of parking spaces provided may contribute to the ease of use of the property and may enhance or detract from property value.
   f) Height - the height of the improvement (in stories) is indicative of the income-generating capability of the property and thus may reflect property value.

3.2.2 Location Characteristics

Location characteristics are the characteristics of the property relative to other properties in the area. Location factors exert a strong influence on property values. The components of location characteristics to be examined in the development of the pre-Metro Rail predictive equations include:

1) Access to the Property - accessibility to the property is a major determinant of value. It can be expected that if access to a particular property is good, the value of that property will be higher than a similar property with poorer access. Components of accessibility include:

a) Distance from nearest Metro Rail station - this component will be used as an independent variable in the bivariate analysis of residual property value and as a control for multicollinearity in the development of the pre-Metro Rail predictive equations. As discussed above, it is important that no influence of Metro Rail be included in the pre-Metro Rail predictive equations. In addition to measured physical distance to the Metro Rail system, behavioral models for measuring proximity to Metro Rail (travel time savings, cost savings) may also be developed.
b) Bus Usage - this component will be measured as the number of passenger boardings and alightings (on and offs) measured at bus stops in proximity to the property. The higher the bus patronage, possibly the greater the accessibility to the property and thus the higher the property value.
c) Street Frontage - the street(s) which the property fronts may affect the property value. Frontage on "desirable" streets may enhance property value.
d) Average distance to the nearest freeway on and off-ramps - this measure of access to freeways may reflect enhanced property value resulting from improved accessibility to the property. Alternatively, closeness to the freeway may also have a negative effect by introducing factors such as noise and congestion which may depress property value.

2) Surrounding Amenities, Surrounding Land Use, Surrounding Parking - these factors represent the "linkage" of properties to supporting facilities. The availability of other services and supporting land uses may enhance property value by improving the income-generating potential of the property.
3) Crime statistics - the number of crimes reported in the vicinity of the property may be an indicator of the relative safety and security of the area, which may influence property value.

3.2.3 Market Characteristics

Market characteristics reflect the level of economic activity in the area in which a property is contained. The underlying level of economic activity is a significant determinant of property value because it affects the level of income which can be generated by any specific property. In a strong market area, property values are generally also strong. Where market activity is depressed, property values tend to be similarly depressed. The following components of market characteristics will be examined for potential inclusion in the pre-Metro Rail predictive equation(s):

1) Regional and National Market Conditions - a number of indicators can be used to represent these larger economic trends, including:
   a) Gross National Product - property values would be expected to rise as the economy grows.
   b) Prime Interest Rate - as interest rates rise, economic activity slows and rises in property values would be expected to be dampened.
   c) Consumer Price Index (CPI-U for LA/Long Beach region) - as inflation rises, interest rates also tend to rise with the same dampening effect on property values as noted above.
   d) Construction Cost Index - as construction costs rise, construction activity would be expected to decline. This would affect the income generating capability of property and negatively affect property value.

e) Foreign Exchange Rates - foreign investment is a major factor in downtown Los Angeles. The level of foreign exchange rates may influence the amount of foreign investment in downtown properties and thus may affect property value.
f) Unemployment rate - the unemployment rate is an indicator of background economic activity which could conceivably impact property value.

2) Employment and Population - as employment and population rise in a particular area, the potential for increased economic activity rises and property values would also be expected to rise.
3) Vacancy rates - the vacancy rate for office space is an indicator of demand and economic activity which may contribute to income-generating capacity of property and property value.
4) Background Parking Cost - parking costs may enhance or depress economic activity. It would be expected that higher parking costs would discourage economic activity and depress property value. Alternatively, higher parking costs could reflect high levels of economic activity and thus enhanced property value.

3.2.4 Policy Characteristics

Policy characteristics are the characteristics stemming from public policy and regulations which may affect the development of a particular property. The components of policy characteristics to be examined in the development of the pre-Metro Rail predictive equations include:

1) Redevelopment Area/Subarea - location of a property in a redevelopment area or a subarea of a redevelopment area may influence the property value since public investment may be concentrated in these areas.
2) Zoning - the zoning of the property will determine the potential development of the property and thus the overall income-generating potential of the property.
3) CRA Investment by Subarea - the level of public investment in a particular area may influence property value positively by providing improved amenities in the area. The level of public investment may also be indicative of a depressing effect on property value because public investment is often concentrated in areas which experience the greatest degree of problems.
4) Parking Requirements - the regulations governing provision of parking for a particular property may influence property value. Increased parking requirements may limit the income generating potential of property by reducing the income generating square footage of the property.
5) Specific Plan Designated Land Use/Density - Specific Plans supercede zoning and determine the potential development of the property and thus the income-generating potential of the property.
6) General Plan Designated Land Use/Density - the General Plan does not directly regulate the development of property. However, the City of Los Angeles is under court order to change zoning to conform with the General Plan which, in the long run, will increase the significance of this factor in determining the potential development of the property and thus the income-generating potential of the property.

7) Proposition U affected - in 1986, the voters of Los Angeles reduced the height limit on specified properties in the City, based on the zoning classification. Any property affected by this growth control would have its development potential reduced which would affect the income-generating potential of the property and thus the property value.

3.2.5 Sort/Aggregation Codes

In addition to the independent variables listed above, the following information will be coded for each parcel in the A1 and A2 benefit assessment districts to allow parcels to be sorted and aggregated for purposes of developing the best possible pre-Metro Rail predictive equations.

1) Los Angeles County Assessor's mapbook-page-parcel identifier. A parcel number is assigned to each piece of property in Los Angeles County and constitutes a legal description of the property.
2) Zip Code
3) Census Tract
4) Los Angeles Police Department Zone. The LAPD has divided the city into a series of zones to track actual and reported crimes in different areas of the city. Roughly 35 of these zones are located in the study area.
5) Traffic Analysis Zone (SCAG 1325 zone system)
6) Benefit Assessment District (downtown or Wilshire/Alvarado)

Each of the hypotheses presented in the preceding sections will be tested in the course of developing the pre-Metro Rail predictive equations. Only the independent variables which exhibit the highest correlation to actual property values and the most significance in predicting property value will be included in the predictive equations. To conduct this analysis and develop the predictive equations, data needs to be collected on both the dependent and independent variables. Using these data, the regression model can be constructed and calibrated. In the following section, the data collection plan for collecting each of these data items is outlined.

3.3 DATA COLLECTION PLAN

In the examination of potential data sources and evaluation of data useability conducted in Tasks 2 and 3 of the Before-and-After Study, the universe of potential data sources was identified. From that evaluation, the following data sources are recommended for use in the remaining tasks of the Before-and-After Study. This selection was made on the basis of completeness, reliability, availability, cost, and ease of use. At least one source is provided for each dependent and independent variable listed in Section 3.2 above.

1) DAMAR - DAMAR is an on-line computerized real estate information service which sells information comprised of data from the County Assessor and "member input." Members consist of two real estate organizations: the California Market Data Collective, which is limited to residential properties, and the Society of Real Estate Appraisers, which includes commercial properties. DAMAR receives information from both sources on a daily basis. In addition to its on-line subscription services, DAMAR could provide special runs of specified information. Such a run was ordered for this study and included the following fields for all parcels located in the A1 and A2 benefit assessment districts:

Field	Purpose/Data Provided
SITUS	Situs Address/Reference
APN	Parcel Number/Reference
USE	Land Use Cross Check
TRANSFER DATE	Most Recent Sale Date
PRICE	Most Recent Sale Price
PRIOR SALE	Previous Sale Date
PRIOR AMT	Previous Sale Price
BLDG CLASS	Building Construction Classification
ZONING	Zoning Cross Check
YRBLT/EFF	Year Built
# STORIES	Height
PARK TYPE	Type of Parking Facilities/Cross Check
PARK SPACES	Number of Parking Spaces
COMMENTS	Descriptive Comments for Property
PHYS CHARS	Physical Characteristics of Property

This data was received in a diskette format and joined with the Before-and-After data base. Although this system could conceivably have provided two previous sales prices, thereby providing two data points for each property, numerous gaps in the data were found, necessitating additional manipulation to provide estimates for the missing data from the DAMAR data which was provided. The methodology and results of this analysis are provided in Technical Memorandum 88.4.7. The benefit assessment data base, an alternative source for this information, could have provided only one previous sale price and therefore only one data point. With the need to maximize the number of data points to provide for a reasonable confidence level for the analysis, DAMAR still offered the advantage. DAMAR also provided the additional information listed above. DAMAR also conducts additional research into some sales which provided full value of property transactions, including trades, in some cases where it would have been otherwise unavailable.

2) Building Owners and Managers Association Office Market Guide - contains address by address lease rate information on office space in buildings of 20,000 square feet or more. The following years' data is available from BOMA: 1985, 1986, 1987, 1988. Can also provide information on year built and height of buildings for cross check purposes.

3) Benefit Assessment Data Base - the benefit assessment data base can be used to provide the following data: parcel numbers of all parcels contained in the benefit assessment districts, parcel size, improvement size, square footage by land use, census identifiers, zip code, zoning.

4) CRA's Projstat Data Base - This in-house data base maintained by the CRA tracks major renovations and construction and public investment in CRA project areas. Can also provide cross check on height, FAR and development cost for major projects. Available without charge from the CRA. Available from 1985.

5) Business Pattern Data - Central City Association - contains employment information aggregated by zip code for downtown Los Angeles. This report compares 1982 and 1984 employment data and is based on information obtained from the U.S. Department of Commerce.

6) CRA: Development Rights Transfers. The CRA file on the transfer of development rights documents development rights transfers activity. This information is available to RTD without charge.

7) US Government (Department of Commerce; Bureau of Labor Statistics; Council of Economic Advisors), Wall Street Journal, State Department of Finance: California Statistical Abstract - to be consulted to obtain prime interest rate, GNP, CPI-U for LA/Long Beach region, Construction Cost Index data, unemployment rate, foreign exchange index.

8) SCRTD On and Off Counts - provides counts of passenger boarding and alightings at bus stops in downtown Los Angeles, aggregated by census tract. This data is available for the following years: 1984, 1985, 1986, 1987.

9) Los Angeles County Assessor maps - contains maps of all properties in the study area with street frontages.

10) To be measured for every property in the benefit assessment districts - walking distance to the nearest Metro Rail station portal; average distance from nearest freeway on- and off-ramps

11) Downtown News Quarterly Commercial Real Estate supplement - provide cross check data on square footage, development cost, parking facilities for selected projects in downtown.

12) Los Angeles Police Department - tracks reported and actual crimes in zones located throughout the city. Data is available for the entire time period of the study (1976 to present).

13) To be calculated for each property - land uses and parking in block in which property is located and for one block surrounding property.

14) CRA Maps and Annual Work Programs - identify properties within Redevelopment Areas and subareas and level of CRA investment in each subarea

15) General Plans for Central City and Westlake Community Areas - identify general plan designated land use and density for each property

16) Specific Plans - identify specific plan designated land use and density for each property contained within an adopted Specific Plan area

17) Coldwell Banker - Coldwell Banker produces an annual report entitled Office Vacancy Index of the United States which can provide office vacancy information for downtown Los Angeles from 1979 to the present. This publication is available at no charge.

18) Parking Price Survey, Downtown Los Angeles, Community Redevelopment Agency - a one-time survey (1986) of parking cost in downtown Los Angeles which can provide background parking cost information.

19) California Employment Development Department - provides annual employment information by employment category code, aggregated at the County level. Data is available to the mid-1970's.

20) Los Angeles County Department of Regional Planning - issues quarterly reports of population for Los Angeles County aggregated at the County Statistical area level. Available to 1975.

21) State Board of Equalization - an additional research question which has been suggested would involve the collection of data to determine trends in retail sales in Metro Rail station areas. Data on sales by individual businesses, aggregated to protect privacy, can be furnished by the State Board of Equalization. Data could be collected for aggregates of 10-15 businesses in various areas throughout the CBD and Wilshire/Alvarado for a reasonable cost. Suggested locations would include:

a) Financial District (e.g., Broadway Plaza, Citicorp Plaza)
b) Pershing Square
c) Civic Center
d) Broadway
e) Little Tokyo
f) Chinatown
g) West of Harbor Freeway
h) Wilshire/Alvarado

It would be necessary to manually identify the individual businesses and addresses to the State Board of Equalization in order to proceed with this project. These data could be examined and reported in a case study format. As a non-random (judgment) sample, a statistically valid analysis would not be possible for retail sales, however, subjective conclusions could be drawn from the observations made from the data.

4.0 BASIC DATA BASE DESIGN AND ANALYSIS SOFTWARE

The data collected as outlined in the previous sections will be entered into a data base of recorded sales for all properties contained within benefit assessment districts A1 and A2. Basically, the data base will contain a separate record for each recorded sale containing the characteristics for the parcel (e.g., size, access, land use, distance from Metro Rail et al.) and the economic and background conditions at the time of the sale. The record will also contain the identifiers for each parcel described in the previous sections. This basic data base organization allows for maximum opportunity to aggregate and disaggregate data and to sort data sets for differing characteristics of parcels (e.g., produce a data set to develop a regression equation for all parcels in Little Tokyo, etc.). Since SPSS/PC+ will be used to conduct the regression analysis, the data base will be developed using SPSS/PC+.

The specific structure of the data base (e.C[e field sizes, file organization, etc.) cannot be discerned with confidence at this time. Rather, this will be dependent upon the form and format of the data collected and will become more clear as the data is collected and the data base is built in Task 6. Documentation produced for this data base (Technical Memorandum 88.4.7) will contain the detailed data base structure.

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