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Transportation Center

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ABSTRACT

Regulation XV of the South Coast Air Quality Management District in Southern California requires all work sites at which there are 100 or more employees to implement a ridesharing program by which the organization's "average vehicle ridership" is intended to be increased to a specified target level. This paper summarizes the requirements and procedures required by the regulation. It also presents the first evaluation of the results of this far-reaching program after more than one year of experience. The preliminary evaluation is based on a small number of observations comprising a sample of employment sites which is less than fully representative of all sites affected by the regulation. The early results are encouraging, and show that there has been a small but significant increase in average vehicle ridership, and a corresponding decrease in commuting by single-occupant automobile. Most of the change is found to be the result of increased carpooling, while the use of compressed work hours and walking and bicycling also increased. The research reported here is ongoing and will in time should yield more definitive results.

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1. INTRODUCTION

Southern California, for eighty years known as the most automobile-oriented region in the world, is today engaged in a far-reaching experiment aimed at reducing commuters' reliance on the single-occupant automobile for the journey to work. The severe air quality problem in the Los Angeles area has given rise to Regulation XV, also known as "The Commuter Program," an important element of the region's air quality management plan. This regulation requires employers to take responsibility for encouraging workers to consider alternatives to driving to work alone, including public transit, carpooling, vanpooling, walking, telecommuting, and cycling. Regulation XV is giving rise to probably the single largest effort at "transportation demand management" yet undertaken anywhere.

Because of the likely national interest in the successes and failures of efforts conducted under Regulation XV, a team of researchers from the University of Southern California and the University of California, Los Angeles is working with staff members of the South Coast Air Quality Management District (SCAQMD) to closely follow the implementation of the regulation, and is attempting to document its effects on commuting. This paper is an early report of some partial results of our evaluative study. The program is so new that our results are very tentative, and surely subject to change as a larger sample of companies over longer time periods becomes available. The high level of interest in the program, however, demands that even partial and tentative results be widely circulated.

2. PROVISIONS OF REGULATION XV

The SCAQMD is the regional agency responsible for developing and implementing the Air Quality Management Plan for the Southern California metropolitan area, including Los Angeles, Orange, Riverside and San Bernardino Counties. Because of the severe air quality problem in this region, exacerbated by rapid population and economic growth, topography and climate, the air quality management plan calls for behavioral changes as well as technological advances in the control of stationary and mobile sources of air pollution. One of the most challenging requirements of the plan is the substantial reduction of automotive air pollution by reducing reliance upon singly-occupied automobiles for journeys to and from work. While work trips are

known to be decreasing as a proportion of all travel, they constitute more than a third of all daily trips, and are made primarily at peak hours, when congestion is most severe. Work trips are also believed to be more susceptible to change, since alternative travel options are more likely to be available for work trips than they are for trips made for other purposes.

2.1 History and Coverage of Regulation XV

Regulation XV was adopted by the Board of the South Coast Air Quality Management District in October of 1987, and its implementation began July 1, 1988. It requires that public and private employers (firms, government agencies, schools, hospitals, etc.) having 100 or more workers at any work site complete and file a plan for that site by which they intend to increase the Average Vehicle Ridership to a specified level within one year of the SCAQMD's approval of its plan.[1] Average vehicle ridership (AVR) is defined roughly as the quotient of: the number of employees reporting to work between 6:00 and 10:00 a.m., divided by the number of motor vehicles driven by these employees. The ratio is calculated over a five-day work week to account for the growing use of modified work weeks, and certain adjustments are made to the ratio to account, for example, for employees who telecommute. Credits are also given for employees who travel to work in automobiles powered by clean fuels such as methanol, propane, and electricity.

The South Coast Air Quality Management District estimates that there are about 9,000 firms, agencies, and institutions which employ 100 or more workers at individual sites and are subject to this regulation. Together they employ approximately 3.8 million workers, or about two thirds of the wage earners in the four county metropolitan area (State of California, 1989). Implementation began on July 1, 1988 when the District began notifying firms having work sites with 500 or more employees. Within one year, noticing began for work sites with 200 or more employees, and within two years noticing began for work sites with 100 or more employees. By November 30, 1990, 6,288 firms had been notified.

[1] If an employer has two work sites which are within one-half mile of one another they may treat them as a single combined work site with the prior explicit approval of the SCAQMD.

2.2 Compliance Requirements

Compliance with the Regulation requires three tasks: 1) submission of an implementation plan within 90 days of notification, 2) designating and training of an on-site Employee Transportation Coordinator(ETC), and 3) approval of the plan by SCAQMD. Upon notification by SCAQMD, an employer has 90 days to prepare and submit to the SCAQMD an implementation plan for achieving its AVR target within one year. The plan must include information on the current AVR of the employer's work force, and the regulation specifies that the current AVR calculation must be based on the results of a questionnaire survey of employees.[2] The survey is not considered valid, and the plan is rejected, unless a minimum of 75% of the workers in the organization respond to the questionnaire.[3] Furthermore, all non-respondents to the survey are assumed in the AVR calculations to be commuting to work alone. Thus, it is very much in the interest of the employer to achieve a very high response rate.

Each work site must plan to achieve an AVR level of 1.3, 1.5, or 1.75, depending upon where it is located. The regulation requires employers whose sites are located in the central business district of Los Angeles to achieve a level of 1.75, since that area has excellent transit access and active vanpool programs. Work sites in outlying, low density areas are directed to achieve an AVR of 1.3, in part because they have little or no public transit access. Intermediate areas are assigned AVR targets of 1.5. (See Figure 1) Based on available data, it is estimated that the regional average vehicle occupancy (roughly equivalent to AVR) was somewhere between 1.1 and 1.2 at the inception of the program.

The plan which accompanies the AVR survey results and calculations may consist of any number of incentives and disincentives by which the company or agency plans to increase its AVR to the target in the succeeding year, if it is not already achieving its target. A wide range of such incentives have been included in the plans submitted thus far. Typical examples include the institution of free parking and preferential

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[2] Early in the program work sites could use a questionnaire survey or perform occupancy checks of vehicles entering the parking lots at their work sites. In May 1990 the regulation was amended to eliminate the parking lot surveys, which were found to be highly inaccurate.

[3] This minimum requirement was introduced in the May 1990 amendments to the regulation; previously plans were accepted with lower response rates.

parking locations for carpools and vanpools, and on-site sale of monthly transit passes. Some firms have added financial incentives, such as paying part of the cost of a seat in a vanpool or part of the cost of a monthly transit pass. Many have adopted carpool and vanpool matching procedures, and most have added promotional activities, such as posters, prizes, and events promoting ridesharing. A few have added activities on site, such as automatic teller machines, health clubs, and eating facilities, to reduce the employees' needs for automobiles at the work site. Some have tried clever and off-beat incentives, such as an express line in the cafeteria for carpoolers, vanpoolers and transit users only. Disincentives to discourage driving alone may also be a part of the plan, but disincentives have thus far been used far less frequently than incentives. An example of a disincentive is the withdrawal of an employee parking subsidy which has previously been given to workers who drive to work alone.

The second requirement for compliance is the designation of at least one employee at each work site to become a trained Employee Transportation Coordinator (ETC). The "ETC" must complete a three-day training program prior to the submission of the first plan, and must receive one day per year of "up-date" training in order to remain certified.

The third requirement is SCAQMD approval. When the plan is submitted to the staff of the SCAQMD, it is reviewed to determine whether or not the current AVR has been correctly calculated, and whether or not the plan for achieving the required AVR within one year is considered adequate. The SCAQMD staff may reject the plan and require resubmission if the plan does not seem appropriate for any of several reasons. Examples of reasons for rejecting the plan include: incorrect calculation of AVR; inadequate survey of employees or inadequate response rate; absence of a properly certified ETC; absence of a letter from management committing itself to the implementation of the plan; or inadequate incentives to achieve the intended AVR. In most cases, the employers negotiate with the SCAQMD staff if their plans are rejected, and they make appropriate efforts to satisfy the criteria, but in some cases employers have simply ignored the requirements of Regulation XV, and they have been found to be in violation of the regulation.

Table 1 summarizes the activity which has taken place as the Commuter Program was implemented between July 1, 1988 and November 30, 1990. The table indicates the extent of the public and private effort

which has gone into implementing Regulation XV since its inception, and also shows that dozens of firms have been fined for violating its provisions. As of the end of November, 1990, the most common reason for being found in violation is simple failure to submit a plan. A total of 42 organizations have been fined more than $549,000, the largest single fine thus far being $150,000, with two additional fines in excess of $70,000, and several other fines having been levied between $10,000 and $30,000. If a plan is accepted by the District's staff, the employer is then expected to implement the plan. A year later, the employer again receives notice and must again survey its employees. The new AVR is a measure of the success of the plan during the first year. If the employer has failed to meet its target AVR after one year it is not found to be in violation of the regulation. The employer must, however, revise its plan, adopting new incentives and disincentives, and must then implement those during the second year. The process is repeated each successive year.

In recent months, the South Coast Air Quality Management District has begun a program of monitoring and auditing employers affected by Regulation XV. Teams composed of SCAQMD inspectors and Regulation XV staff members may visit employers to review their Regulation XV documents, and to monitor the extent to which elements of the plan are being implemented. If they find that the records are false or incomplete, or that elements of the employer's implementation program are being ignored, those employers may be fined.

3. THE NEED FOR RESEARCH EVALUATING REGULATION XV

There are several reasons why a careful evaluation of Regulation XV even at this early stage of implementation is justified. First, thousands of employers are devoting substantial resources in the form of employee time, money, and energy to the development of plans to satisfy the regulation, and the South Coast Air Quality Management District will soon have a staff in excess of fifty people devoting themselves exclusively to the implementation of this program. Because there are so many employers who are subject to the regulation the Commuter Program has, in a short time, produced a new industry in Southern California. Several thousand people are now identified as Employee Transportation Coordinators, six to ten consulting firms have grown to prominence as preparers of plans for employers in compliance with Regulation XV, and the South Coast Air Quality Management District has certified several organizations as providers of the

necessary three-day training program, for which fees of $300 to $500 are now charged. Further, employees are being asked to make significant changes in travel behavior that may have impacts both in the work place and at home.

It is believed that all of this effort and these substantial expenditures are in the public interest, but their continuation can only be justified if it can be shown that this program is having a positive effect on air quality in the South Coast Air Basin, and in turn that requires that there be some measurable impacts of Regulation XV on commuting patterns. In addition, the regional Air Quality Management Plan states that at some time subsequent to 1993 the regulation may, if necessary, be extended so that it will apply to all work sites having more than 25 employees. That means an expansion to tens of thousands of additional firms, and smaller firms can be presumed to have fewer resources to devote to the implementation of transportation programs. Thus, expansion to smaller firms and institutions should be based upon clear evidence that the program has shown promise when applied first to the larger employers. A third reason for carefully evaluating the impacts of Regulation XV is the great interest being shown in the program by other cities and regions having serious air quality management problems. If this program is to be the model for others, it is critically important that we collectively learn from its successes and failures so that its successes can be emulated and its failures avoided.

Accordingly, we have begun a multi-year evaluation of the Regulation. The primary purpose of our research is to determine how Regulation XV has affected commuting behavior among employees in firms which have been subject to the Regulation. Our first year research is mainly descriptive, since we were unable to make any assessment of the Regulation's effectiveness until Year 2 plans were available. The remainder of this paper summarizes preliminary findings to date.

4. METHODOLOGY

In order to determine how implementation of Regulation XV is affecting travel behavior we ideally would like to examine results from a representative sample of employment sites, with representativeness determined by the factors which affect employee commuting behavior. Our research problem is illustrated in

Figure 2. Commuting behavior (expressed as "AVR") is a function of 1) environmental characteristics, 2) employee characteristics, and 3) intra-organizational characteristics, as well as the set of incentives contained in the Regulation XV plan. Environmental characteristics include the availability of transit and other alternatives to driving alone, the level of traffic congestion, parking availability, etc. Employee characteristics include commute distance, income, auto availability and related household characteristics. Intra-organizational factors include the need to have employees at work at the same time, the extent to which work-related individual vehicle travel is required, the flexibility of operating hours, etc.

We also expect that the nature and effectiveness of the Regulation XV plan will be affected by these three sets of factors. For example, the compressed work week may be less viable for jobs which cause significant physical or mental fatigue; while free transit passes may have little effect in areas poorly served, but a significant effect in areas with good transit access, particularly among low wage workers.

Our objectives for the first year of this research were twofold. First, we wanted to develop as large a sample as possible of employment sites with approved plans which could be used to 1) determine the extent and reliability of data provided in the Regulation XV plan submissions, and 2) develop an appropriate basis for collecting a representative sample in the second year. Second, we wanted to conduct a preliminary analysis on the effects of Regulation XV after one year of implementation.

5. DATA

All of the data utilized in this analysis were collected from the SCAQMD. Data sources include the approved plans and related materials submitted by employers, as well as data files of the subject firms compiled and maintained by SCAQMD.

5.1 Data Limitations

There are three factors which limit our first year analysis. First, very little information on firm and locational characteristics are provided, and there is no information on employee characteristics. Thus the three sets of factors described in Section 4 can be captured in only a very general way. Second, the Regulation is

enforced on the basis of employment site, and not the basis of employment firms. Firms with multiple sites are free to develop one plan covering all sites, or individual plans for each site. We have followed SCAQMD's practice and used employment sites as the unit of analysis. Each site has a unique plan, but not all sites of a multiple site firm are necessarily in the data base. Third, many details relating to reporting requirements, AVR definitions, etc. have changed over the course of Regulation XV's implementation. For example, a parent carpooling with a child (and dropping him/her off at school or childcare) could be counted as a 2 person carpool in Year 1 but is counted as a solo driver in year 2. Similarly, the definition of telecommuting has changed between year 1 and year 2. These differences may limit the comparability of the data.

5.2 Data Samples

Results reported here are based on two data sets. The first (Sample 1) is a large cross-section, by employment site, for companies which had approved year 1 plans as of December 1989. The original sample was almost 800 observations; after deleting cases with missing or inconsistent data the final sample consists of 621 observations, or almost half of all of the approved plans as of December 1989. The second data set (Sample 2) is a small (76 observations) sample of year 1 and year 2 data. The data, also by employment site, were collected from employers which had approved year 2 plans, comparable data for both year 1 and year 2, and whose plans were available to the research team as of August 1990.

6. RESULTS

We discuss our findings in three parts. First, we present descriptive statistics on the subject firms and discuss the representativeness of our sample. Second, we show how commuting behavior has changed at the 76 sites for which comparable data were available. Finally, we provide some preliminary analysis of the effectiveness of the Regulation XV program.

6.1 Baseline Conditions: Company Site Characteristics

As mentioned previously, some companies have more than one site.[4] Our Sample 1 data set is comprised of 523 firms and 688 sites. Of the 523 firms, 476 (91 percent) have just one site, and the remaining 47 firms have two or more sites. As Table 2 indicates, the numbers of sites per firm is quite small for the vast majority of firms. This distribution is relatively consistent with the characteristics of the total sites on file with SCAQMD as of July 1990. Total sites include 3,271 firms and 4,482 sites. Of these 3,271 firms, 3,080 (94 percent) have single sites. The frequency distribution of multiple site firms is also quite similar, with less than 1 percent of all firms having more than 10 sites, and most multiple site firms having only 2 or 3 sites.

6.1.1 Employment Site Characteristics

Employment sites are described in terms of size, industrial sector and geographic location. Table 3 shows sites to be rather evenly distributed across a range of sizes, as measured by number of employees. The mean size is 836, and the range is from 105 to 16,037 employees. Because the phasing of notifications has been based on site size, our sample has more larger sites than the total population of sites that will eventually be subject to the Regulation. However, the sample is probably quite representative of the sites which have approved plans as of December 1989.

Table 4 gives the distribution of sites by industrial sector. These are based on the Standard Industrial Classification (SIC) code, either reported in company reports, or when not reported, assigned by the project team according to each company's description of its business. The largest proportion of sites are engaged in manufacturing (38.8%), followed by services (26.6%). Substantially smaller proportions are represented by transportation/communications, wholesale and retail trade, public administration and FIRE (finance, insurance and real estate). As may be expected, very few firms are in agriculture/forestry mining. Industrial sector, however, gives only limited information regarding the function of a particular site. For example, the corporate headquarters of an oil company would be classified as part of agriculture/forestry/mining, even though it

[4] An employment site is defined as a work location for a given firm. It may be comprised of more than one building, as long as the buildings are within 1/2 mile of one another and the single site designation is approved by SCAQMD.

provides service functions. It may be noted that the sectoral distribution of the sample need not be representative of the general distribution of employees within the 4 county air district because of the restricted application of Regulation XV to sites with at least 100 workers. Thus industries which have a larger proportion of small firms (for example retail trade) will be "underrepresented."

Geographic location of the employment sites is based on zip code information. Zip codes were aggregated into 3 analysis areas based on development density, transit availability, pre-existing mode split and AVR target. The areas are mapped in Figure 3, and the distribution of sites is given in Table 5. Downtown Los Angeles includes the 1.75 AVR target area. Metro Central includes the more densely developed part of the region, e.g. all of Los Angeles County except the San Fernando Valley. Metro Suburbs includes the remainder of the air district: Orange, Riverside, San Bernardino Counties and the San Fernando Valley.

6.1.2 AVR and Mode Split

As mentioned earlier, several small changes have occurred in the rules governing AVR calculation. In order to be able to use a consistent measure for vehicle ridership, we computed a "modified AVR" (MAVR) based on mode of travel to work and averaged over five days as reported by survey respondents. Unlike the SCAQMD, we do not consider non-respondents in the calculation. Statistically, we expect non-respondents to be representative of the total sample and we therefore assume that they are distributed across modes in the same manner as respondents. We included in our analysis all employers that had survey data, whether it was reported for the entire work force or for workers arriving between 6 and 10 a.m. Employees on compressed work week or telecommuting are counted as 0.8 vehicle trips. The variable "modified AVR" is thus a weekly average vehicle occupancy. The MAVR is in most cases quite similar to SCAQMD's AVR.[5] For the entire sample, the mean, standard deviation and range for SCAQMD's AVR are 1.230, .386, and 1.00 to 8.85. The same values for MAVR are 1.228, .377, and 1.01 to 8.92.

[5] Although the MAVR is equivalent to AVR, it should be noted that employment sites must meet the AVR target as defined and measured by SCAQMD.

Figure 4 shows the frequency distribution of MAVR. Note that the majority of the sample sites (55%) have an MAVR of 1.15 or less. The sample median is 1.137. The sample mean is somewhat skewed by the few sites with very high MAVRs. These were individually validated, and each was characterized by very special conditions. For example, the highest MAVR (8.92) is reported by a company in downtown Los Angeles which employs a large proportion of disabled persons. Eighty four percent of the workers walk or use the bus.

Survey results are reasonably consistent with prior findings on modal share: 75 percent drive alone, 15 percent carpool, 4 percent use the bus and 6 percent use other modes (van, walk, bike, telecommute, compressed work week) for the sample as a whole. Vanpooling, telecommuting and compressed work week are the least prevalent. Nearly three quarters of the sites have no vanpools or no compressed work schedules. Only 10 percent of the sites have any telecommuting, and half of the sites do not have any of these three modal alternatives.

Table 6 gives MAVR and mode shares by analysis area. Again, results are consistent with expectations. L.A. Downtown has the highest MAVR. Metro Central is a distant second, followed by the low density suburban areas. Table 6 also shows that the carpooling rate is rather consistent across all areas, while transit use is heavily concentrated in Los Angeles Downtown. Outside of Downtown, transit use is of the same magnitude as walk or bike, or compressed work week. Vanpooling and telecommuting account for only a very small share of commute trips in all areas; however they are most prevalent in the Downtown area.
Analysis of variance tests were conducted to determine whether differences in ridesharing rates between these groups are statistically significant. The F-statistic indicates significant differences between groups in MAVR, the drive alone share, vanpool, bus share, and telecommute share. These results show that geographic location is important in explaining mode split. Location is a surrogate for development density, congestion and transit availability--factors which have traditionally been shown to be significant predictors of mode split.

Analysis of variance tests were also conducted to determine whether the ridesharing rate and modal distribution are related to other employment site characteristics, namely site size and industrial sector. With regard to size of the site, only the vanpool share was found to differ significantly between groups. As expected,

vanpooling is positively associated with site size: the vanpool share for sites with 1,000 or more employees is 1.8%, compared to the sample mean of 0.76%.

Significant differences were found in all ridesharing modes except vanpooling when sites were segmented by industrial sector. Industrial sectors were aggregated into 3 general categories based on mode share patterns: 1) Manufacturing, 2) Service and related (public administrative, FIRE, transportation/ communications), 3) Other (Agriculture/forestry/mining, construction, wholesale and retail trade). Results are given in Table 7. The highest MAVR is found in the "other" category, and the lowest MAVR is in the service and related category. Manufacturing sites (39 percent of the sample) have the highest carpooling share and lowest bus share. Service sites (50 percent of the sample) have the lowest carpool share and the highest walk/bike and compressed work hours share. Other sites have the highest bus and telecommuting shares.

These differences probably reflect both intra-organization and employee differences. For example, in the case of manufacturing, the higher carpooling rate and lower compressed work week rate are consistent with the fixed work schedules and physical demands often associated with manufacturing, activities. The relatively high transit mode share of the "other" category may reflect a greater than average share of low-wage, transit dependent workers. Unfortunately, however, employee characteristics which are known to be significant predictors of ridesharing (e.g. auto availability, trip distance, household income) are not available in this data set, and thus cannot be further investigated.

Multiple analysis of variance was used to determine how geographic location, size and industry category may jointly affect the ridesharing rate. Results are presented in Table 8. Area and industry categorical variables are as defined previously. The size variable has two categories, less than 250 workers and 250 or more workers. These categories were chosen based on prior research which suggests that ridesharing opportunities are more limited in smaller firms (Bhatt and Higgins, 1989; Ferguson, 1990).

Geographic area is the single most important explanatory factor; the main effect of size is also significant (with smaller firms having slightly lower MAVR). The main effect of industry is not significant, but its joint effect with area is significant. Among downtown area sites, manufacturing firms have the lowest MAVR, but among suburban sites, manufacturing firms have the highest MAVR. The variation in category

group means is smallest for manufacturing sites, suggesting perhaps that work arrangements are less flexible in the manufacturing sector. In contrast, MAVR varies rather widely by area among sites in the other two industry categories. For example, group means for service and related firms are 1.46 in downtown, 1.21 in metro central and 1.15 in the suburbs.

6.2 Year Two Results

Year 2 data were available for only a small number of firms because delays occurred in noticing firms and are occurring in the processing of submitted plans. As stated in Section 5 above, Sample 2 consists of 76 sites which have comparable Year 1 and Year 2 data.

6.2.1 Sample Representativeness

Given the small sample size, it is important to determine whether the sample is representative of the population, e.g. the sites which have been subject to the Regulation for at least one year. If the sample is not representative, our analysis is likely to be biased. There are two issues to consider: representativeness with respect to overall characteristics which influence mode choice (the dependent variable), and representativeness with respect to mode choice itself. In the first case, representativeness can be achieved by appropriately weighting the sample. For example, if the year 2 sample contains proportionately few downtown Los Angeles sites, the sample mode split may be biased downward, since these sites have the highest ridesharing rates. The usual method for correcting such biases is to weight the sample so that the downtown Los Angeles sites are proportionately represented.

The second issue is more serious. If the year 2 sample is not representative in terms of mode split, or if mode split somehow determines the likelihood of a site being in the year 2 sample, there is no straightforward way to correct the sample bias.

We conducted a statistical test to determine the representativeness of Sample 2. We assumed that Sample 1 is representative of the population of sites with first year plans. We then estimated a logit model which predicts the probability of an observation being in Sample 2 as a function of geographic location,

industrial sector, size and year 1 MAVR. As shown earlier, the first three variables were found to be significant explanatory factors of year 1 MAVR; year 1 MAVR represents the dependent variable of interest. The logit model was estimated twice, first with location, sector, and size as the independent variables, and then adding MAVR to the set of independent variables. Sample bias is indicated by the significance level of the independent variable coefficients. Bias related to MAVR is determined by the change in the log-likelihood ratio that results from adding it to the equation, as well as the significance level of the variable coefficient.

Test results are presented in Table 9. Variable categories are identical to those presented earlier. Likelihood of being in Sample 2 is significantly related to area and size, but not to industrial sector or MAVR. It was expected that Sample 2 would contain more larger firms because of the way Regulation XV implementation was phased. Differences in area result from the fact that downtown sites represent only a small proportion (11 percent) of all sites in the overall population. The results suggest that the sample is not representative in terms of the factors that affect mode share. However, the more serious problem of bias with respect to mode share is not indicated. The coefficient of MAVR is not significant, and the log-likelihood ratio is virtually the same for both estimations.

These results also suggest that sample representativeness could be improved by weighting. However, inspection of the actual distribution of Sample 2 across the 18 possible categories revealed several empty categories and several categories with only 1 or 2 cases. These occur primarily in the categories which have the smallest representation in Sample 1. Since weighting under these circumstances could generate other serious distortions, we chose not to weight the sample.

6.2.2 Changes in Commuting Behavior

The intent of Regulation XV is to reduce the number of peak period work trips, thus reducing vehicle miles traveled (VMT), congestion and auto emissions. The AVR goals established for the region are quite ambitious. They require large changes in the ridesharing rate. We estimate that based upon current levels of vehicle occupancy a 25 to 30% improvement is needed to reach the regional goal of 1.50. This, in turn,

requires substantial changes in employee travel behavior. Prior research suggests that such large changes would require correspondingly large changes in the relative costs and convenience of alternative modes.

Table 10 gives the mean AVR values for Year 1 and Year 2, as well as percent change for both SCAQMD's AVR and MAVR. The AVR as computer by the SCAQMD increased by more than 4%, from 1.252 to 1.306, and this change is statistically significant. Similarly, the modified AVR increased by nearly the same percentage, from 1.236 to 1.292, and this was also statistically significant. Table 11 shows the frequency distribution of changes in AVR. Approximately sixty percent of the employers in Sample 2 achieved AVR increases of between zero and fifteen percent since year one. Although the MAVR for year one and the MAVR for year two were both noted earlier to be significantly related to area, one way analysis of variance showed that there was no statistically significant relationship between the change in AVR and the area in which the firm was located. It was also found that the change in MAVR was not associated with the industrial sector of the employment site. The change in MAVR was nearly twice as great among employment sites having more than 250 employees (9.8% change in MAVR) than it was among employment sites having fewer than 250 employees (4.3%), but that difference also fell just below statistical significance.

The change in the MAVR between years one and two was found to be related to the value of the MAVR in year one. Table 12 shows values of MAVR in year one as a function of the observed change in AVR between year one and year two. The analysis of variance results show that sites with lower starting MAVR were more likely to improve; while sites with higher starting AVR were less likely to improve.

It is also of interest to examine the extent to which changes in average vehicle occupancy were related to the target AVR. For example, we asked whether employers having lower AVR targets were more likely to experience improvement in AVR than those having higher targets. The results are shown in Table 13, which again emphasizes the limitations of year one results on the basis of the sample size. The table illustrates that there were no significant associations between target AVR and change in AVR during the first year of the program. Firms having the highest target AVR (1.75) experienced a slight decrease in AVR but had the highest AVR of the three groups; firms required to meet an AVR of 1.50 had the next highest AVR and experienced an increase in AVR of some 4.6%, while employers required to meet an AVR target of 1.3 had

the lowest AVR and experienced a 4.4% increase in AVR. The small number of employment sites in two of the three categories, however, results in a lack of statistical significance in these comparisons.

Changes in AVR of course result from changes in ridesharing behavior, so it is also of interest to determine how mode choice changed between years one and two. The shifts in mode choice which were observed in sample two are summarized in Table 14. They show that the change which occurred in average vehicle occupancy resulted primarily from an increase in carpooling and vanpooling. Compressed hours and walk/bike also increased, but because of their small base they had relatively little impact on the overall ridesharing rate. Further analysis also showed that the greatest increases in MAVR were achieved at sites at which carpooling and walk/bike increased the most. For example, nearly 80 percent of the sites at which MAVR increased by more than 10 percent experienced an increase in carpooling of over 75%.

Similar results were observed for changes in walk or bike. Of the 61 sites at which anyone walked or biked, 12 sites had MAVR increases of more than 10 percent, and 9 of the 12 also had greater than average increases in the walk/bike mode. Just the reverse occurred at the sites which dropped in MAVR; the share of workers walking or biking also dropped. No such relationships were found for any of the other possible mode changes. Thus, while vanpooling and compressed hours increased somewhat overall, these increases were not associated with significant MAVR increases, probably because of the small contribution that even large charges in these modes can make to MAVR.

These results suggest some interesting patterns. First, the gains in ridesharing so far have been accomplished by changes which imply little or no institutional change. Carpooling increases have little effect on work schedules and do not entail the organizational effort that establishing a vanpool program or launching a telecommuting project might. Second, the increase in walking and biking suggests that some workers have very short commutes. Also, unlike carpooling or taking the bus, walking or biking preserves the scheduling flexibility associated with drive-alone commuting. The increased use of these modes may be an indicator of the value commuters place on schedule flexibility.

6.2.3 Use of Incentives

The plan required by the SCAQMD of each employment site consists of a mix of incentives by which ridesharing will be encouraged and commuting by single-occupant auto will be discouraged. It is instructive, therefore, to determine the mix of incentives included among the 74 employment sites in the year two sample, and to determine whether or not any statistically significant relationship exists between the measured change in MAVR and the presence of particular incentives. Unfortunately, the labeling or categorization of particular incentives is quite subjective, and many firms may be using similar labels for incentives which are really quite different from one another, while others may be using different names for the same programs. In addition, there is no information on the extent or intensity of the incentives provided. Table 15 summarizes, to the extent that incentives can be cataloged, those which are included in the ridesharing plans submitted to the SCAQMD by the 74 firms included in the year two sample. Using the total number of incentives offered as a dependent variable and comparing this with the change in MAVR, one-way analysis of variance yielded no statistically significant association. There was also no clear association between the use of certain incentives and the area in which an employer was located nor between incentive use and the size of the employment site.

For purposes of further statistical analysis, incentives were grouped into five categories which were not mutually exclusive. The five groups were: 1) monetary incentives, 2) market incentives, 3) alternative work arrangements, 4) carpool incentives, and 5) parking incentives. Rank scores based upon the number of incentives offered in each category were computed for each work site. The score varied from zero for an employer which offered no incentives in a given category, to a score of 100 for an employment site which offered all possible incentives in that category. Cross tabulations were conducted between the change in MAVR and the use of incentives within each category. The change in carpooling was compared with the presence of carpooling incentives and with the presence or absence of parking incentives. The change in telecommuting and in the use of compressed work hours were each compared with the presence of alternative work hours incentives. In all cases no statistically significant relationships were found.

7 CONCLUSIONS AND FUTURE RESEARCH PLANS

The results of the first year of monitoring the results of Regulation XV show that there has been a statistically significant increase in Average Vehicle Occupancy among firms affected by the regulation. Firms which did not meet their target AVR in year one experienced greater increases in AVR in year 2 than did those which had already met their target in year one. In general, the increases in AVR were small (less than five percent on average) and greater increases will be required in later years in order to bring most employment sites up to their target AVRs. Among the firms which we studied, most of the observed increases in AVR were the result of increased carpooling. Carpooling increases, as well as increases in walk or bike were associated with greater increase in MAVR. Although vanpooling and compressed hours increased somewhat they had little effect on MAVR. The changes which we did observe in AVR were much more difficult to explain in statistical terms, since they appeared to be generally unrelated to such "external factors" as the number of employees at the work site, geographic location of the work site, or industry group of the employer. The change in AVR was also difficult to associate in any statistically meaningful way with the mix of incentives used at the particular work site.

These results are preliminary but must be seen as encouraging in that a significant, though small, increase in AVR was found to be resulting from the first year of implementation of the Regulation XV program. We wish to emphasize that our year two sample consisted of each and every employment site for which we had valid and complete data for years one and two, and that it was not appropriately representative of all the firms affected by Regulation XV. In particular, we believe that it over-represents firms in particular areas, it includes more manufacturing sites than would a truly representative sample, and that it is biased toward larger employment sites. As more data becomes available on more employment sites, we plan to develop a larger and more representative sample with which to continue evaluation of Regulation XV. Such a sample may yield results which are much more interpretable. We plan to track the results of a representative "panel" of employment sites for several years in order to obtain a more complete and valid picture of the impacts of the regulation.

REFERENCES

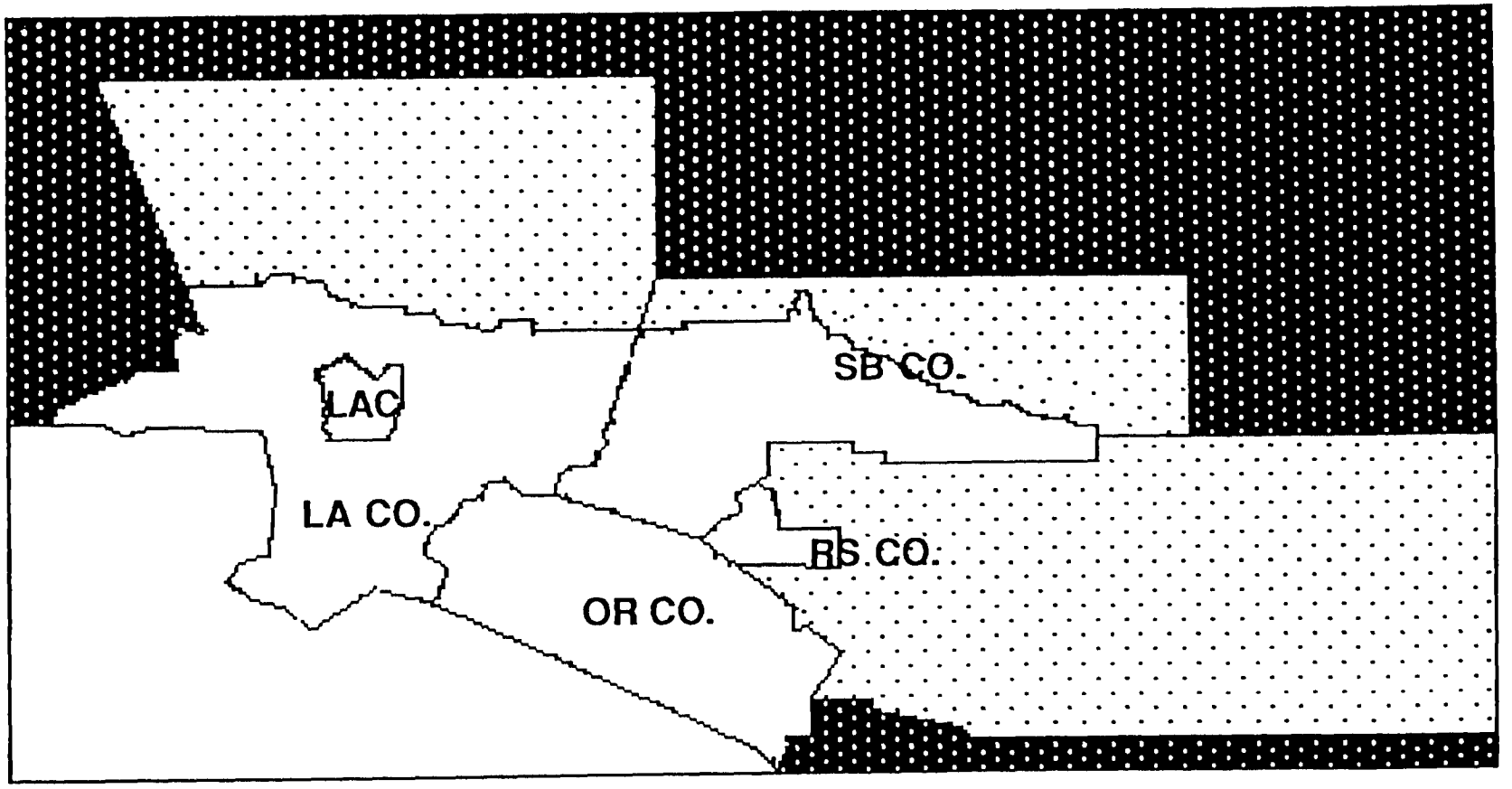
Bhatt, K and Higgins, T. (1989) An Assessment of Travel Demand Management Approaches at Suburban Activity Centers, Final Report. U.S. Department of Transportation, Contract No. DTRS-57-88-c-00113.

Ferguson, E. (1990) "An Evaluation of Employer Ridesharing Programs in Southern California," forthcoming, Transportation Research Record.

State of California, Size of Firm Report, Economic Development Department, Sacramento, California.

Figure 1

SOUTH COAST AIR QUALITY MANAGEMENT DISTRICT



LAC = Los Angeles Central Area, 1.75 AVR target

Suburban Area, 1.5 AVR target

Outlying Area, 1.3 AVR target

Figure 2

The Research Problem

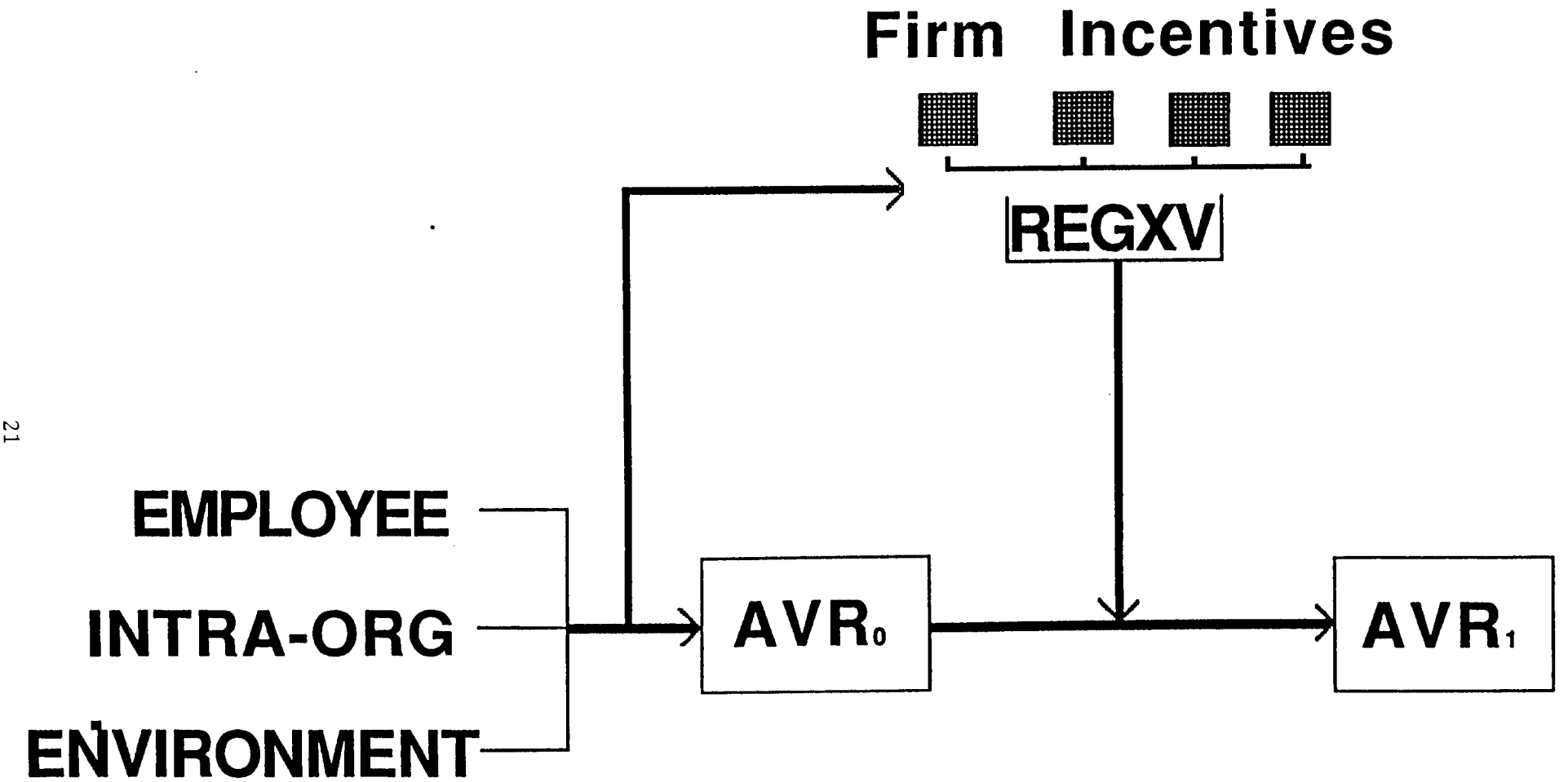
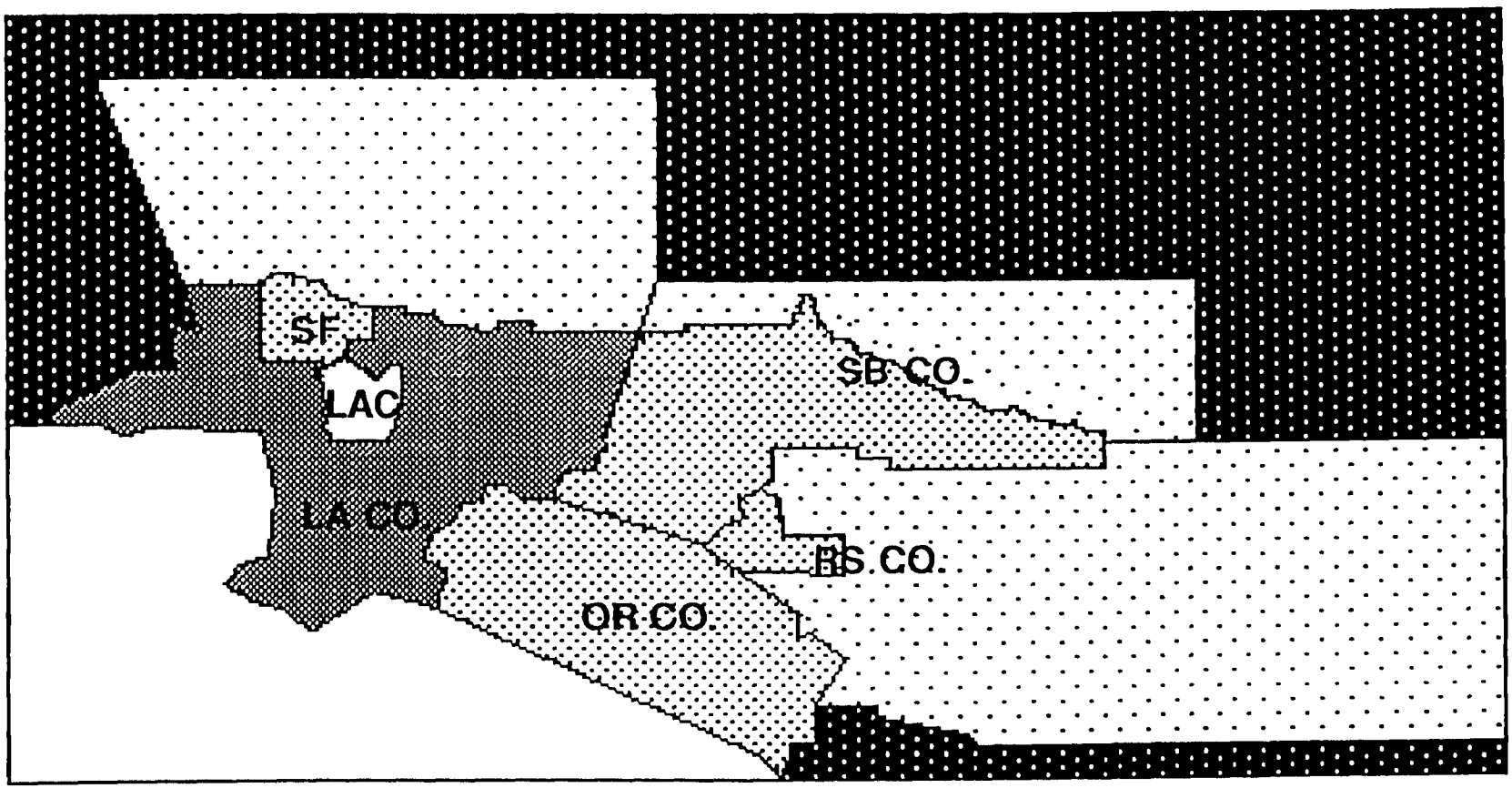


Figure 3

The Study Area



LA Central

Metro Central

Metro Suburbs

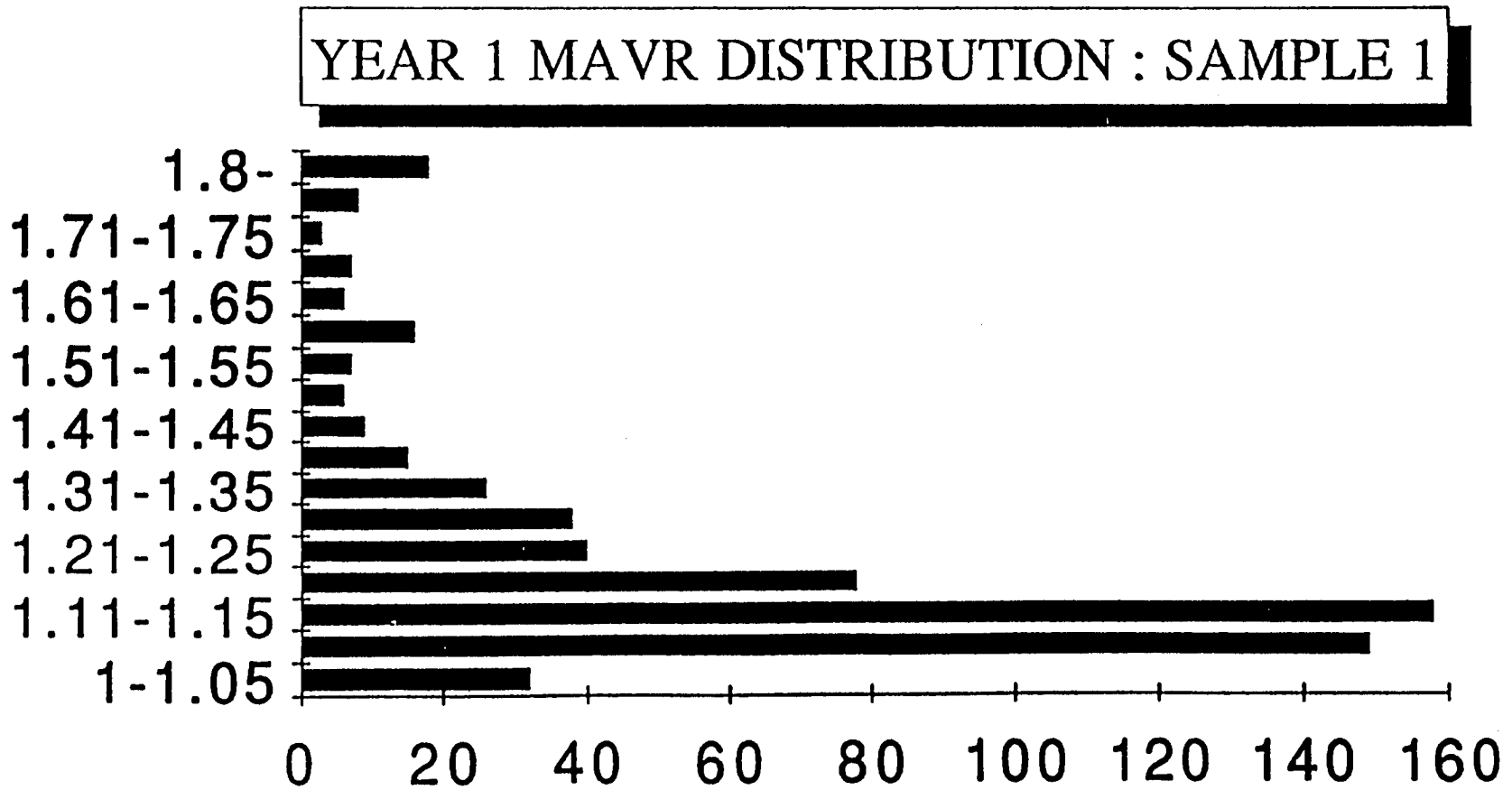

YEAR 1 MAVR DISTRIBUTION : SAMPLE 1
1.8-
1.71-1.75
1.61-1.65
1.51-1.55
1.41-1.45
1.31-1.35
1.21-1.25
1.11-1.15
1-1.05
0
20
40
60
80
100
120
140
160

TABLE 1

Summary of Actions Taken Under Regulation XV

July 1, 1988 through November 30, 1990

Notices Sent to Employers (Including Initial Notices and Annual Update Notices)	6,288
Plans Approved by SCAQMD (Initial and Update Plans)	2,547
Employers Found to be Exempt (Out of Business, Fewer than 100 employees, etc.)	1,487
Plans to be Received (Notices Sent, Plans due after June 30, 1990)	1,708
Plans Being Evaluated by SCAQMD Staff (Submitted but not yet approved or disapproved)	1,179
Plans Currently Disapproved (Some will be approved when revised)	259
Violation Notices Issued (1)	245
Cases Settled, Employers Fined (1)	42

(1) Two hundred and forty-five(245) violation notices were issued for failure to submit plans to the District. Of these, 42 cases were settled by mutual settlement agreement and the payment of civil penalties. Total settlements assessed have been $549,510. The other 56 cases were in various stages of processing as of November 30, 1990.

TABLE 2

Employers by Number of Sites

Number of Sites	Number of Firms
1	476
2	23
3	11
4	2
5	4
6-10	4
11-20	2
> 20	1

TABLE 3

Employment Sites by Size

SIZE	NUMBER	PERCENT
Less than 250	115	20
$\geq$ 250 < 500	195	34
$\geq$ 500 < 1,000	162	28
$\geq$ 1,000	107	18

TABLE 4

SIC	INDUSTRY	FREQUENCY	%
0110 ~ 1499	Agri/Forest/Mine	10	1.5
2000 ~ 3999	Manufacturing	254	38.8
4000 ~ 4999	Trans./Comm.	78	11.9
5000 ~ 5999	Whole/Retail Trade	60	9.2
6000 ~ 6799	FIRE	32	4.9
7000 ~ 8999	Service	174	26.6
9100 ~ 9999	Public Admin	46	7.0
	TOTAL	654	100.0

TABLE 5

Distribution of Employment Sites by Analysis Area

Analysis Area	Number	Percent
Downtown	68	11
Metro Central	321	52
Metro Suburbs	232	37

TABLE 6

YEAR-ONE MODE SHARE

AREA	AVR	DA	CP	VAN	BUS	WALK/ BIKE	TEL	COMP
LA Downtown	1.510	.652	.156	.015	.124	.029	.014	.011
Metro Central	1.212	.750	.152	.008	.030	.032	.005	.024
Metro Suburbs	1.168	.779	.137	.005	.020	.024	.004	.031
F-Stat	23.86*	18.81*	1.57	4.56*	64.33*	2.08	3.67*	2.05

Legend: DA= Drive Alone; CP= Carpool; TEL= Telecommute; COMP= Compressed Work Hours

* Differences between groups significant at $P \leq .05$

TABLE 7
Year One Mode Share by Industry Category

CATEGORY	AVR	DA	CP	VAN	BUS	WALK/ BIKE	TEL	COMP
Manufacturing	1.223	.743	.119	.010	.026	.024	.002	.015
Service and Related	1.211	.755	.089	.005	.040	.032	.006	.037
All Other	1.346	.755	.114	.010	.066	.023	.014	.011
F-Stat	3.38*	.47	20.58*	2.59	7.38*	3.64*	5.57*	7.25*

* Difference between groups significant at $P \leq .05$

TABLE 8

Analysis of Variance
MAVR by Area, Industry and Size

Dependent Variable: MAVR

Source of Variation	Mean Square	F
Main Effects	.606	15.17**
Area	1.436	35.94**
Industry	.007	.18
Size	.177	4.43*
Two-Way Interactions	.125	3.14*
Area by Industry	.200	5.00**
Area by Size	.056	1.41
Industry by Size	.028	.70
Three-Way Interactions	.033	.48
Explained	.258	6.46**
N of Observations	550	

* Significant at $p \leq .05$
** Significant at $p \leq .01$

TABLE 9

Sample 2 Bias Test Results

PARAMETER	COEFFICIENT	
	Equation 1	Equation 2
Area-1	-1.09*	-1.23*
Area-2	.60*	.65*
Area-3	.49a	.58a
Industry-1	.44	.43
Industry-2	-.87*	-.86*
Industry-3	.43a	.44a
Size-1	-.51*	-.50*
Size-2	.51*a	.50*a
MAVR	---	.76
Constant	-2.98**	-3.95**
-2 Log Likelihood	419.65	418.17

* Sig. at $p < .05$
** Sig. at $p < .01$

[a] Significance level obtained by estimating equations with first category as reference category.

TABLE 10

Mean Change in Ridesharing Rate

	AQMDAVR	MAVR
Year 1	1.252	1.236
Year 2	1.306	1.292
% change	4.3%	4.5%
t-value	3.24	4.45
significance	.002	.000

TABLE 11

Frequency Distribution of Change in MAVR

Change in AVR	Number of Cases	Percent of Sample
Less than 0	21	28.4%
0 to 5%	22	29.7%
5 to 10%	14	18.9%
10 to 15%	8	10.8%
15 to 20%	4	5.4%
20 to 25%	3	4.1%
More than 25%	1	1.4%

TABLE 12

Change in MAVR Vs. Year One AVR

Change in AVR from Year One to Year Two	Mean MAVR In Year One	Number of work sites
Less than Zero	1.362	21
0 to 10%	1.184	36
More than 10%	1.195	16

F=4.06 Level of Significance = 0.02

TABLE 13

Change in AVR by AVR Target

Target AVR	Mean Year 1 AVR	Mean Year 2 AVR	Target Group Change in MAVR(%)	Frequency
1.75	1.792	1.740	-2.9%	2
1.50	1.224	1.280	+4.6%	69
1.30	1.111	1.160	+4.4%	2

TABLE 14

Changes in Mode Share

Mode	Year 1	Year 2
Drive Alone	.743	.675
Carpool	.144	.192
Vanpool	.014	.020
Bus	.039	.038
Walk/Bike	.032	.036
Telecommuting	.005	.005
Compressed Hours	.023	.033

TABLE 15

NUMBER OF EMPLOYMENT SITES OFFERING VARIOUS TYPES OF INCENTIVES

Type of Incentive	Number of Sites Offering It
Preferential Parking for Ridesharers	59
Bicycle Incentives (parking, racks, locks, etc.)	49
Ridesharing Marketing Programs	48
Ridesharing Matching Services	44
Provision of Transit Information	42
Prizes and Drawings for Ridesharers	33
Vanpool Subsidies	30
Transit Pass Programs	29
Walking Incentives	27
Flextime	22
Carpool Subsidies	21
Other	18
Other Indirect Incentives	17
Guaranteed Ride Home	17
Compressed Work Hours	15
Telecommuting Programs	10
On-Site Services	7
Monetary Benefits	6
Parking Subsidies to Ridesharers	5