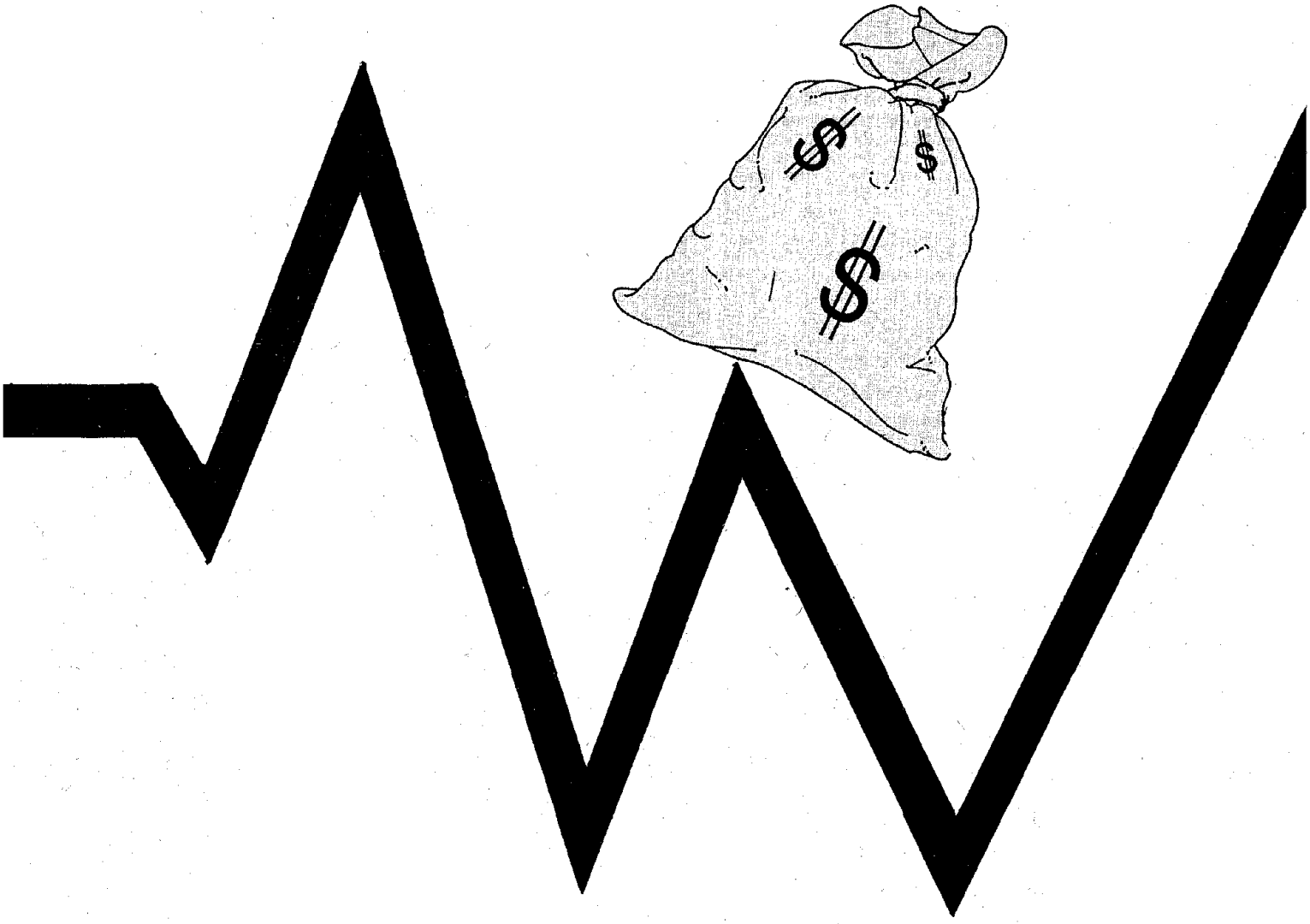
MACROECONOMIC EFFECTS OF THE LOMA PRIETA EARTHQUAKE



NOVEMBER 1991

ASSOCIATION OF BAY AREA GOVERNMENTS

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Acknowledgements:

We would like to thank the following individuals for their thoughtful comments.
Kenneth Ballard -- Pacific Gas and Electric Company
Catherine Bauman -- City and County of San Francisco
Charles Eadie -- City of Santa Cruz
Cynthia Kroll -- University of California, Berkeley
Joel Markowitz -- Metropolitan Transportation Commission
Sarah Nathe -- Bay Area Regional Earthquake Preparedness Project (BAREPP)

The production of this report was financed in part with a grant from the National Science Foundation. The report does not reflect the views of any federal agency, including NSF.

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SUMMARY

The Loma Prieta earthquake produced minimal disruption to the overall economy of the Bay Area and its environs. This economic research suggests that approximately 7,100 workers were affected by layoffs due to the earthquake. The actual number could be higher because not all workers are eligible for unemployment claims. However, a statistical analysis of the employment data suggests that the actual number is likely to be close to that estimate. This disruption lasted a maximum of four months, with a direct potential loss of wages and salaries of about $54 million, resulting in a minimum potential loss in gross output (including wages and salaries) of about $110 million during this period. The total economic disruption resulted in an estimated maximum potential Gross Regional Product (GRP) loss ranging from $725 million in one month to $2.9 billion over a maximum of two months following the Loma Prieta quake. However, at least 80 percent of that loss was recovered during the first and second quarters of 1990. This implies that ***maximum GRP lost*** as a result of the Loma Prieta earthquake ranges from $181 million to $725 million.

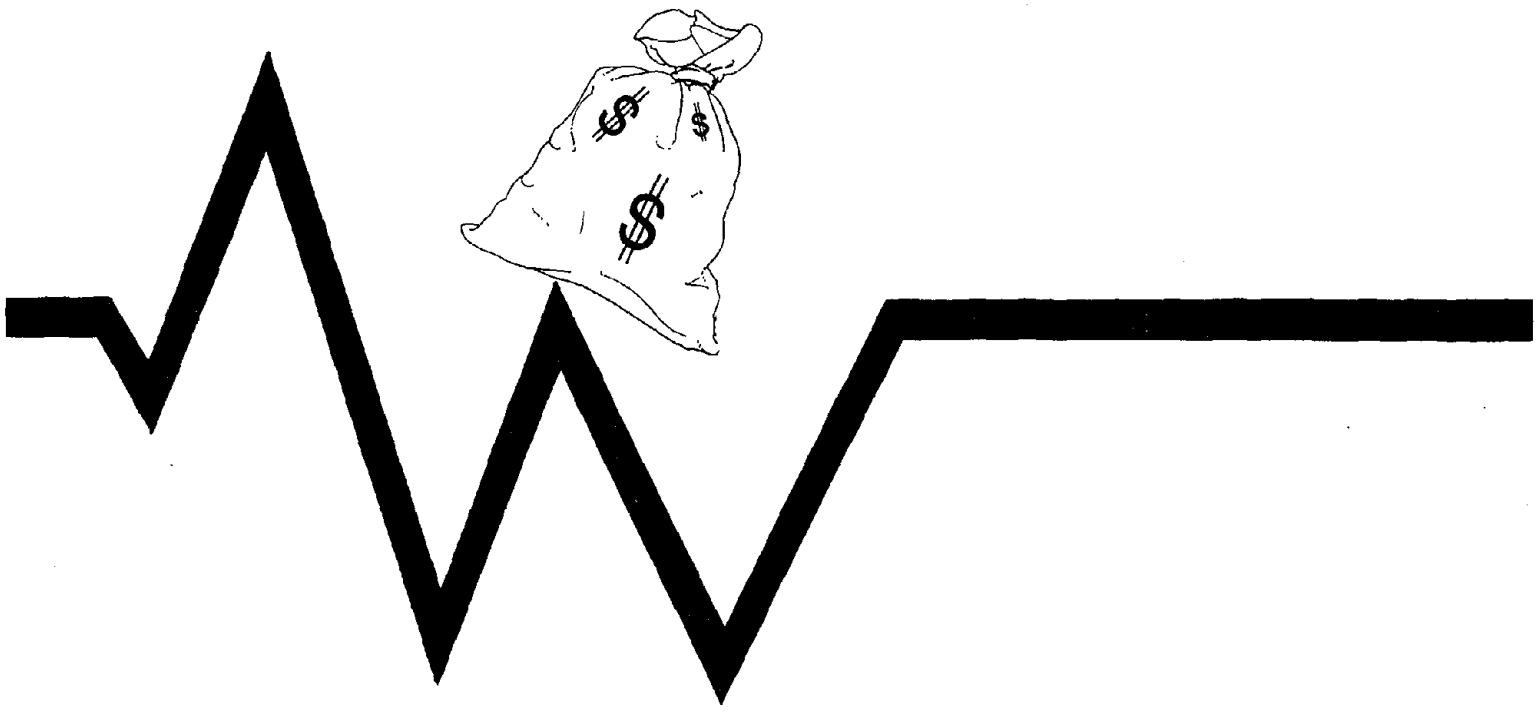
These losses, when compared to the total size of the regional economy, can only be viewed as isolated. For example, the potential short-term loss of approximately 7,100 jobs over an average duration of four months amounts to a loss of less than a quarter of one percent of the jobs in an economy of more than 3 million jobs. The GRP loss is even smaller when compared to an economy with a Gross Regional Product of $174 billion in 1989. This economic loss is even quite small in comparison to the direct physical damage due to the

earthquake of $5.9 billion. The loss was primarily concentrated in retail and selected manufacturing activity.

San Francisco experienced the greatest loss in retail activity for the fourth quarter. Data analysis indicates the loss of approximately $73 million in taxable sales. This loss was, however, not regionally felt. Economic activity merely shifted to other parts of the region. Because the only direct damages which were disproportionately high in San Francisco were to transportation and power facilities, this points to the critical role that transportation and infrastructure play in maintaining economic activity, and gives a glimpse of the potential impact on the economy from a major failure of these systems in a future earthquake.

The job losses were most severe in Santa Cruz County, which experienced an 85 percent increase in unemployment insurance claims between the 3rd week of October and the 2nd week of November over the same period in 1988. In 1988, the unemployment claims were 3,910; in 1989, they jumped to 7,246. Statistical analysis suggests that the actual employment data for November 1989 were, at a minimum, about 1,700 jobs fewer than would have been likely without an earthquake. The reduction for December was similar to that for November.

To perform these analyses, ABAG used a methodology built around an Input-Output model of the San Francisco Bay Area previously developed by ABAG staff. This work illustrates how secondary impacts of earthquakes can be measured in large urban areas. The methodology is designed as a quick-response mechanism to give policy makers estimates of macroeconomic loss based on sets of data and assumptions about duration of earthquake impacts on economic activity.



I. INTRODUCTION

On October 17, 1989 at 5:04 p.m., an earthquake of a 7.1 magnitude struck the San Francisco Bay Area and its environs. It was felt by millions of people over an area covering approximately 400,000 square miles.[1] The earthquake caused over $5.9 billion in direct property damage and disrupted transportation, communications and utilities.[2] A breakdown of the damage patterns is provided in Table 1. How did this damage and disruption translate into impacts on the region's economy?

Macroeconomic impacts are defined as recordable disruptions in business activity and employment. These impacts are viewed as short-term economic phenomena and are differentiated from property loss impacts. Thus, the objective of this research report is to identify the macroeconomic impacts of the Loma Prieta earthquake.

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[1] State/Federal Hazard Mitigation Survey Team, 1990. ***State and Federal Hazard Survey Team Report for the October 17, 1989 Loma Prieta, California***: FEMA-845-DR-CA, 73 pp.

[2] Written communication with the State Office of Emergency Services (OES), Region II, dated September 27, 1990 on "Damage Assessment Summaries."

Table 1
Estimated Loma Prieta Damage[3]

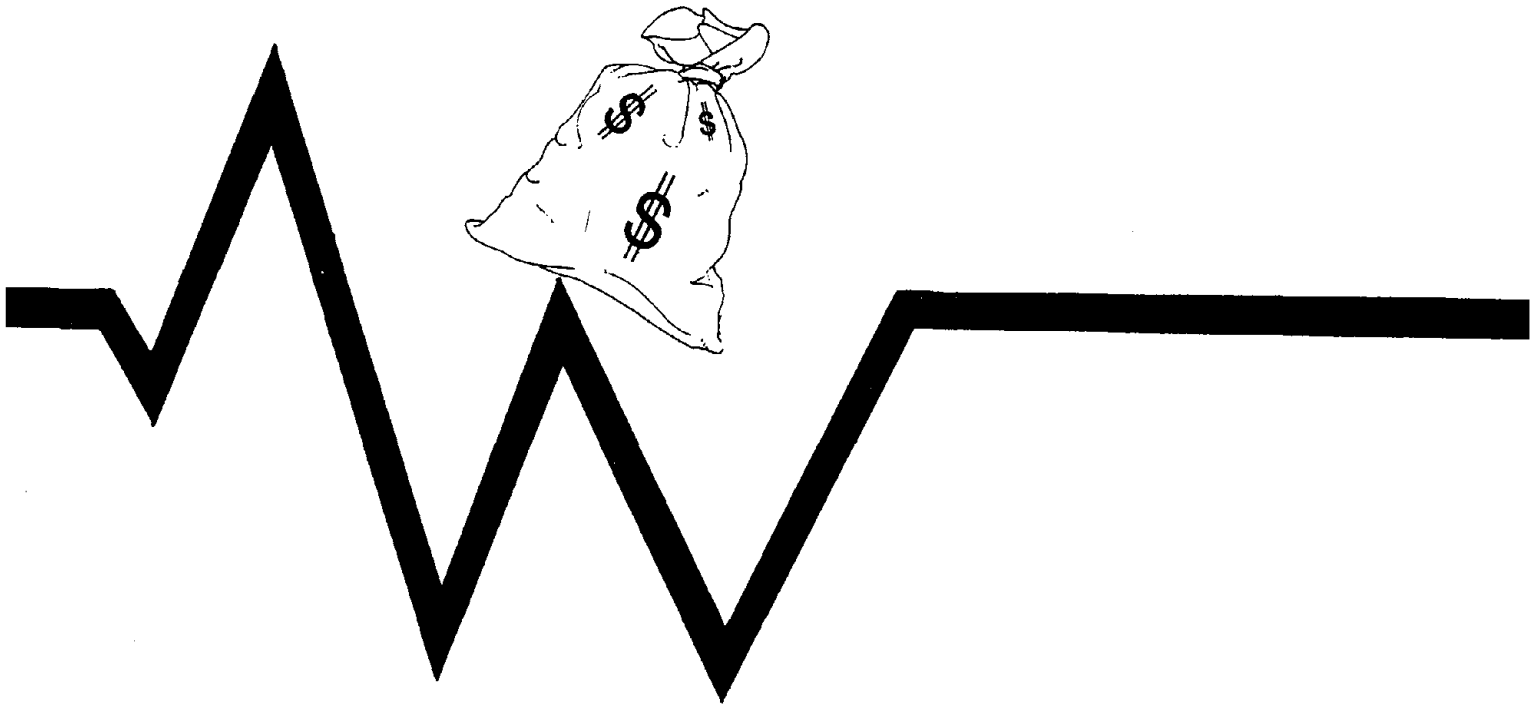
Amount of Damage	Ala-meda	Contra Costa	Marin	Mon-terey	San Benito	San Fran-cisco[4]	San Mateo	Santa Clara	Santa Cruz	Sol-ano	Total
Total Damage in $M	1472	25	6	118	102	2759	294	728	433	4	5940
Homes Damaged	2765	485	24	341	174	1321	782	5124	13329	2	24347
Homes Destroyed	20	0	0	19	62	512	1	131	774	0	1119
Businesses Damaged	397	124	20	48	35	920	793	364	1615	0	4316
Businesses Destroyed	16	0	0	11	22	16	1	6	310	0	382
Road Damage in $M[5]	559	0.6	3.6	0.6	0.3	212	9.2	5.3	40.3	0.5	833
Public Utilities Damage in $M	0.05	0.17	0.39	~0	0	37	0	0	5	0	43
PG&E Losses in $M[6]	4.1, total		0.5	see San Mateo and	Santa Clara	33.1, total		25.5, total		0.1	74 to PG&E only

[3] Most data are from a written communication with the State Office of Emergency Services (OES), Region II, dated 9/27/90 on "Damage Assessment Summaries."

[4] Data on homes and businesses damaged and destroyed are taken from San Francisco Planning Dept., March 1991. "San Francisco's Loma Prieta Experience." The numbers are significantly higher than in the OES data. Destroyed numbers include those destroyed in the earthquake or red-tagged and demolished. Damaged numbers include those secured or yellow-tagged. The number of dwelling units in residential buildings destroyed or secured was known, and all units are included in the totals. However, the numbers may be low for damaged homes due to an assumption of one unit per building for yellow-tagged buildings. Similarly, for commercial and industrial facilities, it was assumed that there was a single business per building, which underestimates the actual number of impacted businesses.

[5] Data from the Region II OES "Damage Assessment Surveys" for local roads was added to data from a written communication with CalTrans District 4 "Earthquake Damage Status Report as of September 14, 1990" and personal communications with Dist. 5 and 10 staff. San Francisco-Oakland Bay Bridge repairs are included in the values for Alameda County, not San Francisco. In addition, all Region II OES values were checked with the counties. This process resulted in an increase for Monterey County.

[6] Data from Pacific Gas and Electric Company, Insurance Department. Personal communication in September 1991. Data supplied by PG&E multi-county region. These regions follow, but are not identical to, county boundaries. Damage for the East Bay Region (Alameda and Contra Costa counties) appears under Alameda and Contra Costa counties is this table. Damage for the Redwood Region (Marin, Sonoma, Napa and a small portion of Solano counties) appears under Marin County in this table. Damage for the Mission Trail Region (Monterey, San Benito, most of Santa Clara and Santa Cruz counties) appears under Santa Clara and Santa Cruz counties. Damage for the Golden Gate Region (San Francisco, the headquarters offices, San Mateo and a very small portion of Santa Clara counties) appears under San Francisco and San Mateo counties in this table. Because much of Solano County is in the Sacramento Valley Region, the total damage for this large area is listed under this single county. The $0.6 million damage in the San Joaquin Valley Region and $10 million of indirect costs do not appear in this table except in the "Total" column.



II. METHODOLOGY

The macroeconomic impacts of the Loma Prieta earthquake are of three major types: 1) the employment impacts, 2) the impacts on regional sales, and 3) wage and output impacts.

A. Techniques for Assessing the Employment Impacts of Loma Prieta

The most effective and simplest way to assess employment impacts is to view the data over time and to compare data trends with other historical periods. Therefore, the initial step in this analysis was to plot month-by-month employment data for selected counties and PMSAs (Primary Statistical Metropolitan Area) in the immediately affected region. In the case of the Bay Area, the following areas were analyzed:

a. Santa Cruz County
b. San Benito County
c. Monterey County
d. Oakland PMSA (Alameda and Contra Costa Counties)
e. San Francisco PMSA (Marin, San Francisco, San Mateo Counties)
f. San Jose PMSA (Santa Clara County)
g. Santa Rosa-Petaluma PMSA (Sonoma County)
h. Vallejo-Fairfield-Napa PMSA (Napa and Solano Counties)

The monthly data for 1988 were compared against monthly data for 1989 to identify changes in trend that could be associated with the Loma Prieta earthquake. These trend data are identified in Appendix A. Next, AutoRegressive Integrated Moving Average (ARIMA) and least squares time series models were developed for each county or PMSA. Data used in the ARIMA models covered the twelve months of 1988 and ten months in 1989. For the least squares, the data series covered the period from September 1988 to September 1989. The independent variable in the linear least squares models was California employment for the month. ARIMA and least squares were used as a check against each other. An ARIMA is not likely to pick up macroeconomic "noise" in the data, since it calculates the forecast on the trend. The least squares model uses California employment as the independent variable.

A macroeconomic downturn would show up in this data and could be differentiated from the rise in unemployment or slowdown in job growth that was specifically related to the Loma Prieta earthquake. Both forecasting techniques were used to predict November and December. If the forecast employment came in greater than the actual employment, the difference was analyzed using both forecasting techniques to identify the Loma Prieta earthquake impact.

Unemployment Insurance (UI) claims data were collected from the California Employment Development Department (EDD) from the 3rd week in October to the 2nd week of November for both 1988 and 1989. The difference between the claims from these two periods was analyzed.

Two critical assumptions were made. First, it was assumed that 80 percent of the difference was associated with the Loma Prieta earthquake. There was some concern that an assumption of 100 percent leaves little room for microeconomic disruptions that had nothing to do with the earthquake, such as a plant closing, and general macroeconomic disruptions, such as a general slowdown in growth. Therefore, the 80 percent value appears reasonable. Second, it was assumed that the economic disruption in employment and output lasted a ***maximum*** of four months. This ***conservative*** assumption was based upon an analysis by the California EDD, in which "claim loads returned to normal levels within four weeks."[7]

After estimating the number of UI claims, these numbers were compared against the employment estimates by the ARIMA or least squares for the PMSA or county.

B. Techniques for Assessing the Retail Sales Impacts of Loma Prieta

Taxable sales data were collected from the California Board of Equalization for twelve quarters covering the period 1987-1989 for the twelve counties affected by the Loma Prieta

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[7] California Employment Development Department (EDD), February 1990. ***Effects of the October 17,1989 Earthquake on Employment***: California EDD Report, p. 6.

earthquake. Data were plotted by quarter for the periods 1987-1988 and 1988-1989. The 1987-1988 data were used as a benchmark to identify quarterly trend data. The 1988-1989 series was plotted on the same table to ascertain whether the quarterly patterns were similar. When it was clear that the slope change between the 3rd and 4th quarters of 1988 differs from that of the same quarters in 1989, an ARIMA and least squares were used to predict the taxable sales for the 4th quarter based upon trend data for the twelve quarters.

C. Techniques for Assessing the Wage and Total Output Loss Associated with Loma Prieta

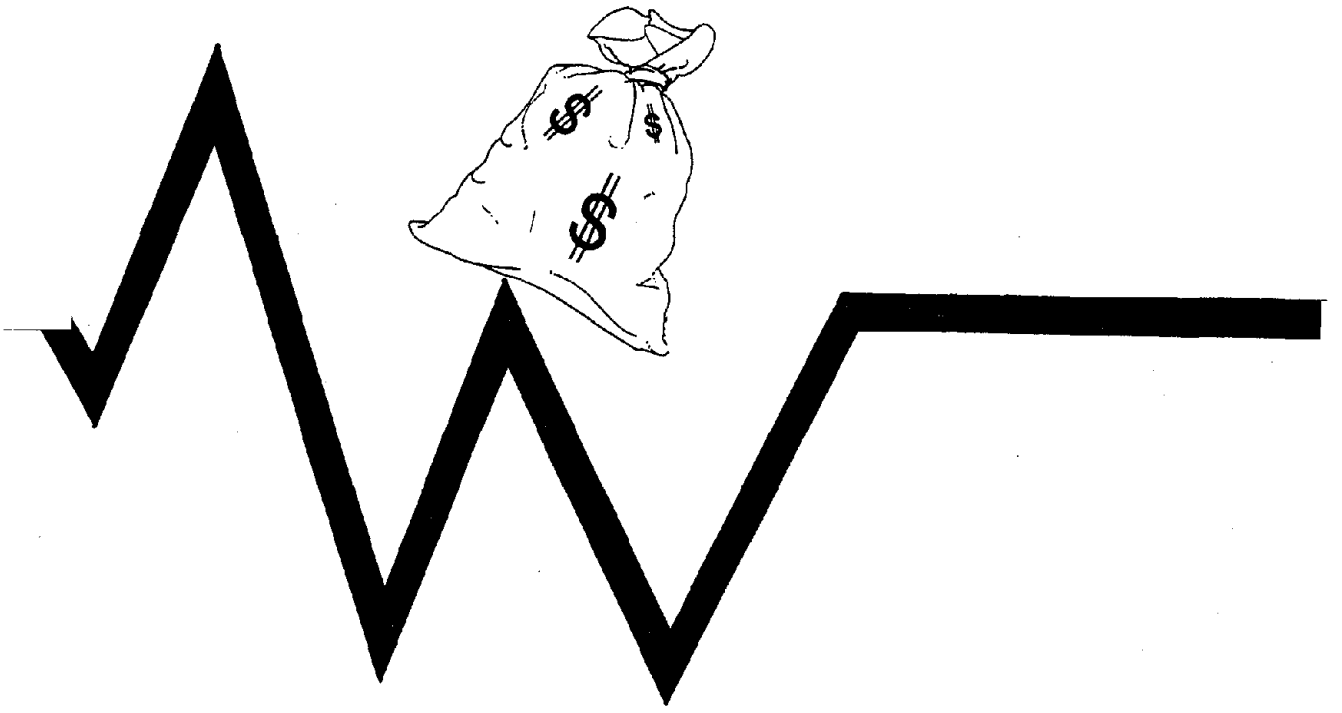
After the employment losses were calculated, wage and salary losses were calculated for each county affected by the earthquake. Using ***County Business Patterns*** data from the U.S. Commerce Department, average ***annual*** wages per employee were calculated for 1989. The average wage by county was multiplied by the employment loss.

Since, as explained in section A above, it was assumed that the duration of layoffs due to the earthquake was four months, the average annual wages were multiplied by 4/12 to obtain wage and salary loss for this shorter period. Next, using data on the ratio of wages to gross output gathered when updating the ABAG regional Input-Output table, an estimate of the gross output loss ***associated directly with the employment loss*** was calculated. The average duration of the loss covered four months.

An estimate of the decline in potential gross output associated with economic disruption was calculated for the twelve county area. The disruption affected output where employment layoffs were associated with the earthquake. This potential decline in gross output reflects the minimum potential lost due to the earthquake.

Finally, an estimate of the range of regional gross output disrupted by or lost due to the Loma Prieta earthquake was calculated. This estimate was based upon the gross output for the quarter for the twelve-county area. Of this estimated value, most was recovered in the months following the earthquake. However, a conservative estimate was developed of the total loss in gross output that was not recovered.

Throughout this process, several assumptions have been made. The overriding rule, however, has been to make these assumptions as conservative as practical. Thus, if the conclusion of this effort is that the impact on total regional output is small, this conclusion was reached in spite of the conservative assumptions made during the analysis.



III. ANALYSIS OF THE MACROECONOMIC IMPACTS OF LOMA PRIETA

A. Analysis of County or PMSA Employment Impacts

Figures 1A - 8A in Appendix A plot monthly employment trends for 1988 and 1989 for the twelve counties within the study area. For the nine-county Bay Area, the areas were delineated by PMSA (Primary Metropolitan Statistical Area). There are five PMSAs in the Bay Area, identified under Section A in the description of the methodology. Individual data exists for the counties of Monterey, San Benito and Santa Cruz counties.

Table 2 identifies unemployment claims for the 3rd week in October through the 2nd week in November for the years 1988 and 1989. The data give a relatively good picture of the direct job impacts of the Loma Prieta quake. As described in the previous section, it was assumed that between 70 and 90 percent of the increase in unemployment claims was associated with the October 17th earthquake. This varies by county or PMSA. It was assumed that 90 percent of the increase in claims in Santa Cruz County was associated with the October 17th quake, and 70 percent of the increase in the San Jose PMSA was associated with the quake. The lower value of 70 percent was used for the San Jose PMSA because of an economic slowdown independent of the earthquake. All other areas were 80 percent.

Table 2
Unemployment Claims in Counties Affected by the Loma Prieta Quake
3rd Week October--2nd Week November

	1988	1989	Actual Increase	Assumed % of Increase Due to EQ	Calculated EQ-Related Increase
Santa Cruz County	3910	7246	3336	90	3002
San Benito County	642	926	284	80	227
Monterey County	7521	8205	684	80	547
Oakland PMSA	9410	10778	1368	80	1094
San Francisco PMSA	7541	9270	1729	80	1383
San Jose PMSA	6929	8147	1218	70	853
Total	35953	44572	8619		7106

Source: ***Effects of the October 17, 1989 Earthquake on Employment,*** California EDD, pp. 7-8, February 1990.

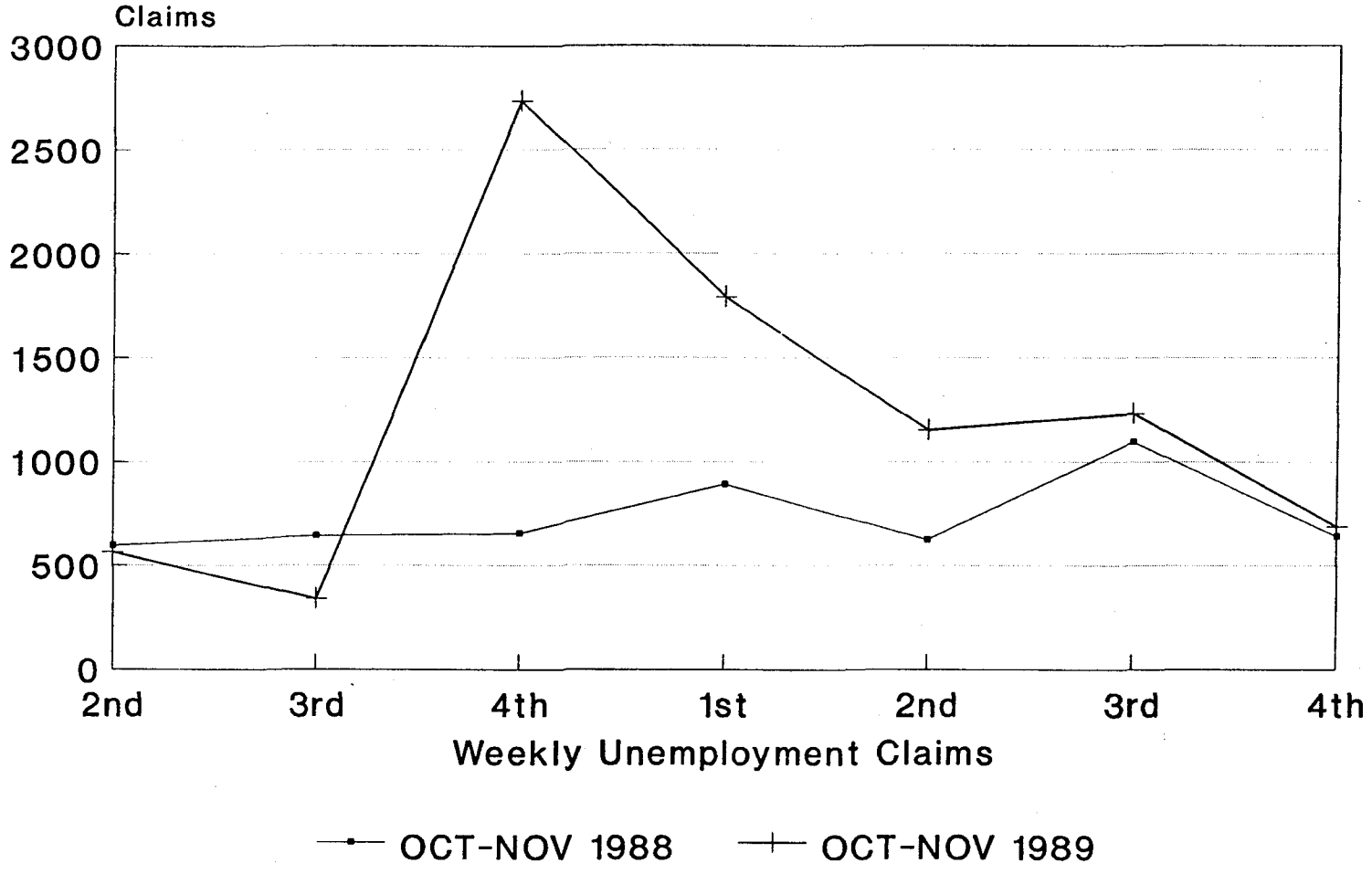
Based upon the above assumptions, it was estimated that, of the total increase in claims of 8,619 during this period, approximately 7,100 were associated with the Loma Prieta earthquake. Over 42 percent of the estimated increase in claims due to the earthquake were located in Santa Cruz County. San Francisco PMSA (Marin, San Francisco and San Mateo counties) accounted for about 20 percent of the increase. The Oakland PMSA accounted for about 15 percent, and the San Jose PMSA share was about 12 percent of the total. San Benito and Monterey counties accounted for the remaining 11 percent of the claims.

Santa Cruz County

Figure 2A in Appendix A shows that the trend of employment growth was disrupted in October 1989. Unemployment claims increased by 3336 from the 3rd week in October to the 2nd week of November 1989. An ARIMA model was developed to predict non-agricultural employment for November and December 1989, based upon twenty months of time series covering 1988 and 1989. The predicted value for November 1989 was 84,800 jobs. The actual value was 1,700 jobs lower than the predicted. A statistical analysis indicated the true value is between 82,500 and 87,000, with a 95 percent confidence value. If one assumes the upper value is closer to the true value than the predicted value, this comes close to the increase in unemployment claims identified. For December, the predicted value is 84,100 which is 1,800 jobs higher than the actual employment; the upper limit of the ARIMA model's prediction is 87,700 with a 95 percent confidence value. Hence, the model tended to verify the observed increase in UI claims as shown in Figure 1 of this section, and the decline in employment as identified in Appendix A, Figure 2A.

Figure 1

Unemployment Claims in Santa Cruz County
Impact of Loma Prieta Earthquake



Source: California EDD

San Benito County

San Benito County was close in proximity to the Loma Prieta quake, but the economy was marginally affected. Figure 1A in Appendix A shows the trend in employment in 1988 and 1989. No discernible shifts in growth could be identified. Unemployment claims increased by 284 during the period.

An ARIMA was developed for non-agricultural jobs for twenty months covering 1988 and 1989, and does indicate a predicted level of jobs greater than the actual. For November the forecast suggest 8,263 jobs in the county. The actual is 8,075. This difference is close to the claims filed. In December, 8,414 jobs were forecast for the county and the actual number was 8,100 jobs. This indicates continued weakness into December in the local economy.

Monterey County

Unemployment claims increased by 684 individuals during the period from the 3rd week in October through the 2nd week in November of 1989 over the same period in 1988. An ARIMA model was constructed to predict November and December 1989 non-agricultural employment. These predicted data were compared with the actual data for the period. The forecast model tends to verify that the Loma Prieta quake did have some impact on the county's employment growth. The ARIMA forecast for jobs in November 1989 was 600 higher than the reported employment growth by EDD. In December, the forecast was 400 jobs higher than that reported by EDD.

The actual employment in November 1989 was 112,200, and in December, it was 111,800. The difference in the forecast and actual numbers appears to be confirmed by the jump in unemployment claims. However, the increase clearly is minimal when compared to the total jobs in the county.

Oakland PMSA

The Oakland PMSA consists of Alameda and Contra Costa counties. As shown in Figure 4A in Appendix A, the Loma Prieta quake had minimal impacts on job growth during the affected period. In fact, the graph shows an acceleration of job growth from October-December 1989 over the same period in 1988. Unemployment claims did jump by 1,368 during this period, when compared to the same period in 1988. The increase appears to have been limited to the Berkeley-Oakland area. The Hayward-Fremont areas further south area experienced a jump in claims during the week of 28th October of about 392 claims over the same period in 1988. However, the number of claims dropped dramatically after this week. Kroll and others speculated that "employment trends in the East Bay (Oakland MSA) suggest that the earthquake may have induced a mini boom for the end of October and the

month of November in some sectors, in portions of Alameda and Contra Costa Counties undamaged by the earthquake."[8]

The increase in UI claims associated with the Loma Prieta quake in an economy of 900,000 plus jobs can only be viewed as insignificant. To statistically verify that conclusion a least squares model was constructed for the Oakland PMSA. The independent variables was non-agricultural employment in the state. The dependent variables was non-agricultural employment in the Oakland PMSA. The r^2 for the model was 0.92 and the DW statistic was 2.13, indicating little bias in the model. The results of the simulation indicated that the predicted growth was less than the actual. In short, economic conditions in the PMSA were not inhibited by the Loma Prieta earthquake.

San Francisco PMSA

The San Francisco PMSA consists of Marin, San Francisco and San Mateo counties. Unemployment claims increased by 1,729 in the PMSA over the same period in 1988. Approximately 78 percent of the increase was in the County of San Francisco. Most of the job loss in San Francisco was in retail activity. This loss is verified by Figure 8B in Appendix B which shows a major slump in taxable sales in San Francisco, probably due to transportation disruption.

The overall employment impact in the PMSA was not significant. The job losses accounted for approximately 0.2 percent of total jobs in the PMSA during this period. Figure 5A in Appendix A shows that the trends of employment for the months of October-December 1989 were quite similar to those for the same period in 1988.

San Jose PMSA

The San Jose PMSA consists of Santa Clara County in the southern portion of the Bay Area. Unemployment claims jumped by 1,218 from the 3rd week in October through the 2nd week in November 1989 over the same period in the previous year. Thirty-seven percent of the increase was in the Gilroy area, in southern Santa Clara county.

Approximately one-third of the increase was in the Sunnyvale area, in the northwestern corner of the county. A major fraction of this increase in claims is associated with high-tech lay-offs unrelated to the Loma Prieta quake. Figure 6A in Appendix A indicates a general weakening of employment growth over the year 1989, independent of the Loma Prieta quake in October 1989. The graph shows a jump in employment in December 1989 in sectors normally affected by an economic disruption such as an earthquake. That is, more

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[8] Cynthia A. Kroll, John D. Landis, Qing Shen and Sean Stryker, 1991. Economic Impacts of the Loma Prieta Earthquake: A Focus on Small Business: University of California, Berkeley, Institute of Business and Economic Research, Berkeley, CA, 40 pp.

than 50 percent of the increase from November to December was associated with retail trade activity. An ARIMA model of monthly employment data from January 1988 to October 1989 was developed to predict November and December 1989 employment for the PMSA. The model predicted a November employment level of about 2,000 jobs greater than the actual, but nearly 15,000 lower than the actual for December. The confidence band for the November forecast was about +- 3.5 percent for the forecast of 836,400 jobs. The confidence band deteriorates for the December forecast to about +- 5 percent of the forecast of 820,300 jobs. Therefore, the statistical model is not useful in this case, primarily because the trends illustrated in Figure 6A show a general economic weakening throughout 1989. Therefore, it is argued that little or no evidence exists that Loma Prieta affected economic activity in Santa Clara County in a statistically measurable way.

Santa Rosa and Vallejo-Fairfield-Napa PMSAs

The Santa Rosa PMSA consists of Sonoma County and the Vallejo-Fairfield-Napa PMSA consists of Napa and Solano counties.

These counties are in the northern Bay Area and furthest away from the quake area. Figures 7A and 8A in Appendix A indicate little or no impact from the Loma Prieta quake. Unemployment claims verify this statement. The Vallejo-Fairfield-Napa PMSA did see an increase in claims during this period and a slowing in job growth. These conditions are totally attributable to the early stages of the existing recession, since the losses were associated with residential construction activity.

B. Analysis of County Taxable Sales Impacts

In addition to examining the potential employment impacts of Loma Prieta, the impact on retail sales was analyzed to determine the impacts of the earthquake on consumer behavior during this period.

Santa Cruz County

Given the employment impacts in Santa Cruz from the earthquake, one would have thought that a measurable impact on retail sales also would have been felt. However, as Figure 2B in Appendix B illustrates, the trend for the affected quarter is quite similar to that of 1988.

To verify this observation, an ARIMA model was used to predict taxable sales. Data covered the period from the first quarter of 1987 to the third quarter of 1989, or eleven quarters of data. The forecast for the fourth quarter 1989 was $460,930,000 in taxable sales. The actual amount was $456,900,000 in taxable sales. The difference is less than 1 percent, and therefore statistically insignificant. Therefore, it appears that Loma Prieta had little or no impact on sales activity when viewed in the context of these quarterly data.

One factor minimizing the impact of such losses in Santa Cruz may have been the availability of relief funds for temporary tents to house those businesses displaced in the downtown area. Businesses also were able to relocate to other areas of the county, minimizing the county-level impacts (even though sales tax revenues in the city of Santa Cruz dropped). Another factor may have been the strong economic base of Santa Cruz as the site of an expanding University of California campus, and as a southern annex of Santa Clara County's "Silicon Valley." Finally, spending may have increased as people replaced or repaired those items damaged or destroyed.

San Benito County

Figure 1B in Appendix B shows little or no impact from Loma Prieta in the 4th Quarter 1989 retail sales patterns. In fact, as illustrated, sales jumped in the quarter substantially higher than the trend for the same period in 1988.

Monterey County

Figure 3B in Appendix B indicates that the Loma Prieta quake had little or no impact on taxable sales in the county in the 4th quarter of 1989. An ARIMA model for the same period forecast a taxable sales level of 1.4 percent higher than the actual data. This difference is considered statistically insignificant. In short, it is not likely that the difference was the result of the Loma Prieta quake.

Alameda County

Alameda County is part of the Oakland PMSA. Figure 4B in Appendix B identifies the taxable sales data for the county.

The graph shows that the trends over the 1987-1988 and 1988-1989 period are similar on a quarterly basis. The second and third quarters of 1989 actually were better than those in the 1988. The fourth quarter appears to have flattened out. An ARIMA model, however, for the period forecast a lower 4th quarter than the actual taxable sales. Therefore, one would suggest that little or no evidence exists that the Loma Prieta earthquake had an effect on taxable sales in Alameda county in the 4th quarter 1989.

Contra Costa, Marin and Napa Counties

Figures 5B, 6B and 7B in Appendix B illustrate taxable sales activity for Contra Costa, Marin and Napa counties. The trend data show little or disruption in taxable sales activity in the counties over this period.

San Francisco County

Figure 8B in Appendix B identifies taxable sales activity in San Francisco county. The graph does suggest a shift in the retail sales activity trend for the 4th quarter 1989. Various statistical techniques were used to measure the expected against the actual retail activity. An ARIMA model forecast $73 million above that of the actual. A statistical least squares, using California taxable sales as an independent variable, forecast taxable sales $31 million higher than the actual data. Some of this loss in potential retail activity can be associated with the drop in tourism, which is estimated to be a $3 billion business in San Francisco. Another source of the loss is associated with a shift of retail activity from San Francisco to other counties in the region. This shift may have been due, in part, to the damaged bridge access to San Francisco. A short-term power outage in the Financial and Marina districts may have exacerbated this problem. ARIMA models of retail activity for the 4th quarter 1989 for Alameda, Contra Costa and San Mateo counties indicated higher retail sales than expected for the quarter. A portion of this increased activity can be attributed to a ***shift in retail activity away from San Francisco county to other Bay Area counties in the Bay Area.***

This shift points to a potentially significant reason why the Bay Area's economy was not substantially affected by the October 17th earthquake. As noted earlier, a major portion of the loss in economic activity in San Francisco may have been due to a ***loss in transportation access.*** It suggests that lack of widespread infrastructure damage minimized the economic impact of the earthquake.

San Mateo County

Figure 9B in Appendix B shows retail activity in the 4th quarter 1989 in San Mateo County. The graph suggests that the trend in this activity was not affected by the earthquake. This is verified by an ARIMA model of retail activity which forecast a lower level of growth than actually occurred.

Santa Clara County

Figure 10B in Appendix B identifies taxable sales activity in Santa Clara County over a period covering 1987-1989. Little or no identifiable impact can be observed from the trend data. An ARIMA model for taxable sales for the county covering the periods 1st quarter 1987 through 3rd quarter 1989 was developed. The model results confirmed that the actual sales exceeded expected sales for the 4th quarter 1989.

Solano and Sonoma Counties

Figures 11B and 12B in Appendix B cover Solano and Sonoma counties. These counties are located in the northern portion of the Bay Area. Both tables show little or no impacts from the Loma Prieta Quake on taxable sales in these counties.

C. *Analysis of Wage and Output Impacts*

As noted earlier, long or short-term job disruption affected more than 7,100 individuals after the Loma Prieta earthquake. In order to estimate the impact of this disruption, estimates of the average wages of the affected individuals were made. It was beyond the scope of this project to develop a profile of the workers affected by the Loma Prieta earthquake. Therefore, wage and salary losses reflect averages for the specific county or PMSA. Table 3 contains average wage and salary level in 1989 for the affected counties.

Table 3
Average Annual Wage and Salary By County or PMSA in 1989

Santa Cruz County	$19,400
San Benito County	$18,800
Monterey County	$18,800
Oakland PMSA	$24,000
San Francisco PMSA	$26,800
San Jose PMSA	$30,000

Source: ***Bureau of Economic Analysis***, Wage and Salary Data

After identifying the average wage and salary for 1989 for the affected areas, an estimate of the number of workers affected was made. The affected workers were defined as the difference between the claims for the 3rd week in October through the 2nd week in November multiplied by a fraction. That is, it was assumed that the workers affected by the Loma Prieta quake were not responsible for all of the increase. In the case of Santa Cruz county, it was assumed that 90 percent of the increase was earthquake-related. For Monterey, San Benito counties, the estimate was 80 percent. For the Oakland and San Francisco PMSAs, the estimate was 80 percent. For the San Jose PMSA, the estimate was 70 percent. In the case of the San Jose PMSA, the estimate was 70 percent because an economic slowdown independent of the earthquake was already occurring.

Next, it was assumed that the average maximum duration of a lay-off due to Loma Prieta was 4 months. Data on actual duration of employment were not available. The maximum duration of unemployment was divided into twelve months to obtain the fraction of the year without income. This value was multiplied by the annual wage and salary to obtain lost income. This value reflects ***maximum income lost*** because unemployment benefits received during this period were not subtracted from the wage and salary lost.

Table 4 identifies wage and salary losses associated with reported unemployment due to the Loma Prieta earthquake.

Table 4
Income Losses from Loma Prieta Quake

Santa Cruz County	$19,413,000
San Benito County	$1,423,000
Monterey County	$3,428,000
Oakland PMSA	$8,752,000
San Francisco PMSA	$12,355,000
San Jose PMSA	$8,530,000
Total	$53,900,000

Source: ABAG

After calculating wage and salary losses due to the increase in unemployment, estimates of the impact on output were calculated. In the Bay Area, employee compensation accounts for about 48.9 percent of the total value of output of industries. This is an average found by calculating the employee compensation component of industry inputs.[9] The reciprocal of employee compensation multiplied by the wage and salary lost results in an estimate of the value of output affected ***directly*** by the employee reductions. This value is $110.2 million.

D. Analysis of Economic Disruption Impacts

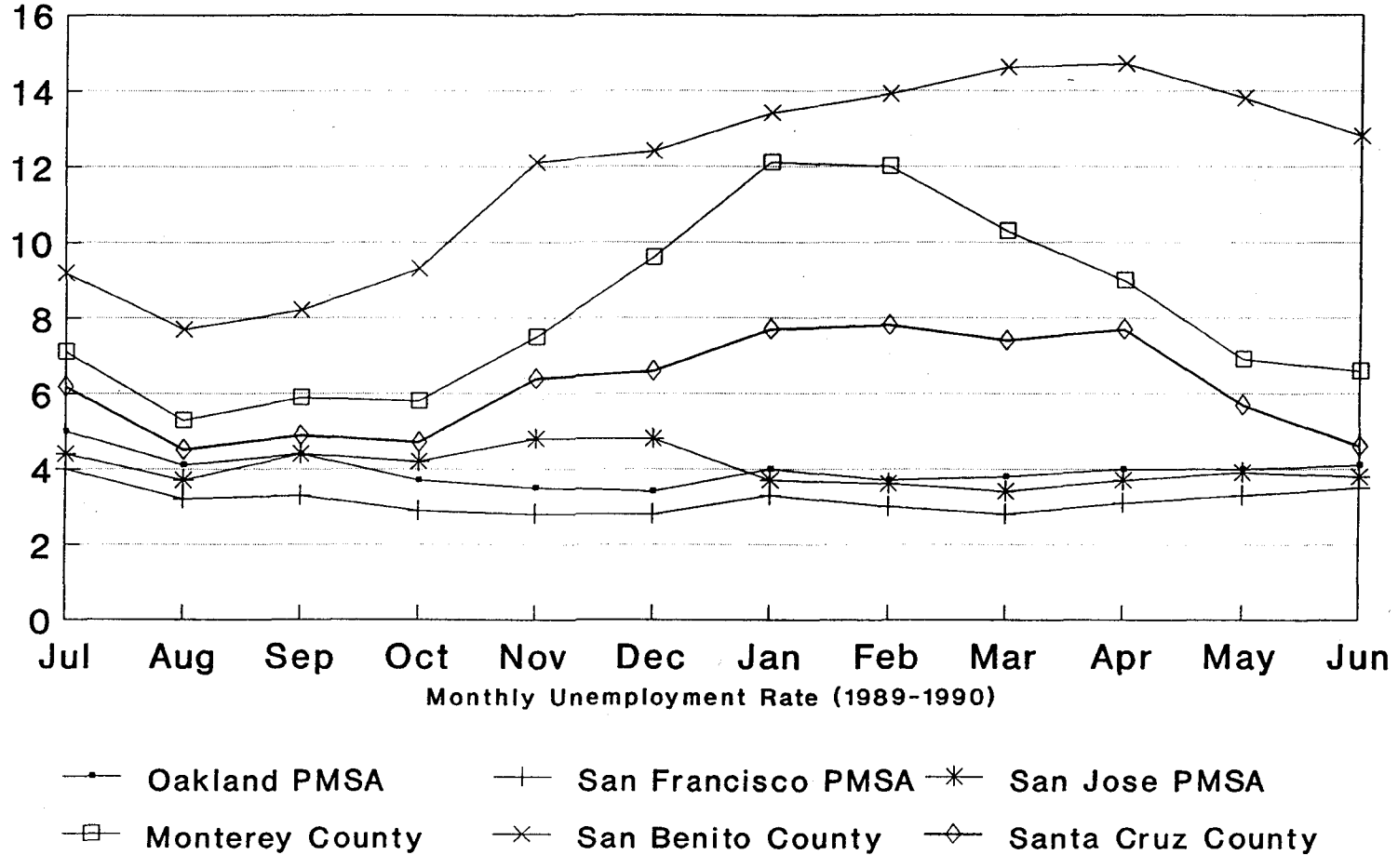
Next, the economic disruption of the earthquake can be calculated. For purposes of this analysis, a set of ***very conservative*** assumptions, based on professional judgement, have been made. At a minimum, 10 percent of the Bay Area's economy was affected for a period of one month, and, at a maximum, 20 percent of the region's economy was affected for two months. It is further assumed that, at a maximum, productivity fell by 50 percent over the affected period ***in affected industries***. The resulting ***indirect*** economic disruption in the 3rd quarter of 1989 cost the region's economy, in loss GRP, about $725 million to $2.9 billion, depending upon the assumptions.

Finally, it was assumed that 75 percent of the lost productivity or production was recovered during the 1st and 2nd quarters of 1990. Thus, the ***permanent loss*** from the earthquake in terms of potential Gross Regional Product (GRP) is between $181 million to $725 million. This amount is quite small compared to the ABAG estimate of the GRP for 1989 of $174 billion, ***in spite of the conservative nature of all of the assumptions on which this analysis is based.***

[9] Unpublished data from ABAG's Regional Input-Output table

Figure 2

Unemployment Rates
Impact of Loma Prieta Quake



Source: Report 400r-Coastal, EDD

Although it is difficult to attach concrete numbers to these values, anecdotal conversations with businesses in the Oakland-Berkeley area, as well as in Silicon Valley, tended to confirm the conservative nature of these assumptions. For example, a survey of seven major Silicon Valley firms determined that the vast majority of their operations were back on-line on October 18th or 19th, with full operational recovery ranging from October 18th or 19th (two firms), November 1989 (one firm), first quarter 1990 (2 firms), and second quarter 1990 (two firms).

E. Employment Impact into the Year 1990

Figure 2 illustrates unemployment rates over the period July 1989-June 1990 by PMSA and selected counties. It shows a jump in unemployment rates in Monterey, San Benito and Santa Cruz counties and the San Jose PMSA starting in October 1989. In Monterey and San Benito almost all of the continued increase is associated with seasonal agricultural employment. In Santa Cruz, after an initial increase from October to November, the rate stabilized and began to increase again in January 1990. The increase in January is associated primarily with seasonal employment. Overall, the unemployment statistics show no long-term lingering impact on employment from Loma Prieta.

F. Why the Minimal Economic Impact ?

Given that over $5.9 billion in property damage was recorded in the Loma Prieta quake, why was the macroeconomic impact so small in comparison to the area's GRP of more than $170 billion with more than 3 million jobs? This is a critical question because it gives us insight into both the flexibility and vulnerability of the region's economy.

Some might argue that luck played a key role in minimizing macroeconomic disruptions to the Bay Area's total economy. The direct earthquake damage was concentrated in isolated areas where the economic impact was substantial. (See Table 1, page 4.) But even in areas such as Santa Cruz County, the macroeconomic impacts were not "major" if viewed in the context of an entire county. Even if one assumes that the 3,300 jump in unemployment claims was minimal, and that the actual number of workers affected were 1,000 more, or 4,300, this number still only represents about 6 percent of the total jobs in the county.

One also could argue that the primary reason the Loma Prieta earthquake had a minimal affect on the macroeconomic factors in the Bay Area was that the transportation and other forms of infrastructure were minimally damaged at the regional level. The damage and disruption to the Bay Bridge connecting San Francisco with the East Bay areas of the region is a good indicator of how a major transportation network disruption could affect economic activity. It is hypothesized that the decline in taxable sales in San Francisco is directly related to the closure of the Bay Bridge for the several week period from October to November 1989. The damage to the Cypress Freeway in Oakland minimally affected

regional transportation activity because of alternative routes. However, economic impacts of approximately $20 million annually were documented in a recent report.[10] Had major freeways been disrupted throughout the Bay Area for any length of time, it is likely that economic activity would have been more substantially affected.

One can also argue that the complexity of the regional economy generates various redundancies which serve to localize the impact of businesses displaced by building damage. A case in point is the City of Santa Cruz, which, from an economic perspective, can be viewed as a southern annex to Santa Clara County's "Silicon Valley." Localized impacts were minimized because businesses were able to relocate to other areas of Santa Cruz County. Such redundancies found in an urban area are not present in a more rural area, such as Coalinga.

Finally, one must give credit to the level of emergency preparedness among the major industrial leaders in "Silicon Valley." Unlike some other Bay Area (and national) industrial areas, these industries are relatively young. Thus, the structures in which they are located are relatively new. Some of these companies are national leaders in the retrofit of non-ductile concrete structures, or had abandoned those buildings (in part, due to earthquake concerns) well before the Loma Prieta earthquake. In addition, because of the rapidly changing technology in which these industries are engaged, the process equipment and contents of the buildings tend to be completely replaced about once per five years. Thus, the companies have every opportunity to upgrade the quality of their equipment and the means by which it is anchored.

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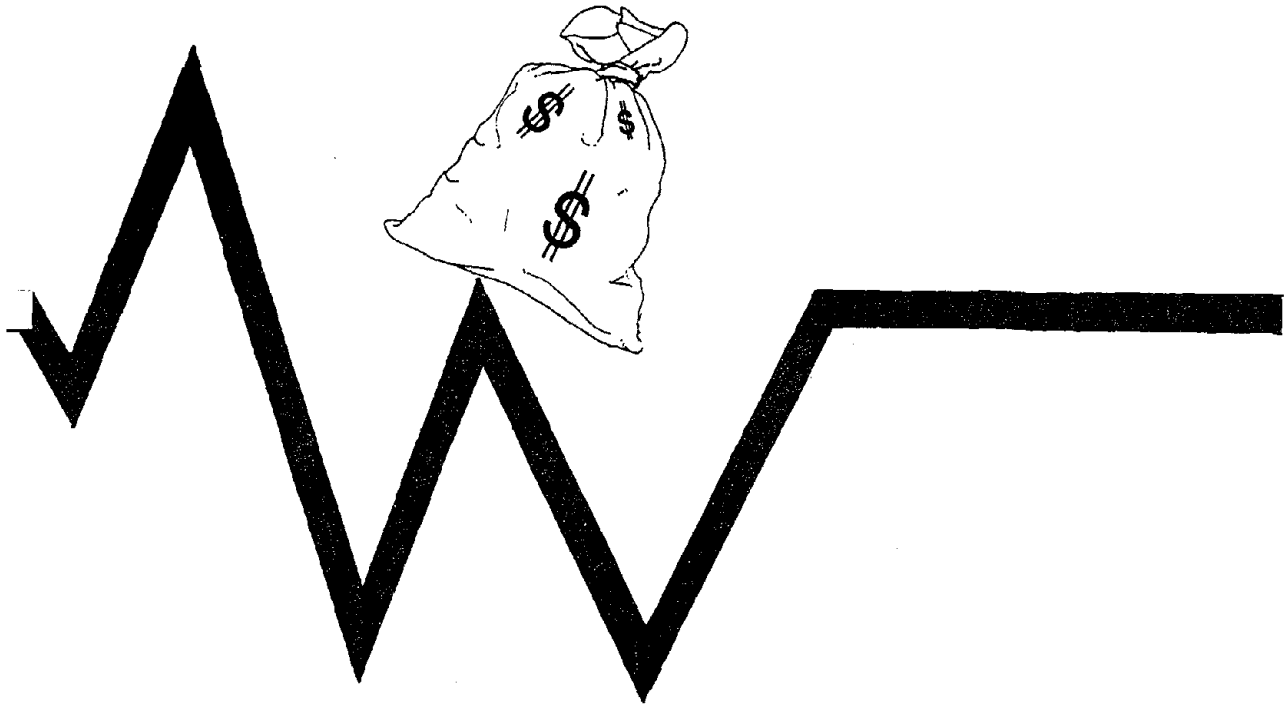
[10] Bay Area Economic Forum and Metropolitan Transportation Commission, 1990. ***The Missing Transportation Link: Economic Impacts of the Closure of the Cypress Freeway on the San Francisco Bay Area***: Bay Area Economic Forum and Metropolitan Transportaion Commission, Oakland, CA, 18 pp.



IV. ASSESSING ECONOMIC IMPACTS FROM VARIOUS DAMAGE PATTERNS IN FUTURE EARTHQUAKES

The previous section focused on the direct macroeconomic disruptions in the San Francisco Bay Area that resulted from the Loma Prieta quake. From a policy perspective, it suggests that the economy was minimally affected because of: (a) the location of the quake, and (b) minimal damage to the overall infrastructure of the region.

Developing a methodology to assess potential, as well as actual, impacts is an essential step to improve the way earthquakes are evaluated in terms of economic costs. This section focuses on an existing model used at ABAG to assist in evaluating the potential economic costs of earthquakes. Kawashima and Kanoh[11] used inter-industry analysis (Input-Output Analysis) to look at the indirect economic effects of an earthquake in Japan. Munroe and Ballard[12] also developed a methodology to assess the indirect economic effects of a natural

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[11] Kazuhiko Kawashima and Takashi Kanoh, 1990. "Evaluation of Indirect Economic Effects Caused by the 1983 Nihonkai-chubu, Japan,Earthquake" in ***Earthquake Spectra***, Vol.6, No.4, 1990, pp. 739-754.

[12] Tapan Munroe and Kenneth P. Ballard, November 1983. "Modeling the Economic Disruption of a Major Earthquake in the San Francisco Bay Area: Impact on California" in ***The Annals of Regional Science***, Vol.XVII, No.3, pp. 23-40.

disaster by use of a statistical modeling technique. The model used in the San Francisco Bay Area is structurally similar to that used by Kawashima and Kanoh since it is a regional Input-Output model.[13] The model is part of a larger forecasting system that integrates economics and demographics to forecast growth and change.[14]

A. Assessing Macroeconomic Impacts Based Upon Damage Scenarios

The system developed in the San Francisco Bay Area can be used to assess the macroeconomic impacts of an earthquake based upon various damage scenarios.

This process is possible because Input-Output models allow one to view an economy in terms of linkages between sectors. In addition, the model structure provides ease at assessing impacts. The usefulness of the system lies in providing better and more timely information to formulate policy on both preparing for and responding to crises.

It is useful to examine two possible damage scenarios to provide a better understanding of the impact of property damage on the region's economy. The scenarios use Input-Output analysis to illustrate that ***what is damaged*** is more important than ***how much is damaged.***

Scenario 1: *An earthquake concentrates damage in the Silicon Valley and in Southern Alameda county. The freeway network is heavily damaged and preliminary assessment indicates that 10 percent of the high-technology business activity has been affected. Because of the extent of damage, business activity will be disrupted for a period of six months. What is the economic impact of this disruption to overall economic activity in the Bay Area?*

In 1989, ABAG estimated that the output value of computers, electronics and instruments produced was $20.4 billion in the Bay Area. Almost 85 percent of the output was located in the southern portion of the Bay Area. The impact of this damage scenario was to reduce output for these sectors to $19.5 billion for the year. This is a $900 million impact, with a potential loss of 7,500 jobs in these sectors. What is the ***region-wide impact*** of this potential disruption? The model suggests that the region-wide impact will be about 12.6 percent higher than that of the individually affected industries, or $113.5 million more, with the loss of an additional 4,500 jobs. Most of this loss is concentrated, by rank of affect, in four Bay Area industries: wholesale trade; Finance,Insurance and Real Estate (FIRE); fabricated metals; and business and professional services. These combined industries accounted for

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[13] Raymond J. Brady and Chin Ming Yang, November 1988. ***1982 Input-Output Model and Economic Multipliers for the San Francisco Bay Region -- 1988 Update***: Association of Bay Area Governments, Oakland, CA, 49 pp.

[14] Raymond J. Brady and Chin Ming Yang, November 1983. "The Design and Implementation of a Regional Economic-Demographic Simulation Model" in ***The Annals of Regional Science***, Vol. XVII, No.3, pp. 1-22.

about 3,700 jobs lost due to the secondary impacts. There are two primary conclusions: a) any disruption to high-technology manufacturing would be more costly to the economy for this scenario than that which actually occurred in the Loma Prieta earthquake; and b) although a higher direct impact occurs for this scenario, the secondary economic impacts are concentrated in a select number of industries.

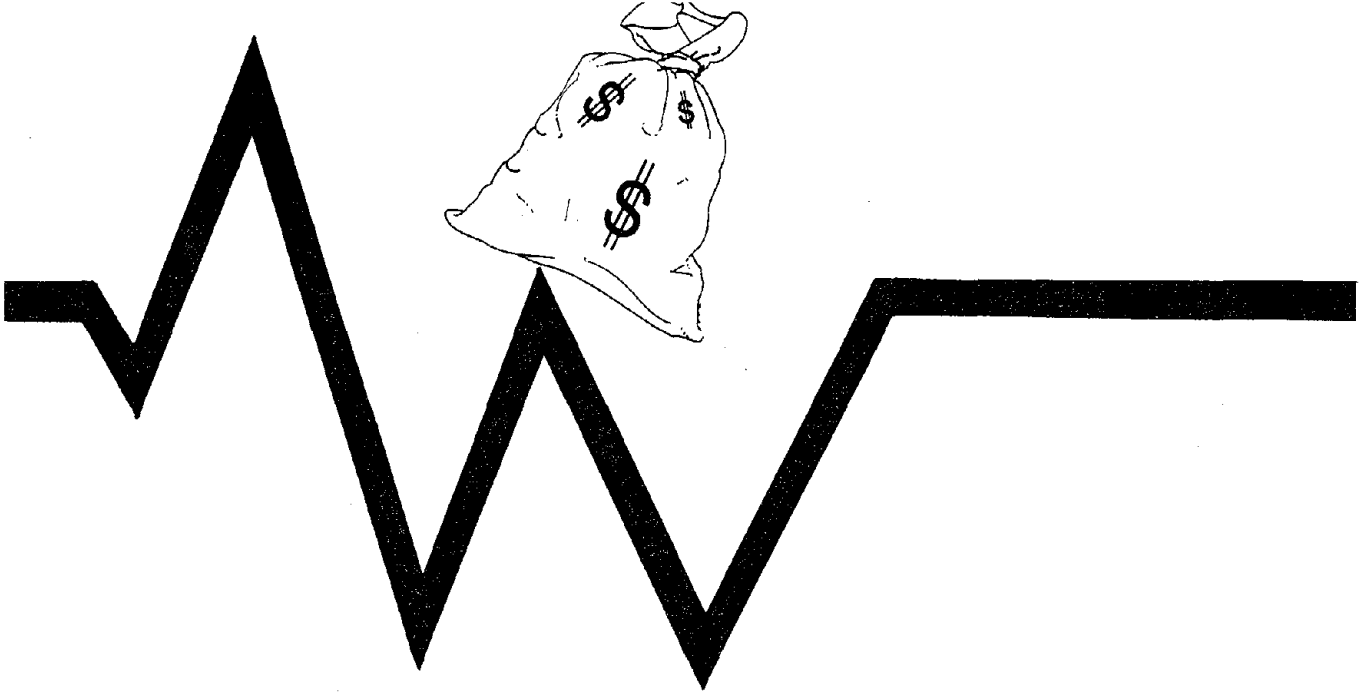
Scenario 2: The Bay and Golden Gate Bridges are substantially damaged for up to a period of six months. Initial economic analysis using the Bay Area Input-Output model suggests that this will affect the economic activity of Finance, Insurance and Real Estate (FIRE); business and professional services; and retail activity. Analysis suggests that the disruption will reduce the supply of services by FIRE by 5 percent, business services by 5 percent, and retail activity by 1 percent for up to six months. This reduction comes from having to shift office or retail operations, a fall-off in demand due to fear, and a general disruption of the productivity of these activities.

The basic analysis suggests that about $1 billion in output from the region's economy would be directly affected by the identified reductions noted above. However, the secondary impacts on the Bay Area economy are far more substantial than for the previous scenario.

In ***Scenario 1***, overall regional output falls by about 0.4 percent as a result of the disruption of the identified industries. Under ***Scenario 2***, regional output falls by 1.1 percent, which is more than double the disruption associated with ***Scenario 1.*** In particular, disruption of business services and FIRE substantially affects computer output which fall by 5 percent, electronics which has a decline in output of about 4 percent, and instruments which also declines in output by about 4 percent. The primary reason for the impact on manufacturing is that financial and business services contains both capital and labor resources that feed into these sectors. Any disruption in the flow of these services affects economic activity.

B. What Can Be Applied to Earthquake Impact Analysis?

The above simple analysis helps identify those sectors which could disrupt overall economic activity, if affected by an earthquake. This approach allows one to develop profiles on earthquake impact on economic activity. These profiles, in turn, could enter into policy discussion on several types of issues. First, decisions about allocating financial and labor resources among repairing, maintaining or strengthening highway networks and infrastructure. Information provided by this process can assist in answering questions such as, "How can the choke points in the highway network be minimized in those locations that have sensitive industries?" Second, the process can help in identifying where to allocate scarce resources after initial damage information assesses the potential industries affected by an earthquake. Any allocation process should focus on getting the economy back on its feet as soon as possible. Such a process requires information about which industries can most disrupt the overall system.



V. CONCLUSIONS

The overall macroeconomic damage to the Bay Area's economy as a result of the Loma Prieta earthquake was minimal.

One reason for this minimal disruption appears to rest in the fact that the highway and rail network was not substantially damaged. If both the BART system and highway network were damaged, it is likely that the economic disruption would have been substantial. Maintaining the Bay Area's infrastructure as a functional system should be top priority before and after an earthquake.

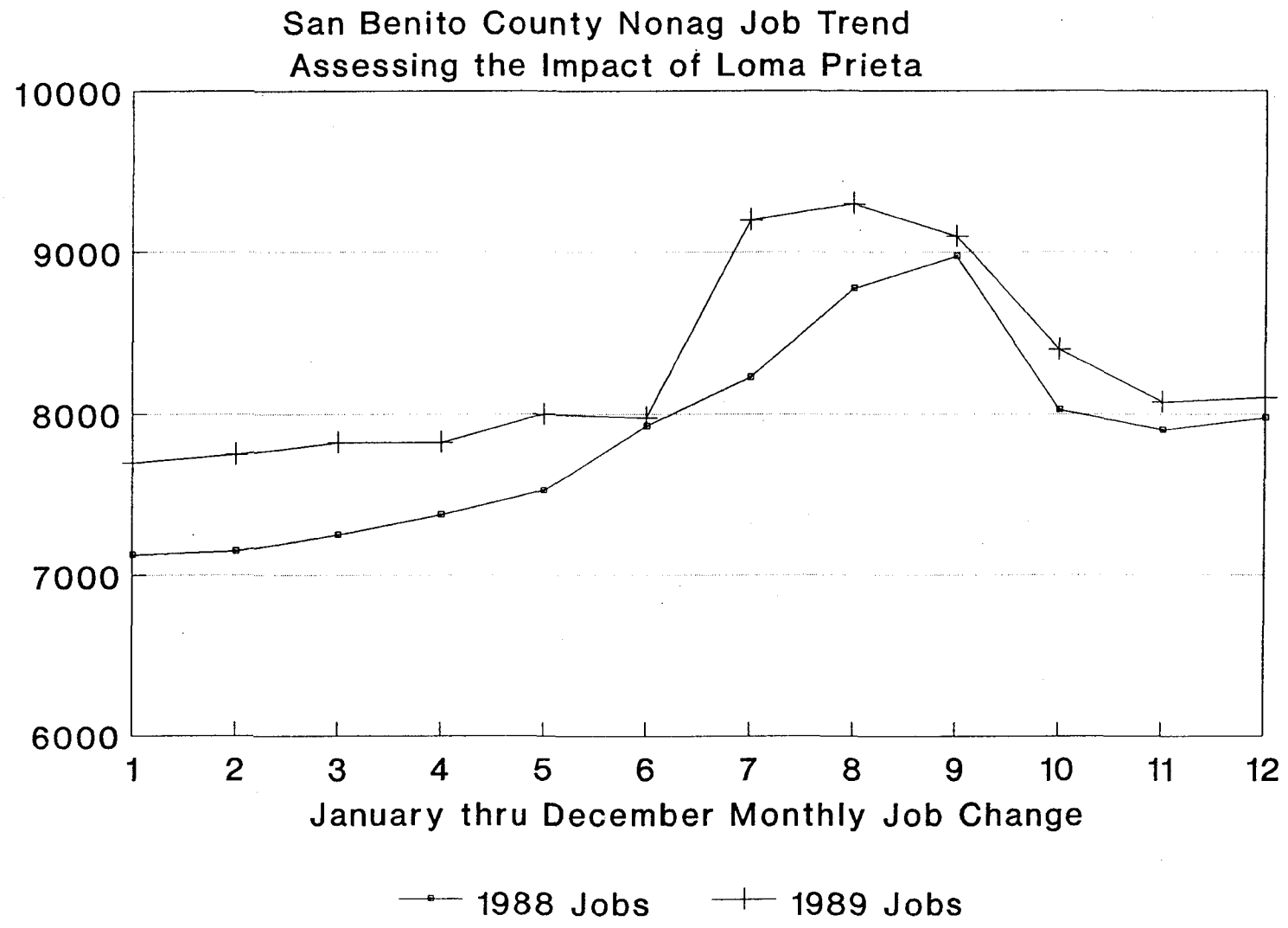
Building property damage is not a good indicator of economic disruption. One factor minimizing the impact of property damage losses on the economy of Santa Cruz County may have been the availability of relief funds for temporary tents to house those businesses displaced in the downtown area. Businesses in downtown Santa Cruz also were able to relocate to other areas of Santa Cruz County. Another factor may have been the strong economic base of Santa Cruz as the site of an expanding University of California campus, and as a southern extension of Santa Clara County's "Silicon Valley."

Input-Output analysis is a simple system to identify and evaluate those industries that might substantially affect the macroeconomy of the Bay Area. It will help in doing both preparatory work in this area, as well as in assessing the dislocation impacts after an earthquake occurs.

APPENDIX A

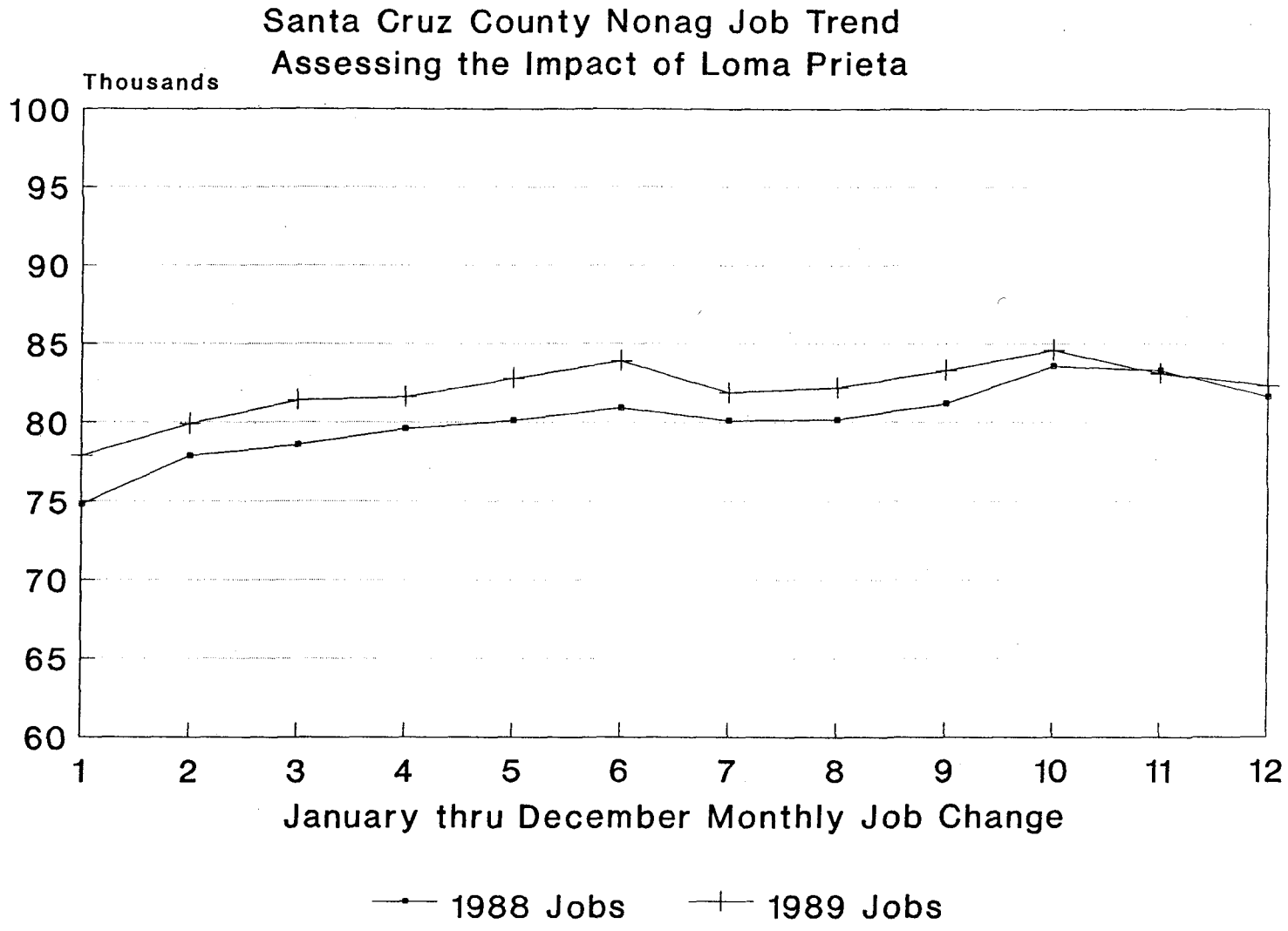
ANALYSIS OF EMPLOYMENT TRENDS

Figure 1A



Source: ABAG; California EDD

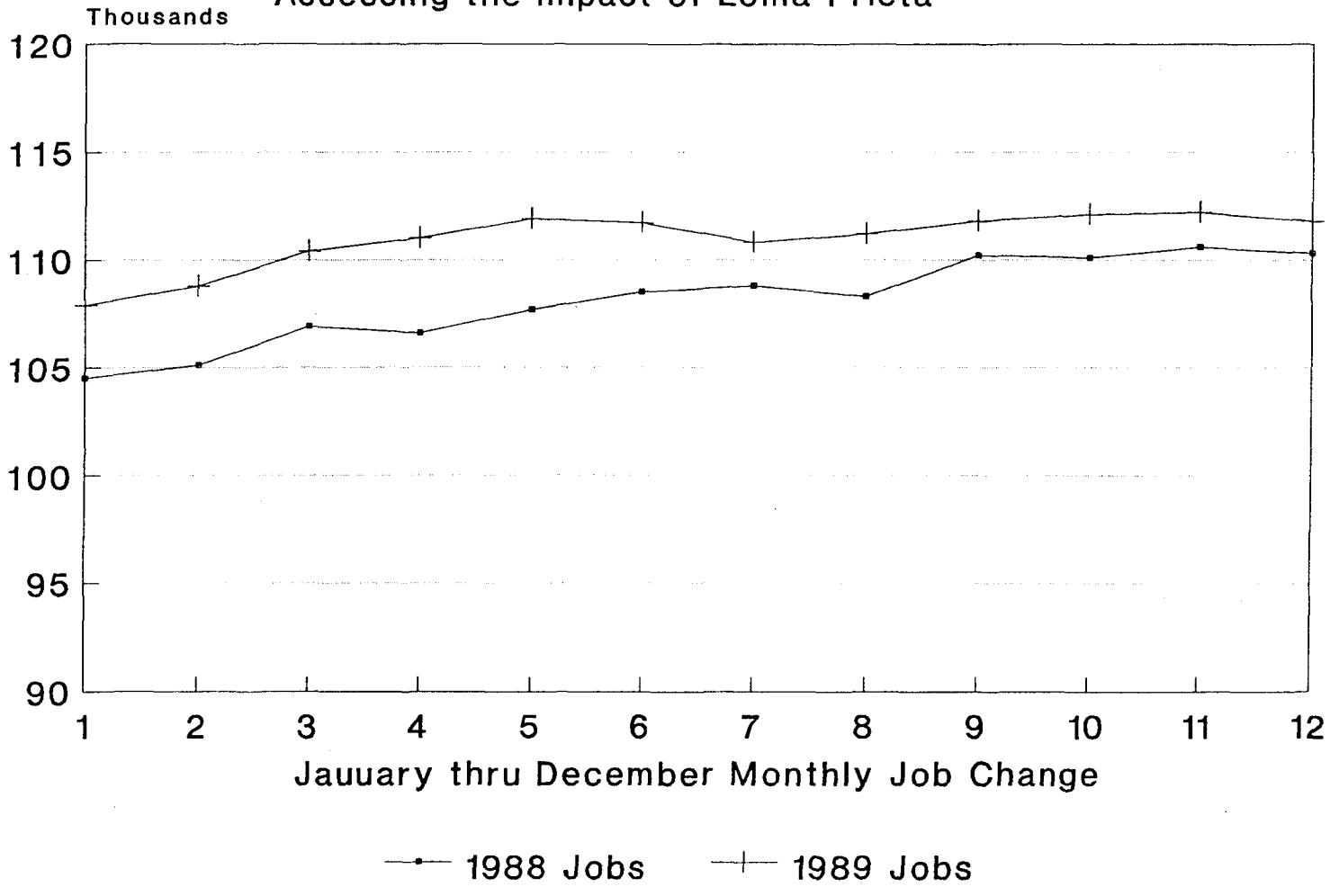
Figure 2A



Source: ABAG; California EDD

Figure 3A

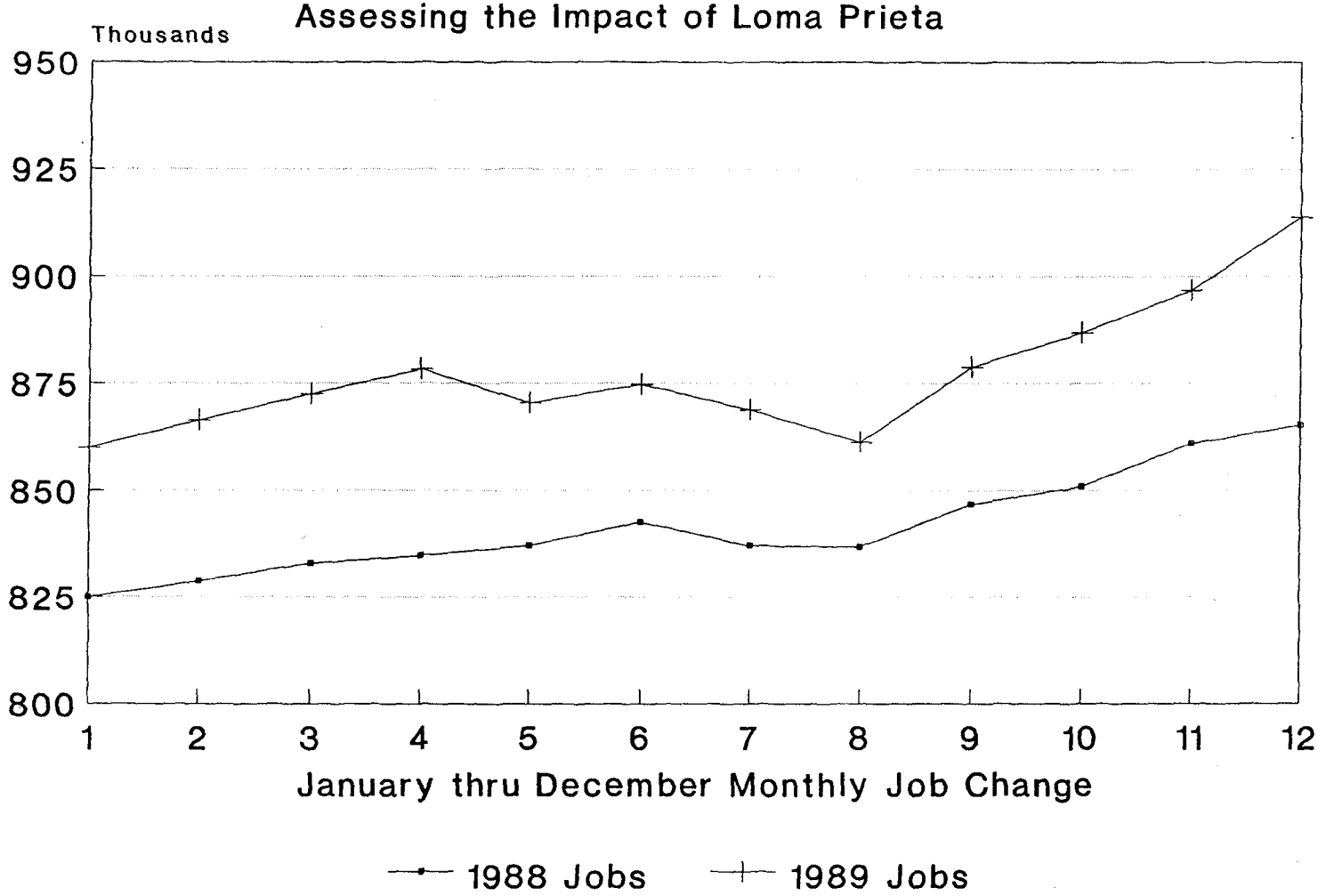
Monterey County Nonag Job Trend
Assessing the Impact of Loma Prieta



Source: ABAG; California EDD

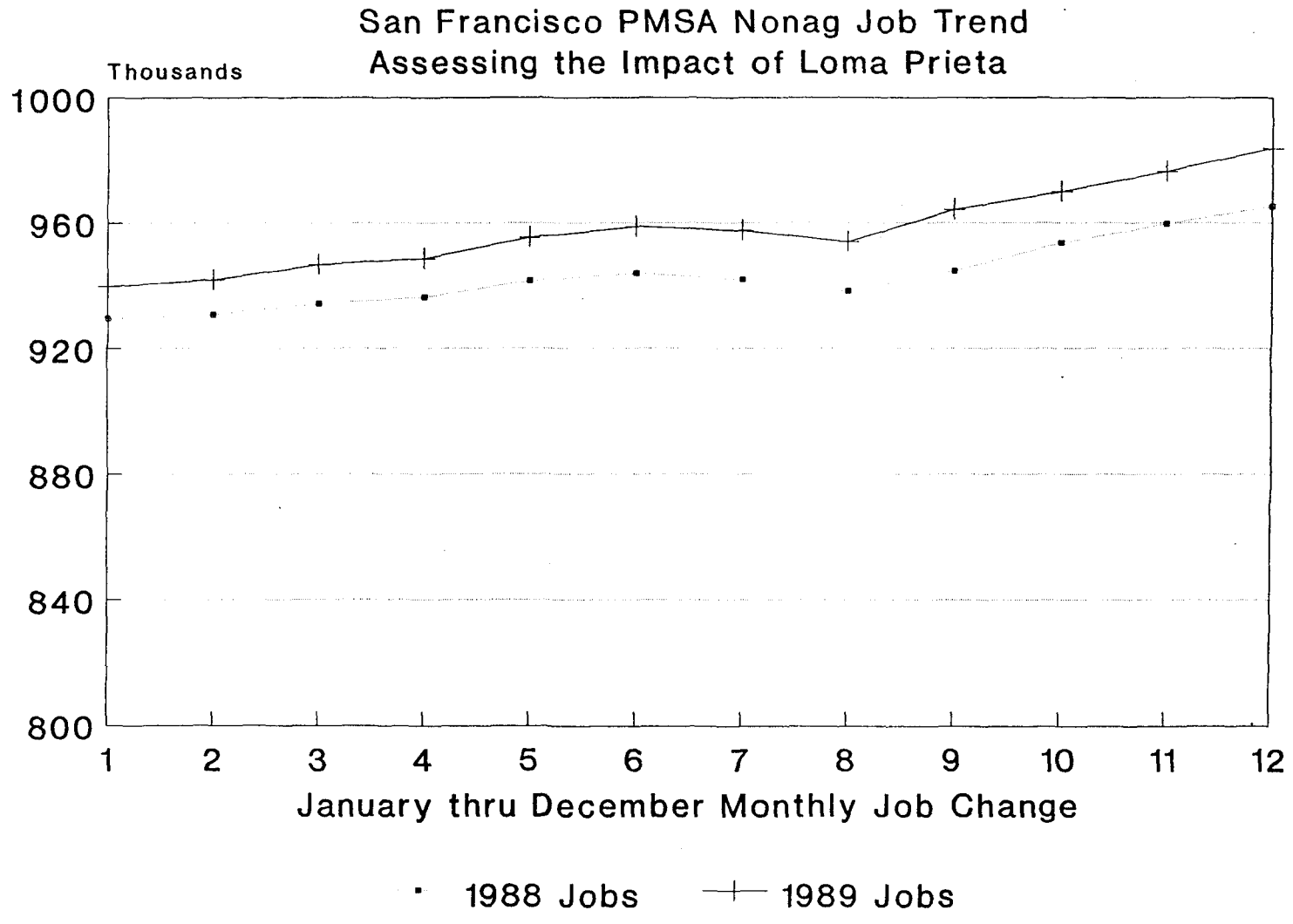
Figure 4A

Oakland PMSA Nonag Job Trend
Assessing the Impact of Loma Prieta



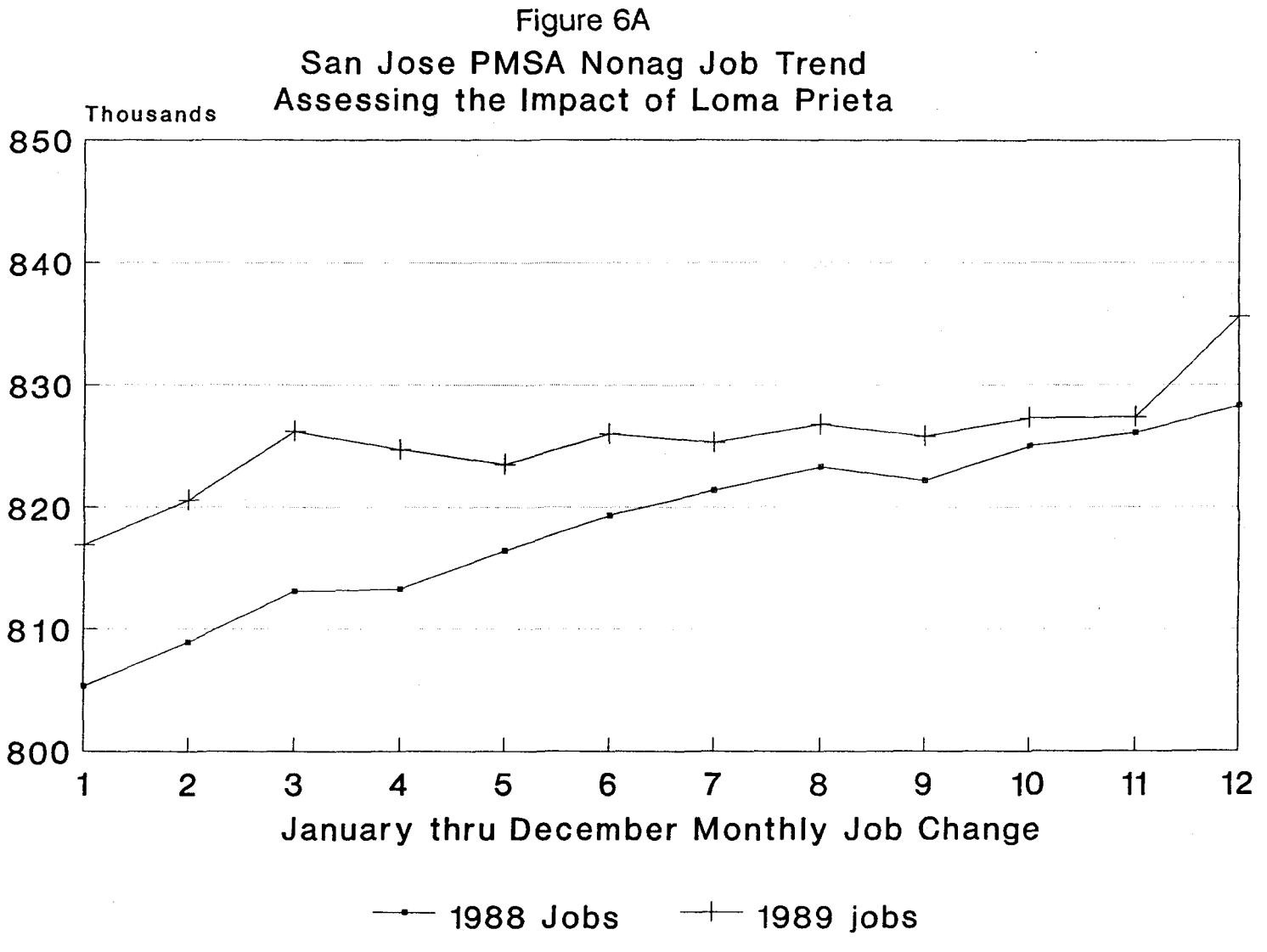
Source: ABAG; California EDD

Figure 5A



Source: ABAG; California EDD

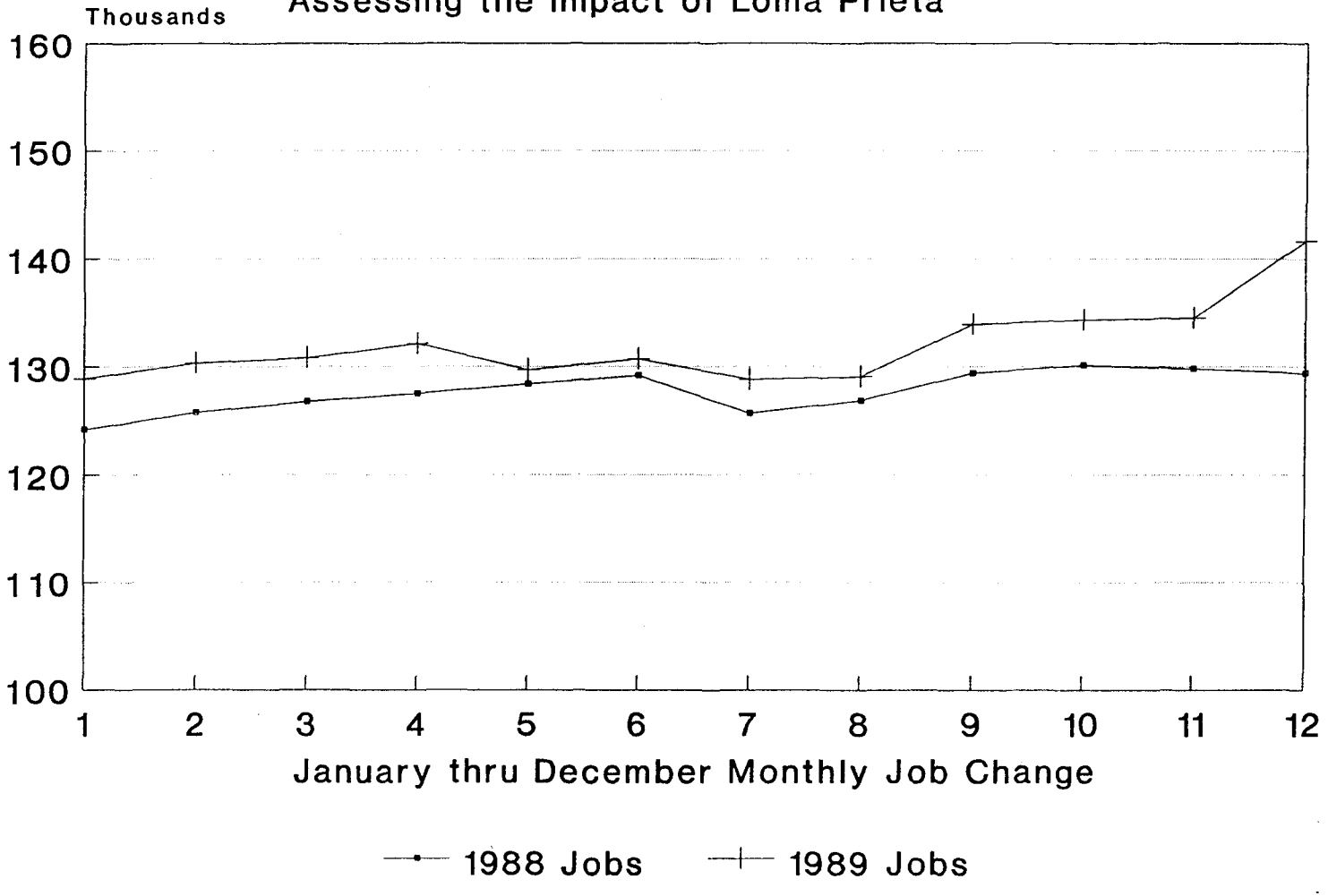
Figure 6A



Source: ABAG; California EDD

Figure 7A

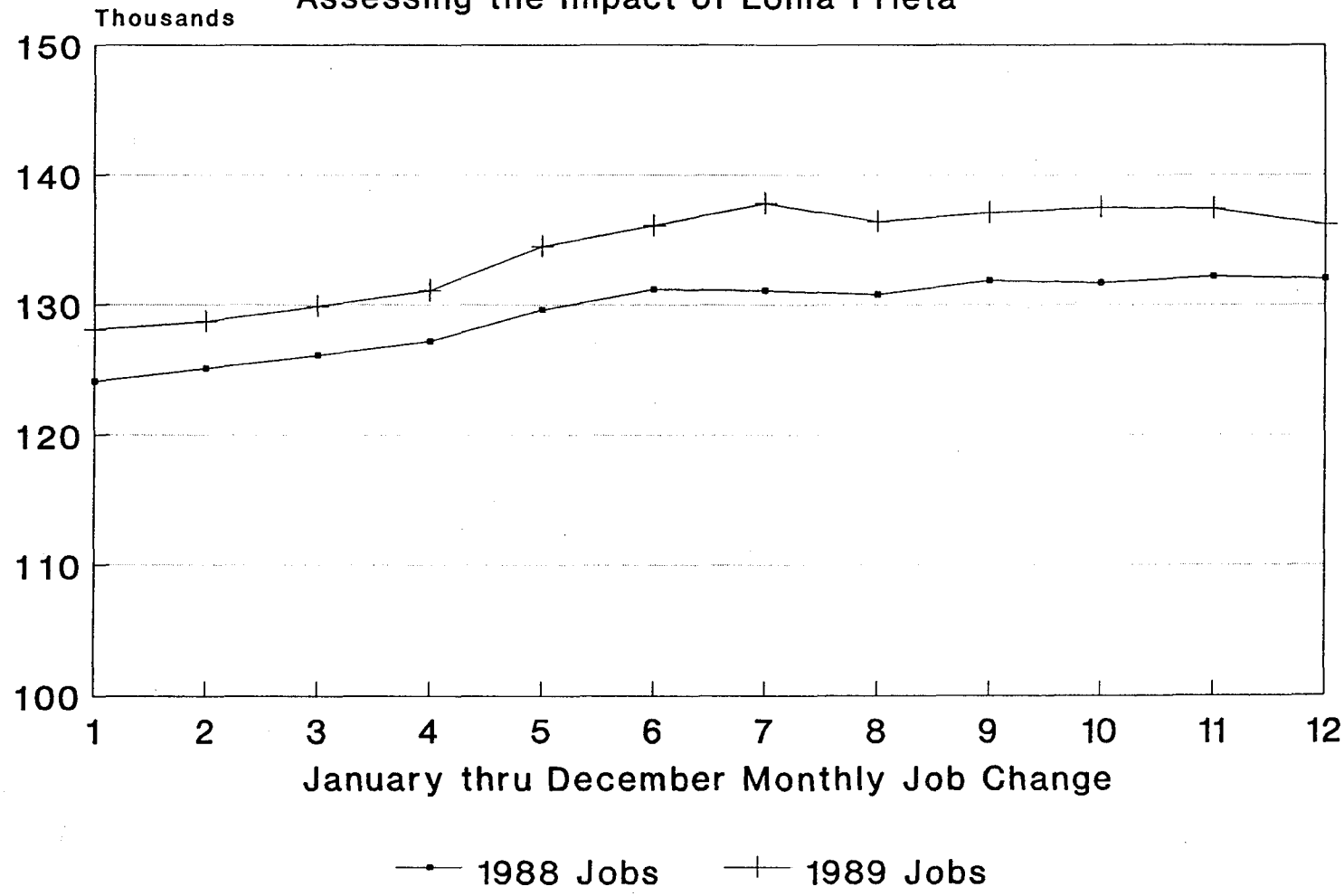
Santa Rosa-Petaluma PMSA Nonag Job Trend
Assessing the Impact of Loma Prieta



Source: ABAG; California EDD

Figure 8A

Vallejo-Fairfield-Napa PMSA Nonag Job Trend
Assessing the Impact of Loma Prieta



Source: ABAG; California EDD

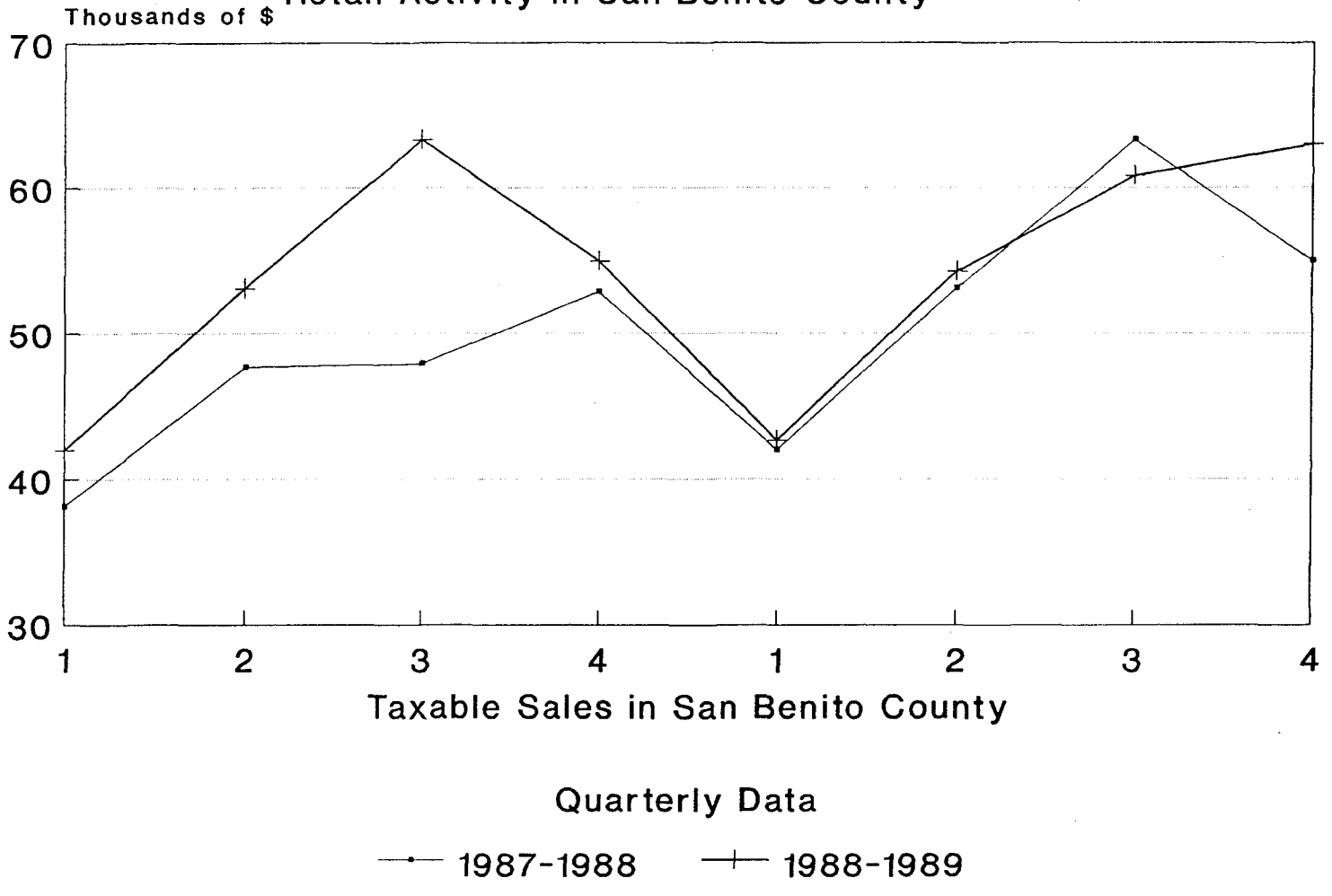
APPENDIX B

ANALYSIS OF RETAIL TREND ACTIVITY

Figure 1B

The Loma Prieta Quake: Economic Analysis

Retail Activity in San Benito County

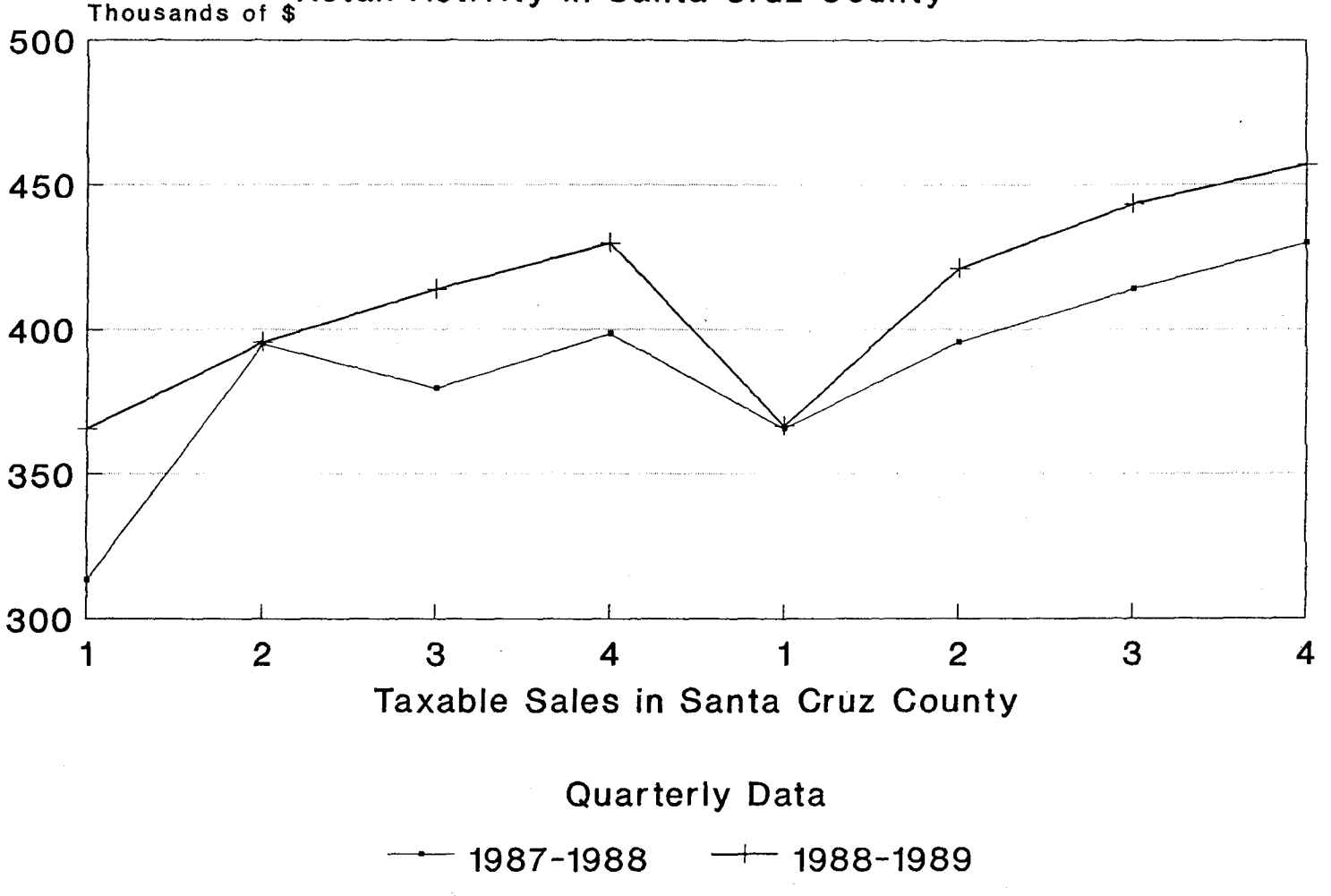


Source: ABAG; Ca. Board of Equalization

Figure 2B

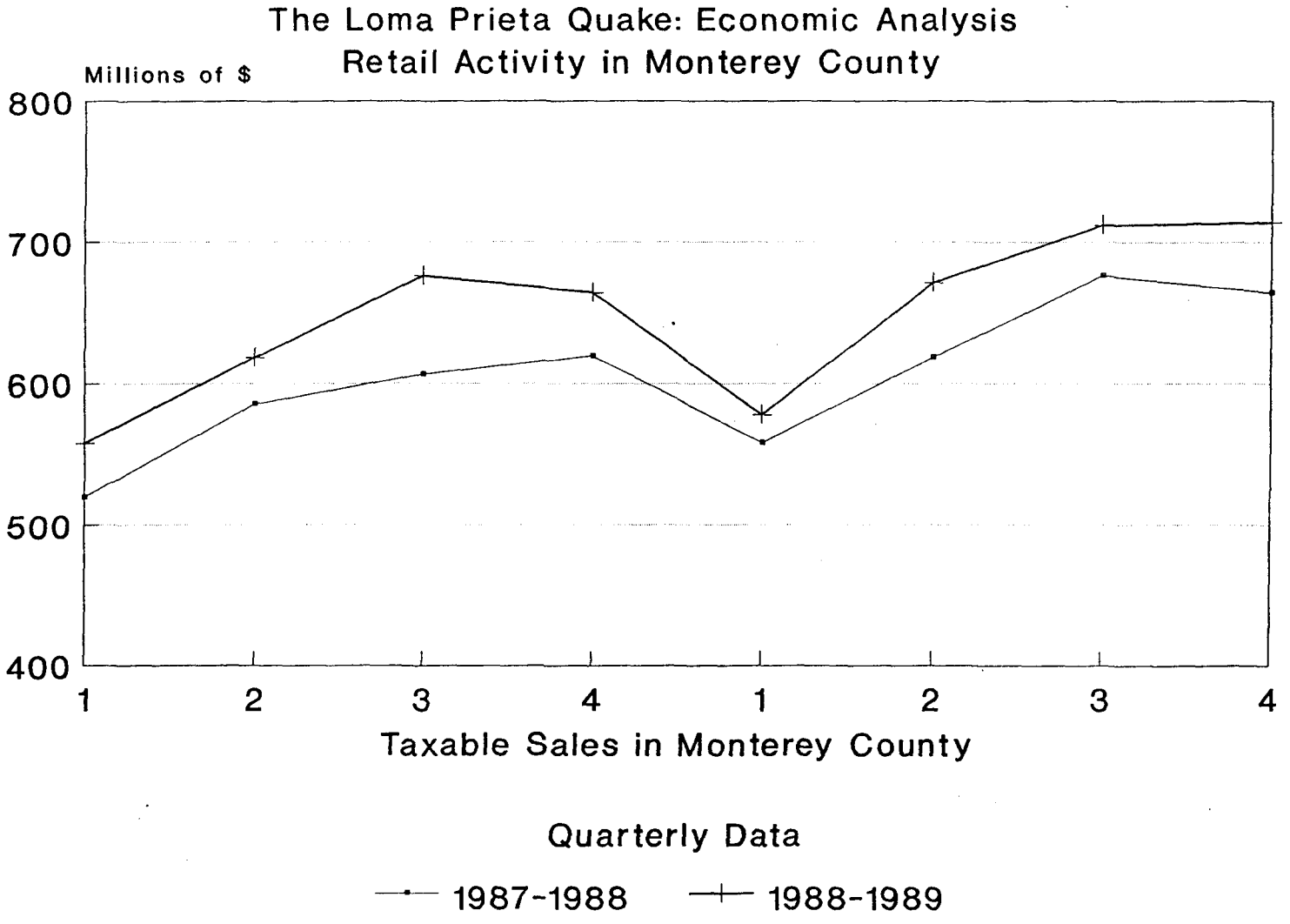
The Loma Prieta Quake: Economic Analysis

Retail Activity in Santa Cruz County



Source: ABAG; Ca. Board of Equalization

Figure 3B

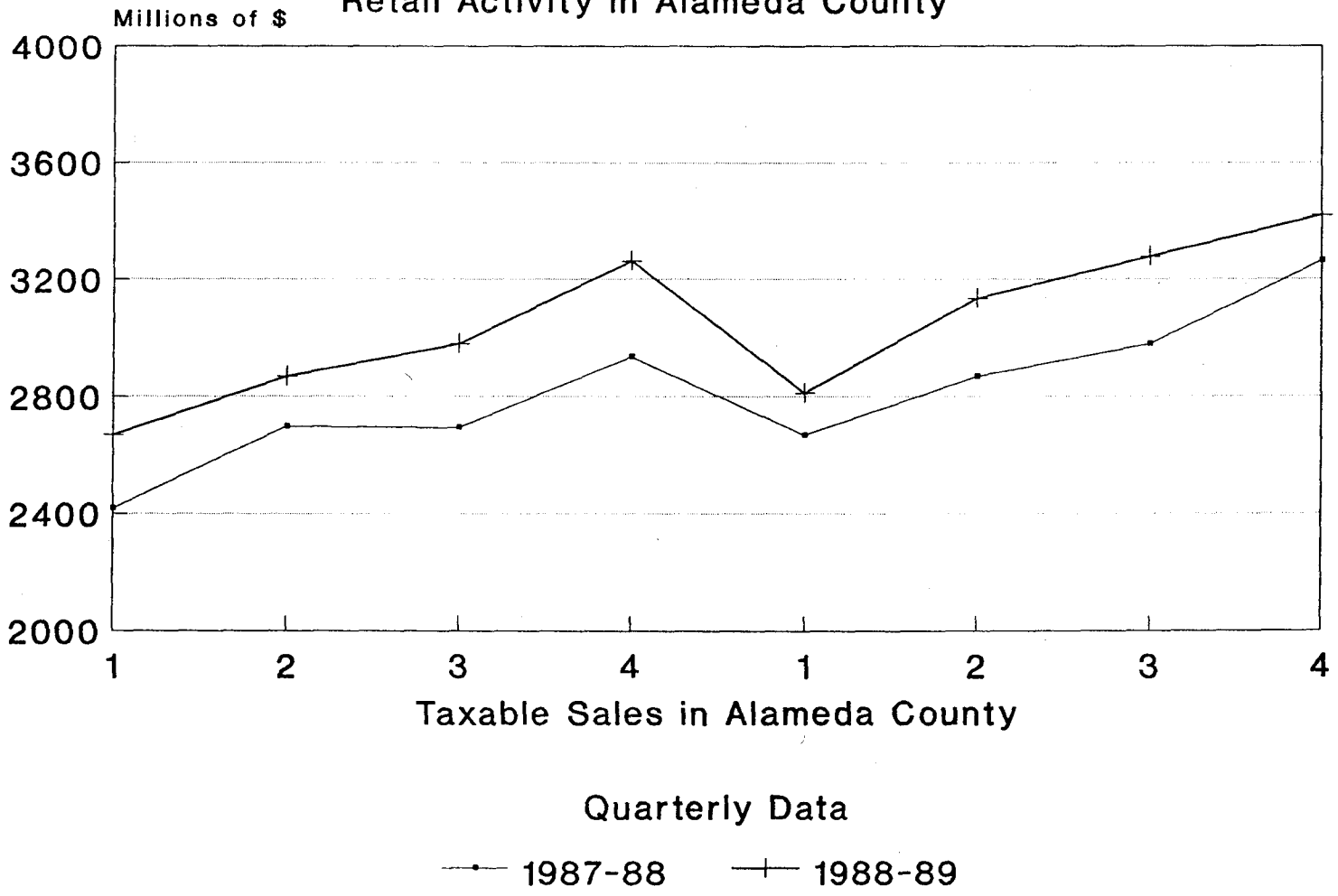


Source: ABAG; Ca. Board of Equalization

Figure 4B

The Loma Prieta Quake: Economic Analysis

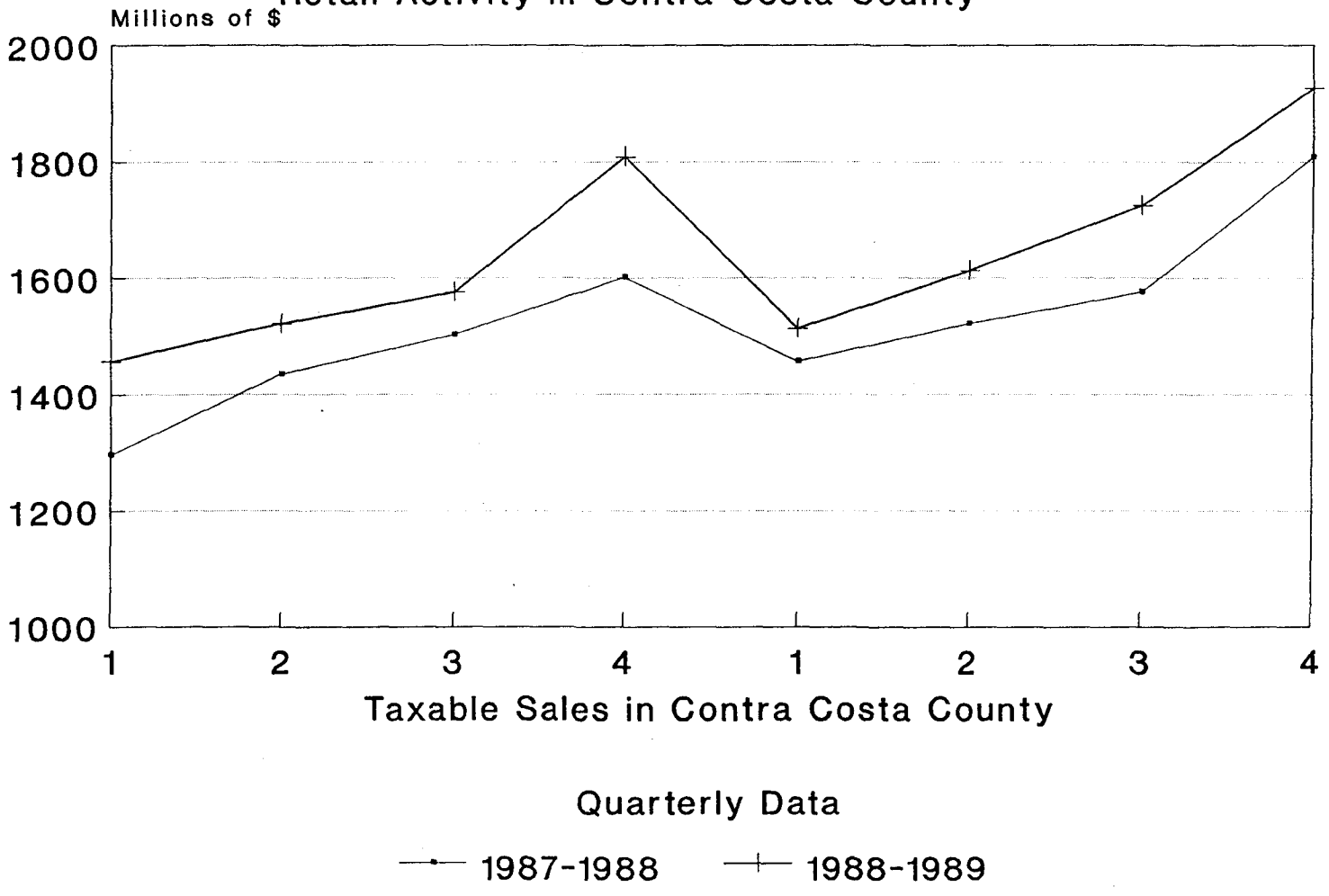
Retail Activity in Alameda County



Source: ABAG; Ca. Board of Equalization

Figure 5B

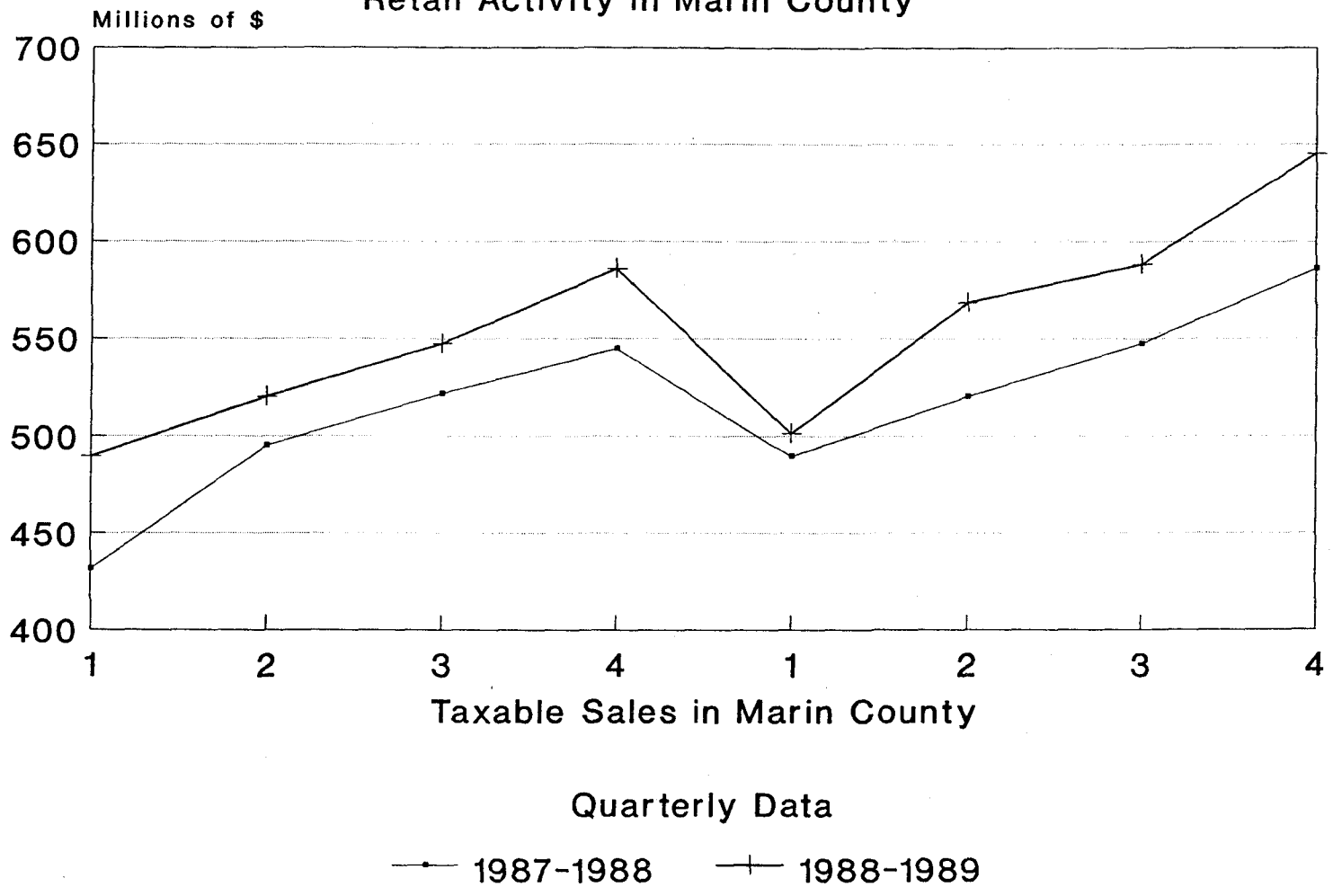
The Loma Prieta Quake: Economic Analysis
Retail Activity in Contra Costa County



Source: ABAG; Ca. Board of Equalization

Figure 6B

The Loma Prieta Quake: Economic Analysis
Retail Activity in Marin County

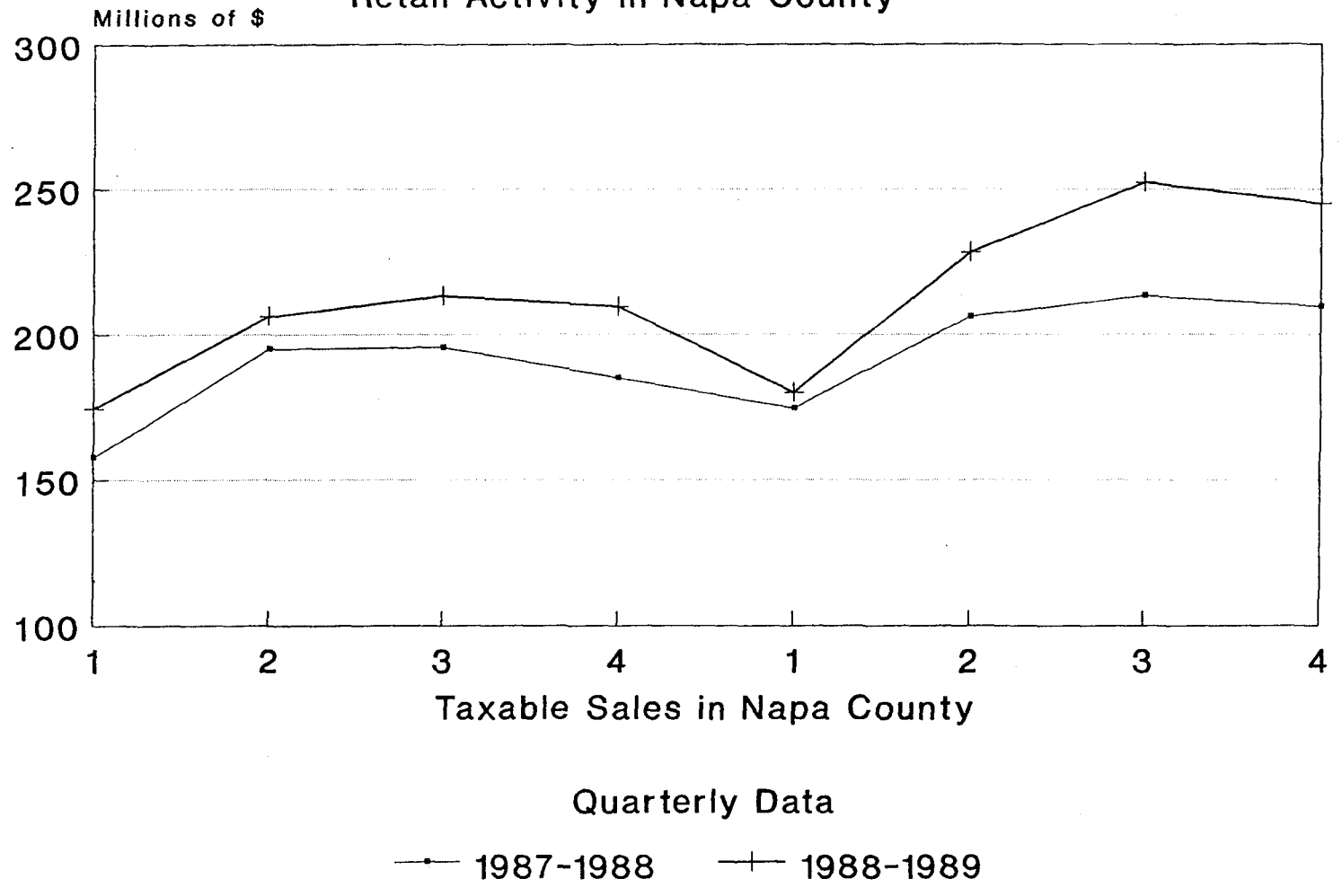


Source: ABAG; Ca. Board of Equalization

Figure 7B

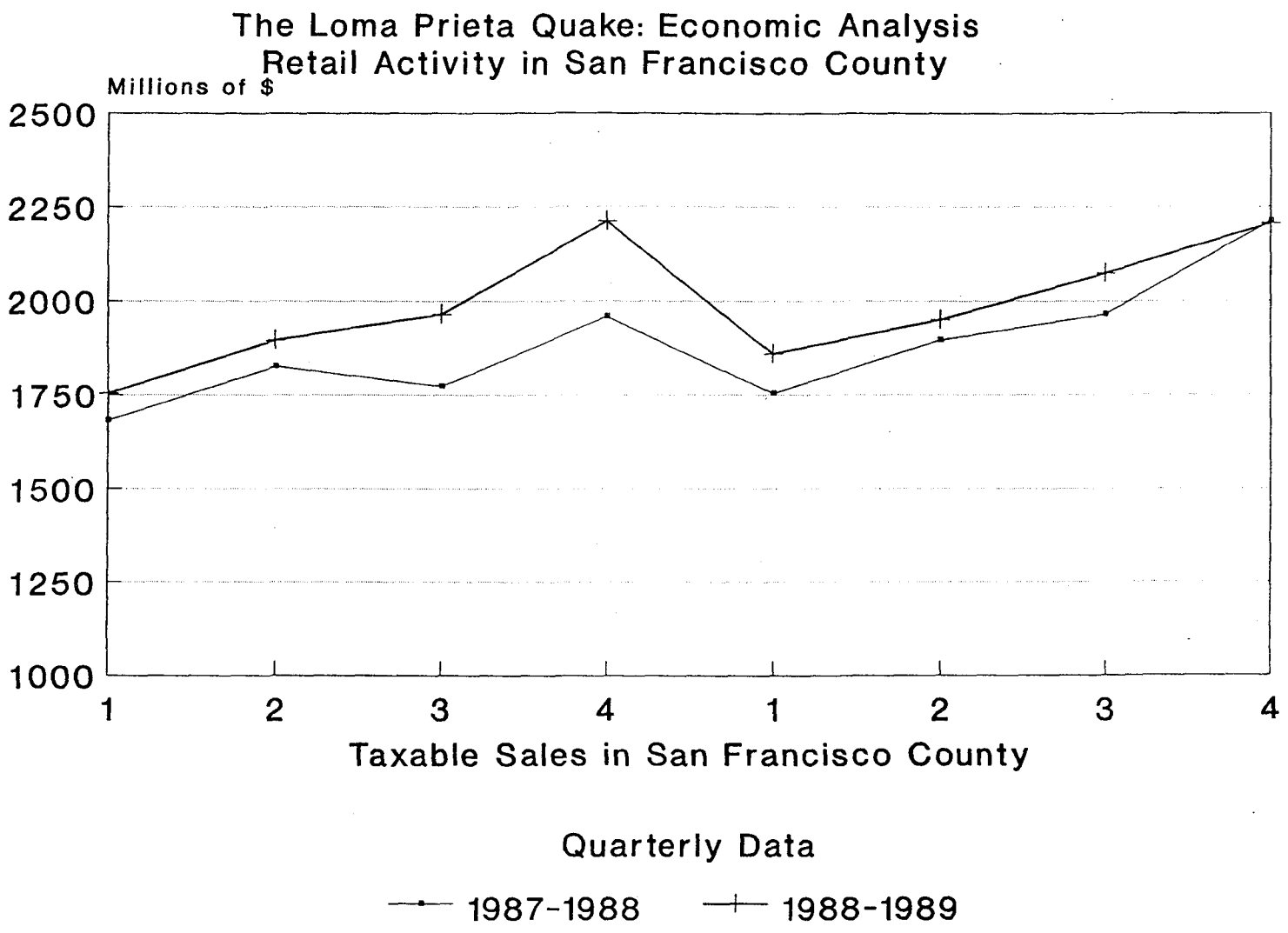
The Loma Prieta Quake: Economic Analysis

Retail Activity in Napa County



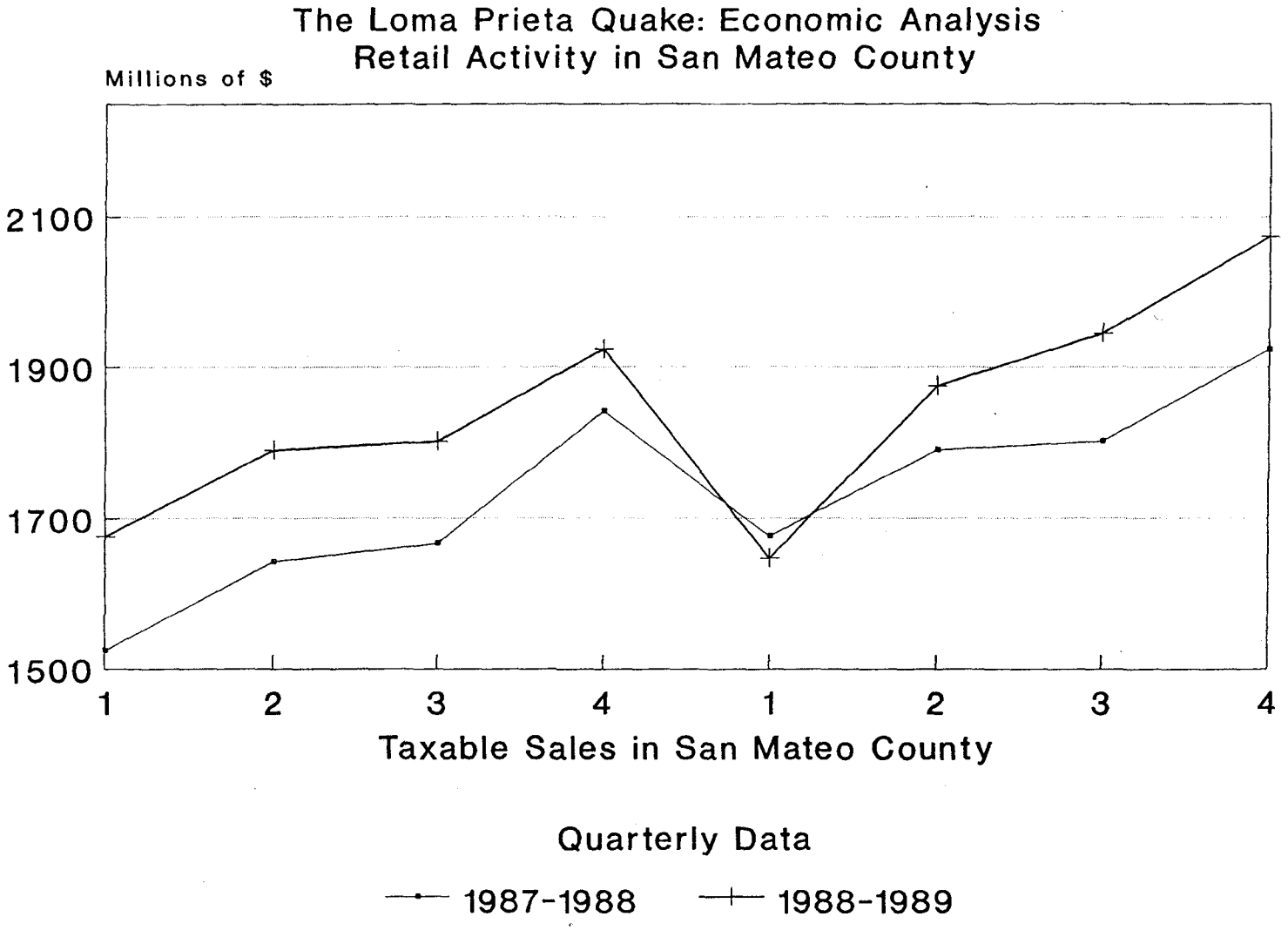
Source: ABAG; Ca. Board of Equalization

Figure 8B



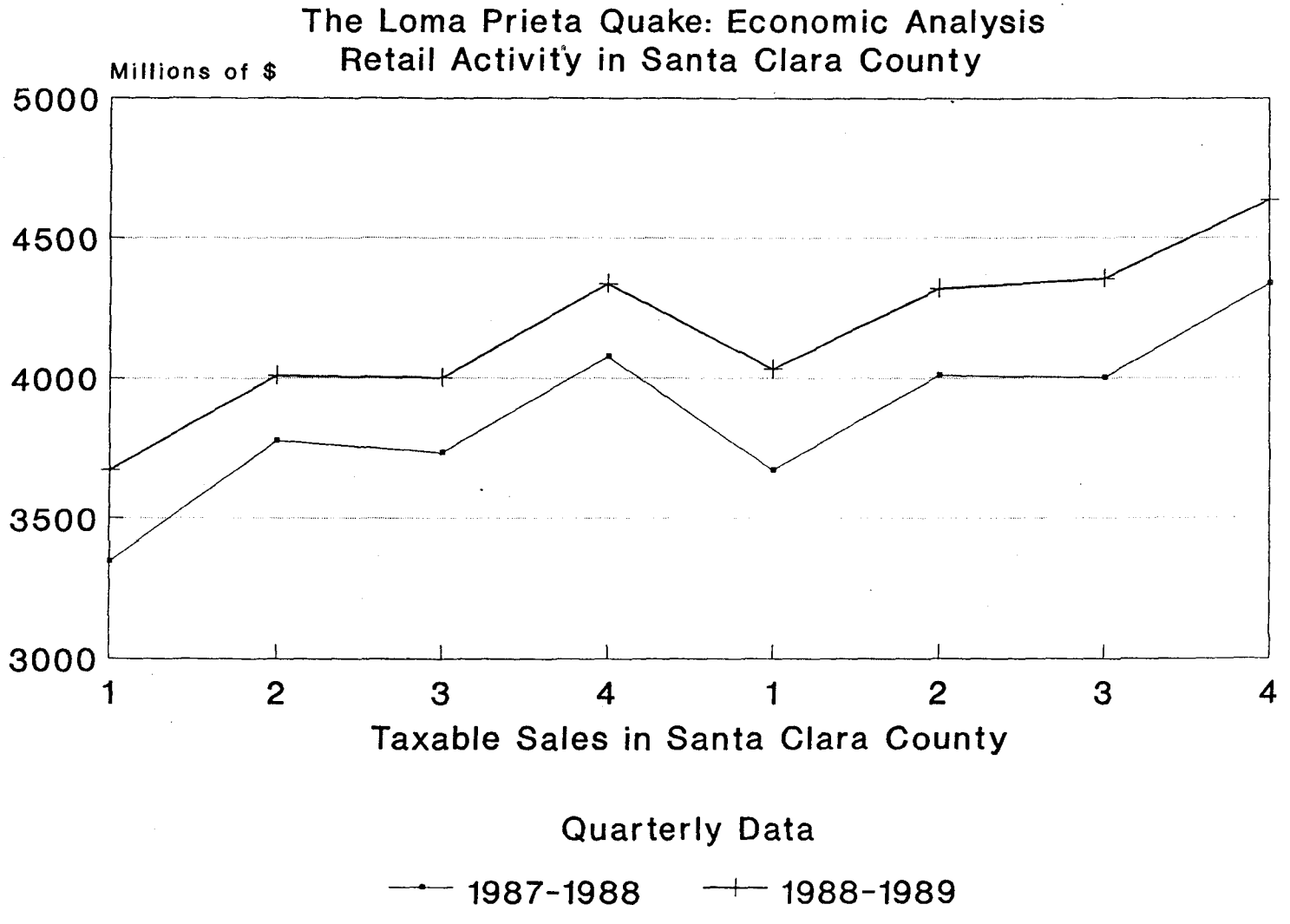
Source: ABAG; Ca. Board of Equalization

Figure 9B



Source: ABAG; Ca. Board of Equalization

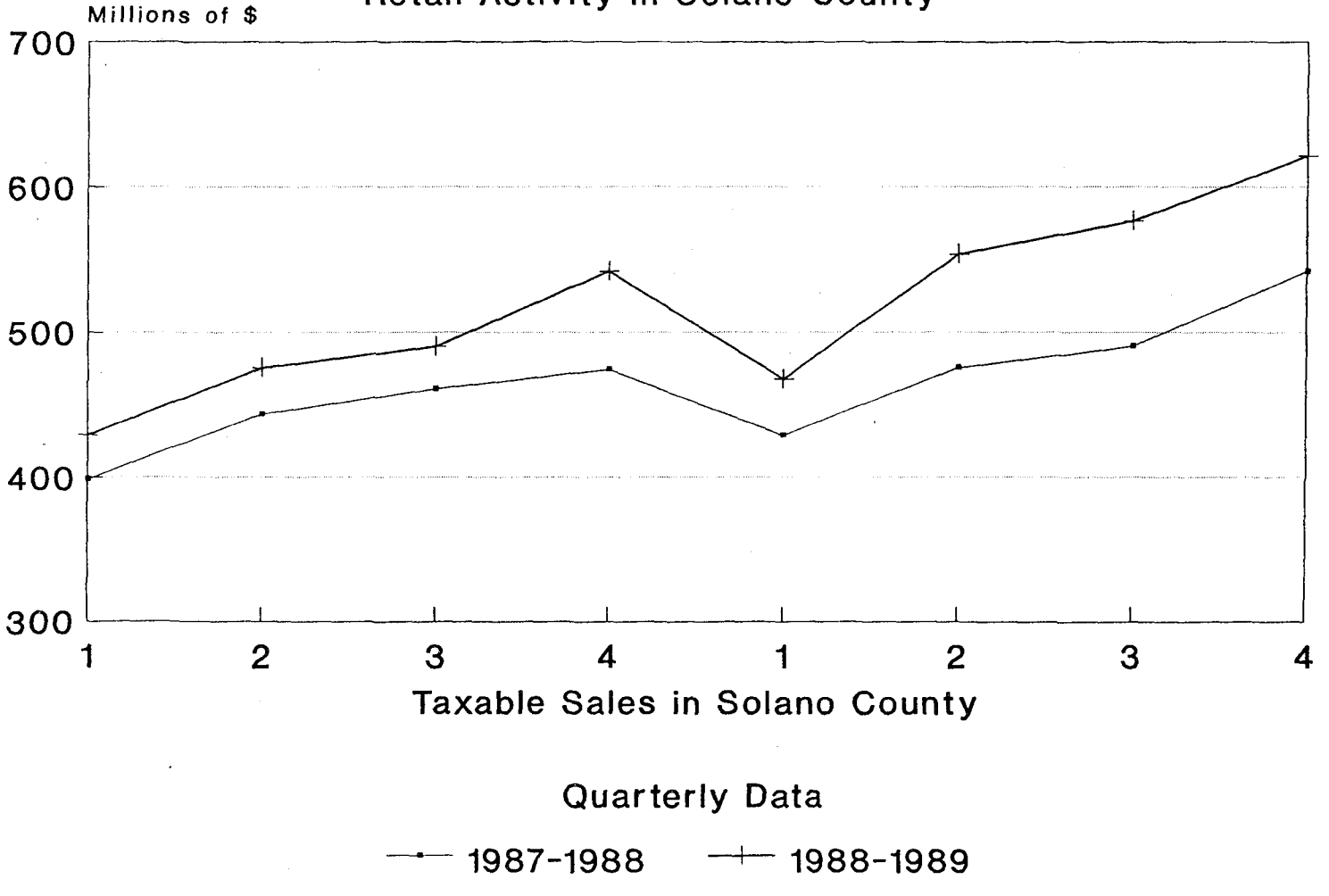
Figure 10B



Source: ABAG; Ca. Board of Equalization

Figure 11B

The Loma Prieta Quake: Economic Analysis
Retail Activity in Solano County

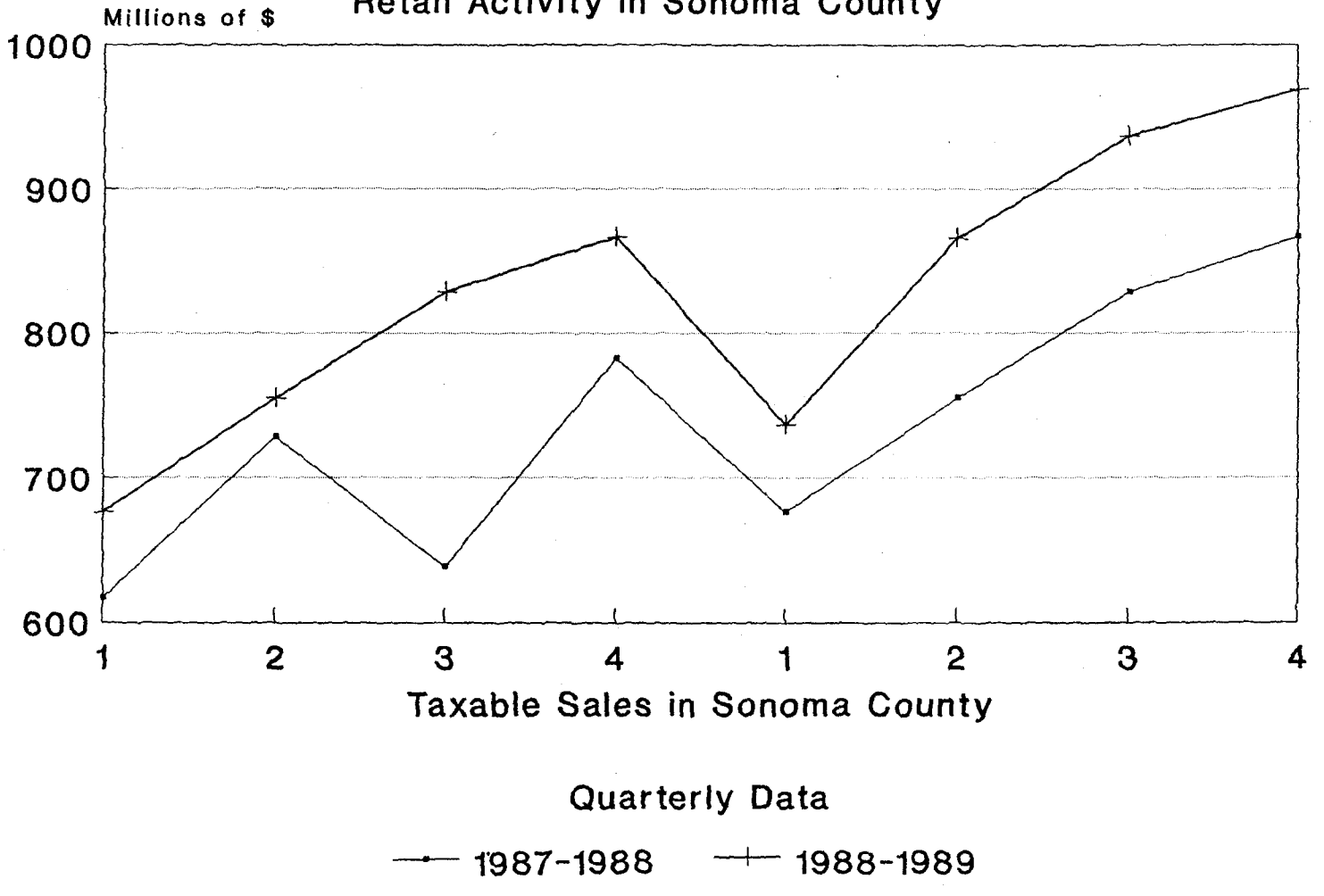


Source: ABAG; Ca. Board of Equalization

Figure 12B

The Loma Prieta Quake: Economic Analysis

Retail Activity in Sonoma County



Source: ABAG; Ca. Board of Equalization