THE BAY AREA JOBS-HOUSING MISMATCH

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EXECUTIVE SUMMARY

The Bay Area faces an ever worsening disconnect between the locations of jobs, and housing that is compatible in price to the wages that those jobs pay. Unless more attention is given to this problem, commute times will continue to increase, pollution will increase, employee productivity will be lost, and the overall quality of life in the Bay Area will decline. This is what we are calling **the problem of the jobs-housing match.** Cities and employers must be impressed as to the importance of this problem, and encouraged to discuss possible ways to alleviate the situation.

This pilot study examines the City of Dublin, one of the fastest growing cities in the Bay Area. Dublin expects to see thousands of jobs move to the area in the next several years. However, very little thought has been given to the types of housing that will be demanded by all these new employees. In fact, many of these employers expect that the vast majority of their new employees will commute from areas where housing is less expensive.

State law recognizes the regional nature of the housing market, and requires every city and county to plan for its fair share of the region's housing needs (655883(a)(1)). As ABAG notes in its "Blueprint for Bay Area Housing," only by identifying and measuring local housing needs can a community design its housing programs appropriately. Communities must take into consideration:

- Future population and employment growth;
- Affordability;
- Existing shortages;
- Replacement of housing which has been, or might be, eliminated;
- Deterioration; and
- Homes for those with special housing needs

In this study we examine only future population and employment growth, and affordability. The mathematical model in this study utilized employee salary data, gathered from three employers that will hire over 4,300 employees for their Dublin offices within the next year. We categorized these salaries into different income brackets and then sorted incomes into households according to factors observed in Census data. These household incomes were then classified according to the type of housing that they will need. This housing match was done solely based on the "amount" of house that could be afforded by a household with this salary.

Our findings demonstrate that over 85% of the incomes for these newly created jobs will be above $60,000, and almost 50% of the jobs created will pay over $100,000 annually. This means that the majority of these employees will require larger-than-average houses, and Dublin must alter its housing plans to accommodate these new employees. However, in this model no job multiplier has been considered, so these results are not an accurate estimate of housing demand. Matching jobs to housing will very likely require Dublin to plan for more low-income housing than this model would indicate.

BACKGROUND TO THE PROBLEM

The Bay Area's Jobs-Housing Situation

The Bay Area faces a severe housing shortage that has created a "jobs-housing mismatch." In the last decade of economic expansion, thousands of jobs were created, attracting new residents to the Bay Area. Many of these recent arrivals to the region, flush with cash from their high-paying jobs, wanted new houses. However, few housing units of any sort were available, so new houses were built on the outskirts of the Bay Area. All this has led to a Bay Area housing market in which there is little relationship between the location of a person's home, and that person's job. The average Bay Area resident spends an ever-increasing amount of time commuting to work every day. And the overall result is a metropolitan area that is continuously growing—gobbling up what used to be beautiful open space, green hills and farmland—and creating gridlock of the sort that used to be found only in Los Angeles.

Businesses, too, are suffering from the housing shortage. It is difficult to find workers to fill lower-paying jobs, because these workers cannot afford to live near their job, nor can they afford to spend a large portion of their day commuting. As a result, businesses are beginning to locate new offices in the outer suburbs, with the plan of attracting workers from outside the Bay Area. Companies that are locating their new offices in Dublin fully expect to attract workers from places where housing is cheaper, such as Stockton and Tracy. As a consequence these workers too will be commuting long distances, adding to the pollution and congestion.

While there is much talk about the need for more housing, few people are concentrating on the fact that **houses need to be built close to jobs**. This is what we are calling the "jobs-housing match." Without a match between jobs and housing that is compatible in price to the wages paid by these jobs, traffic will worsen, worker productivity will decrease, pollution will increase, more open-space will be lost, and the overall quality of life will decrease. This will overall have the effect of limiting the Bay Area's economic growth.

Case Study: Dublin, California

The City of Dublin was selected for this case study because of the phenomenal growth the City is experiencing. With a 12.8% population growth for the period of January 1999 to January 2000, the City of Dublin was the fastest growing city in Alameda County, and the fourth-fastest growing city in California. Dublin is located 35 miles east of San Francisco, and has a population of over 32,000. The City has its own BART station, and is part of the Tri-Valley region, which also includes the cities of Pleasanton, San Ramon and Livermore. Currently, major employers in Dublin include:

Pacific Bell – Advanced Solution	600+employees	Internet Services
MicroDental Laboratories	550 employees	Lab Processing
E-Loan, Inc.	395 employees	Financial Services

The number of jobs in the City of Dublin is expected to grow enormously in the next several years, with many companies opening new offices and bringing thousands of jobs to Dublin. Three of the many companies that plan to locate offices in Dublin are:

Sybase Corporation	1,000 employees	Computer Software
EMC Corporation	200 employees	Info Storage Devices
Simpson Manufacturing	100+employees	Construction Materials

Furthermore, these commercial and industrial employers that are moving to Dublin in turn attract other new businesses to serve and support employees of the commercial and industrial employers. These retail and service companies are often referred to as **support jobs** or non-basic employment. Currently, some of Dublin's major non-basic employers are:

Meryvn's	150 employees	General Merchandise
Regal Cinemas	150 employees	Theater
Target	150 employees	General Merchandise

All of these preliminary figures taken together indicate that Dublin will soon be experiencing a severe housing shortage if action is not taken to build housing for new employees. The question that we attempt to answer in this study is **what types of housing must be built in Dublin to accommodate these new employees?**

DATA COLLECTION

Letters were sent to the CEOs of 11 employers that had indicated that they planned to move to Dublin in the next year. These letters asked employers to provide us with data on the number and types of employees that they intended to hire, as well as the salaries of these employees. However, of these 11 employers, only three responded to our queries. Moreover, this data was obtained through informal contact, and not as a result of the letters that had been sent. Even these three employers did not provide us with all the information that we had requested.

The three employers that did provide us with information—two technology firms and one financial service provider—furnished us with information on employee titles and their respective salaries, which resulted in a total of 4,340 records (see Appendix A). This sample accounts for roughly 20% of the total new jobs that are planned for the area. Because these companies are representative of the types of employers who plan to move to the Dublin area, we feel that these salaries represent accurately the incomes of those employees who will be working in Dublin.

THE MATHEMATICAL MODEL

Assumptions

In order to determine the number of housing units that must be created for all the new employees in Dublin, we examined data from several employers who had committed to locating in Dublin. In order to generate results from this data, it was necessary for us to make several assumptions. Where possible, assumptions have been made on a "scenario" basis, so that the results would show the effects of different assumptions. This allows the city to judge which scenario, and thus, which set of results is the most appropriate. The assumptions were as follows:

1. That every person who takes a job in Dublin must be housed in Dublin.
2. That every new job created will be given to a new resident of Dublin—no current residents of Dublin will take one of these new jobs.
3. That these persons will purchase housing according to their household incomes.

Three Stages

The model used to generate these results follows three estimation stages:

Stage 1:

Gathering data on the raw numbers of new jobs to be added in Dublin. This data was obtained from three employers who had committed to opening new offices in Dublin.

Stage 2:
Estimating the number and incomes of households that will be formed as a result of people taking new jobs.

Stage 3:
Estimating the expected number of housing units and their cost, based on the expected demand of the new households.

RESULTS

Stage I

Exhibit I shows the planned near-term **jobs to be added** by three employers in the City of Dublin. Employers 1 and 2 provided the dollar value of the salaries of the planned jobs, while Employer 3 provided counts of jobs within salary ranges. The vast majority of these jobs are high-paying, high-skill jobs with a relatively small number of administrative or other type of support jobs. (See Appendix A for a complete breakdown of job titles and number of employees).

The subsequent stages of the estimation will use fewer categories than shown on Exhibit I, both to simplify presentation and to deal with the limitations of Employer 3's categories. Exhibit II shows the same data that was presented in Exhibit I, broken into the categories that will be used in the rest of the estimation stages. As we are particularly interested in estimating jobs and households in the lower income categories, the jobs in Employer 3's lowest category are divided up in the same proportions as the jobs planned by Employer 1. (Employer 3 and Employer 1 are both technology companies.)

Exhibit 1

Employer Survey Data
Number of Planned New Jobs in Dublin by Salary Range

Salary Range ($)			Employer 1 (#)	Employer 2 (#)	Employer 3 (#)		New Jobs (#)	New Jobs (%)
0	-	10,000	---	---				
10,001	-	20,000	1	10	32	[1]	128	2.9 [2]
20,001	-	30,000	1	24				
30,001	-	40,000	7	53				
40,001	-	50,000	17	42	61		120	2.8
50,001	-	60,000	48	29	44		121	2.8
60,001	-	70,000	68	44	138		250	5.8
70,001	-	80,000	71	24	319		414	9.5
80,001	-	90,000	116	23	389		528	12.2
90,001	-	100,000	111	28	425		564	13.0
100,001	-	110,000	15	11	476		502	11.6
110,001	-	120,000	31	7	379		417	9.6
120,001	-	130,000	66	8	290		364	8.4
130,001	-	140,000	41	2	294		337	7.8
140,001	-	150,000	23	1	195		219	5.0
150,001	-	160,000	11	3	160		174	4.0
160,001	-	170,000	8	---	91		99	2.3
170,001	-	180,000	1	1	42		44	1.0
180,001	-	190,000	5	---	20		25	0.6
190,001	-	200,000	1	---	20		21	0.5
	>	200,000	4	1	8		13	0.3
Total			646	311	3383		4340	100.0

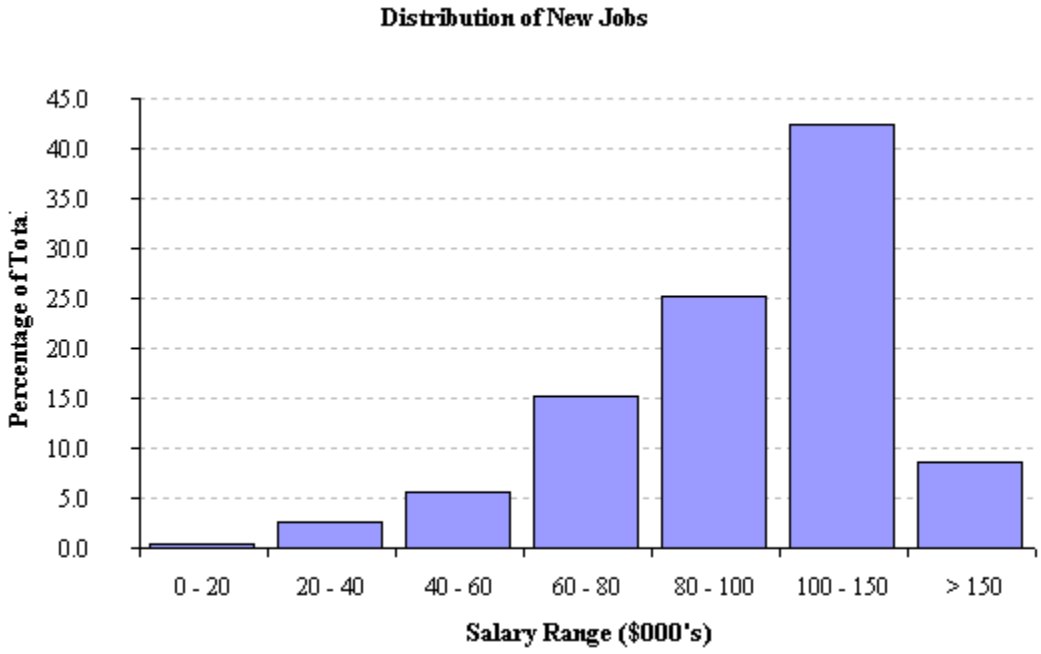
[1] Employer 3's first wage category was 0 - 40,000

[2] The totals are computed using 0-40,000 as the first wage category

Exhibit II

Stage I: Employer Survey Data
Numbers of Planned New Jobs in Dublin, by Wider Salary Range

Salary Range ($)			Employer 1 (#)	Employer 2 (#)	Employer 3 (#)		New Jobs (#)	New Jobs (%)
0	-	20,000	1	10	4	[1]	15	0.3
20,001	-	40,000	8	77	28		113	2.6
40,001	-	60,000	65	71	105		241	5.6
60,001	-	80,000	139	68	457		664	15.3
80,001	-	100,000	227	51	814		1092	25.2
100,001	-	150,000	176	29	1634		1839	42.4
	>	150,000	30	5	341		376	8.7
Total			646	311	3383		4340	100.0



[1] Jobs in Employer 3's first wage category (0 - 40,000) are divided among the first 0 - 20,000 and 20,001 - 40,000 wage categories in the same proportions as the jobs in those categories at Employer 1.

Stage II

In order to estimate how many houses these new workers will need, we must put them into **households** with other wage earners. At the outset, we are assuming that all of the new jobs will go to new residents, not people already living in Dublin.[1] Three scenarios are considered.

The most conservative scenario, with respect to the number of housing units needed, is to imagine that all of the paychecks in the new households come from new jobs. In other words, if a household moves to Dublin for one new job, any other wage earners in that household will also get one of the new jobs estimated in Stage I. We can place wage earners of different salary levels into households based on previously observed distributions of wage earners in households. (See Appendix B for the exact estimation procedure.) Dublin does not need to plan for a housing unit for each new job, because many of the new jobs will overlap in households. This is the "Total Overlap" or "Minimum" scenario.

The least conservative scenario, with respect to the number of housing units, is to imagine that each new household consists of only one new job: The household moves due to the new job of that primary wage-earner. Any secondary wage earners in the household contribute to the household income through jobs they hold outside of Dublin. We can estimate the contribution of the secondary wage earners in the household based on previously observed distributions of wage earners in households. (Again, see Appendix B for the exact estimation procedure.) This is the "No Overlap" or "Maximum" scenario.

It is for Dublin to decide which of these two scenarios is more appropriate. For illustrative purposes, a third scenario is presented where each category's midpoint between "Maximum" and "Minimum" need is calculated. This is the "Midpoint" scenario.

The "Minimum" scenario is the most conservative and, though unlikely to occur, represents the minimum housing demand Dublin can expect from the new jobs. The "Midpoint" scenario is a more realistic approach. The "Maximum" is as unlikely to actually occur as the minimum, but does provide a worst-case impact on Dublin's current housing crunch. These three scenarios are presented in Exhibit III.

[1] While this may not actually happen, planning as though it will avoids worsening any existing jobs-housing imbalance. In addition, the current tight labor markets mean that Dublin probably has little in the way of underemployed residents who could take the new jobs. If this situation changes, however, the estimates here will be too high for the true demand from new residents.

Exhibit III

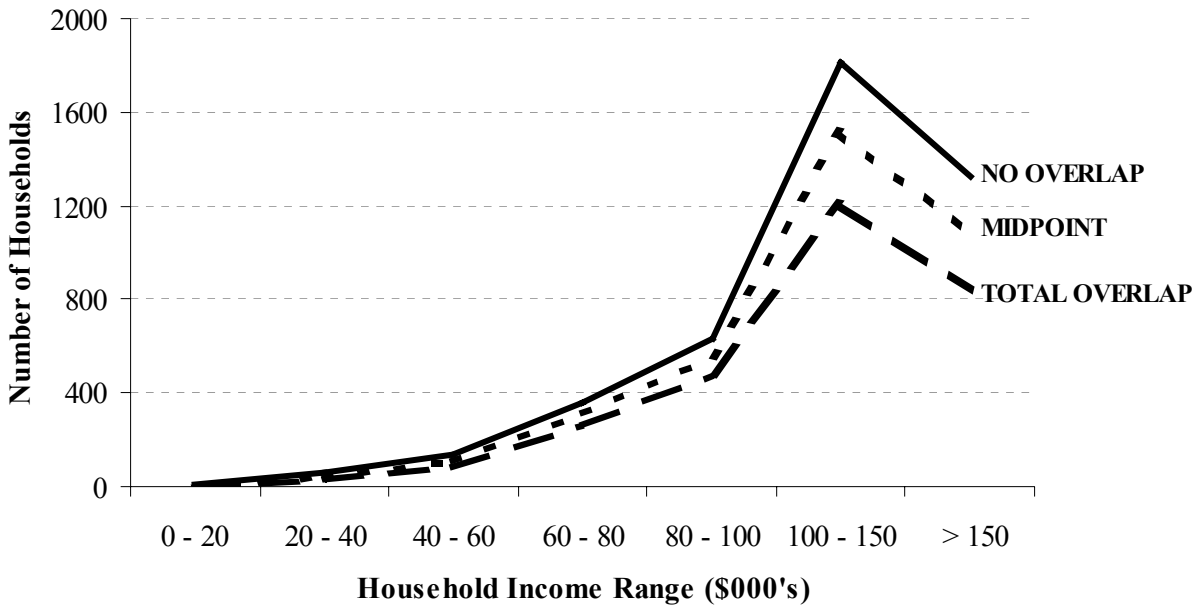
Estimated New Households, by Household Income Range

Job Salary Range ($000's)			New Jobs (#)	New Jobs (%)	TOTAL OVERLAP New Households (#)	TOTAL OVERLAP New Households (%)	MIDPOINT New Households (#)	MIDPOINT New Households (%)	NO OVERLAP New Households (#)	NO OVERLAP New Households (%)	Household Income Range ($)		
	<	20	15	0.3	3	0.1	6	0.2	8	0.2		<	20
20	-	40	113	2.6	30	1.0	45	1.2	61	1.4	20	-	40
40	-	60	241	5.6	89	3.1	114	3.2	140	3.2	40	-	60
60	-	80	664	15.3	268	9.2	314	8.7	361	8.3	60	-	80
80	-	100	1092	25.2	483	16.6	558	15.4	633	14.6	80	-	100
100	-	150	1839	42.4	1208	41.4	1510	41.6	1812	41.7	100	-	150
	>	150	376	8.7	835	28.6	1080	29.8	1326	30.5		>	150
Total			4340	100.0	2916	100.0	3628	100.0	4340	100.0			

Stage III

Exhibit IV presents all of the resulting scenarios in graphical form. Each of the three lines represents household income ranges for each particular combination of job overlap scenarios. The lowest line represents the most conservative scenario and the minimum housing demand for which Dublin needs to plan if it wants to give the new employees an opportunity to live near where they work. The highest line is the maximum number of housing units needed.

Exhibit IV



ANALYSIS

ABAG's Housing Model

Given the different scenarios of household formation, the final stage is to translate that into housing cost and unit recommendations. The Association of Bay Area Governments (ABAG) categorizes households into four groups, as follows:

- Very Low: 50% or less of Bay Area median income
- Low: 51% to 80% of Bay Area median income
- Moderate: 81% to 120% of Bay Area median income
- Above Moderate: greater than 120% of Bay Area median income

ABAG has historically projected the number and types of housing needed in Dublin not by examining specific jobs along with their salaries, but by calculating the number of jobs that will move to the Dublin area, and assuming the incomes for these jobs will match the ratio of incomes in the Bay Area as a whole. Although we have not utilized the support jobs multiplier, our study indicates that the types of jobs that are moving to Dublin have relatively higher salaries, and do not reflect the ratio that we see in the rest of the Bay Area. For this reason, the housing that will be required by these employees is more expensive than would have been indicated using ABAG's methodology.

The ABAG executive board has determined that in order to meet the State mandated regional housing planning needs, cities must house 75% of their total population growth, and the county must absorb the remaining 25%. Using this formula, ABAG determined that Dublin's "fair share" for the years 1999-2006 is 5,436, which was broken down as follows:

Very Low	Low	Moderate	Above Moderate	Total
14.6%	**9.9%**	**26.5%**	**49.0%**	**75% of total housing needed**
796	**531**	**1,441**	**2,668**	**5,436**

Our Model

Our housing calculations utilize our "midpoint" scenario and consider only three different employers **and do not take into consideration the support jobs that will also move to this area.** However, our results show the following distribution, which differs substantially from what ABAG predicts:

Very Low	Low	Moderate	Above Moderate	Total
2.2%	**3.2%**	**24.1%**	**71.4%**	**20% of total housing needed**
51	**114**	**872**	**2590**	**3,628**

This means that, while we are only calculating 20% of all the jobs that are expected to move into the City of Dublin, we have already utilized over two-thirds of the new housing planned. Further, although the "above moderate" category is nearly depleted, there are still many units available in the "very low" and "low" categories, indicating an imbalance in the housing distribution. This is alarming because we can expect that the

income distribution in the three companies we surveyed will be similar to that which will be seen in the other eight companies that are moving into Dublin. Thus, **the imbalance will be magnified dramatically when all firms have moved to Dublin.** Again, it must be emphasized that this model does not take into consideration the number of support jobs that will move to the area, and the support job multiplier is typically in the range of 1.0 – 1.5. However, it would appear that the supply of very-low and low-income housing in the City of Dublin is nearly adequate. Predominantly it is the "moderate" and "above moderate" housing that is needed in order to house these high skilled, higher paid employees.

Affordability of Housing in Dublin

According to the City of Dublin website, the median single-family home price in Dublin as of August 2000 was $362,500. Using a mortgage calculator, and assuming that a household can put 10% down on a house with a 30-year, 7.25% fixed rate loan, a household must earn approximately $120,000 per year to purchase a house of this price. This is assuming that a person does not exceed a total debt ratio of 36%.

The median salary for the employees in our survey is approximately $105,000, which means that making the same assumptions as above, these individuals can only afford a $316,000 house. However, because many households contain two incomes, and because incomes in Dublin are higher than average, we can predict that this person earning the median salary will very likely be partnered with a person earning at least $15,000. Therefore this household would be able to afford the median priced house.

CONCLUSION

This model shows the importance of factoring in employee wages and incomes in determining the types and amount of housing needed in an area. For example, our case study demonstrates that at this point in time, Dublin is not planning to provide the amount of "moderate" and "above moderate" housing that will be necessary in order to accommodate the high skilled, higher paid employees who will be moving to their city. This is because ABAG bases its housing recommendations on the income distributions in the entire Bay Area. However, because the income distributions in each region depend on the types of jobs that are available in each area, these recommendations are not precise enough—and can be inaccurate. Employee salaries specific to each sub-region must be examined when determining the number and types of housing needed, or else the current jobs-housing mismatch, which is contributing to the Bay Area's rapidly increasing traffic and pollution, will only become worse.

Appendix A

Job Titles and Number of Employees

EMPLOYER 1	Number of Employees
Admin	35
Application Architect	14
Business Systems Analyst	12
Config. Mgr.	5
Consultant	41
Data Architect	13
Data Base Analyst	17
Data Modeler	18
Data Warehouse	12
Database Admin	1
Database Developer	18
Database Manager	14
Director	9
E-Commerce Data Specialist	1
E-Commerce Specialist	12
E-mail Admin	11
Firewall Specialist	13
Hardware Analyst	16
Help Desk	33
Info Systems Audit Staff	11
Info Systems Auditor	7
Installer	1
Net Developer	13
Operations Mgr.	12
Product Manager	9
Product Support	20
Programmer/Analyst	16
Programmer/Developer	9
Project Leader	17
Q/A	13
Sales Consultant	31
Security Admin	10
Security Analyst	1
Security Manager	2
Software Config. Mgr.	7
Software Development	14
Software Engineer	1
Software Installer	13
Support	59
Syst Admin	11
Syst Analyst	13
System Development Analyst	17
Systems Architect	1
Trainer	15
Web Master	12

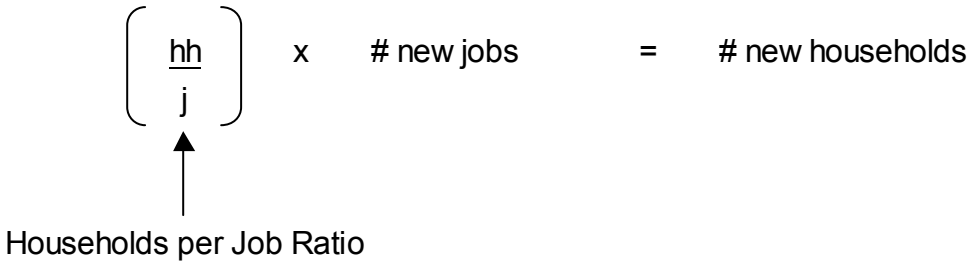
Writer	16
TOTAL	**646**
EMPLOYER 2	**Number of Employees**
Accounting	38
Admin - Clerical	19
Admin - Customer Service	10
Admin - Data entry	15
Admin - Human Resources	9
Admin - Unclass	29
Audit	19
Collections	1
Compensation	1
Controller	5
Credit	11
Finance	26
Legal	17
Misc – Unclass	106
Payroll	4
Tax	1
TOTAL	**311**
EMPLOYER 3	**Number of Employees**
Administration	158
Application Development	527
Applied Web Technologies	173
Business Development/Global Alliances	268
Consulting	356
Customer Relationship Management Products	153
Facilities	38
Finance	4
Human Resources	349
Information Systems	527
Marketing	107
Product Management	230
Sales	271
Software Development	222
TOTAL	**3383**

Appendix B

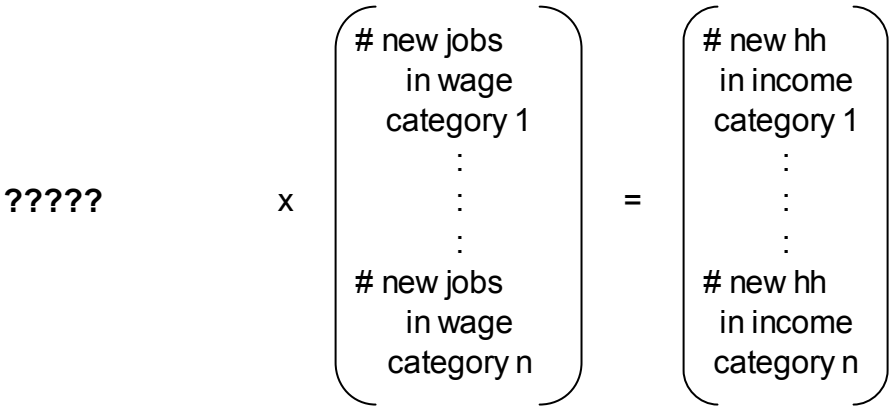
TECHNICAL APPENDIX: FROM JOBS INTO HOUSEHOLDS

Rationale

The main modeling task of estimating housing demand from job data is to estimate a households-per-job ratio[2]. Multiply this ratio by a number of new jobs and you have an estimate of the number of new households that will be created as a result of these new jobs:



In the analysis presented in this paper, we have set ourselves the additional task of sorting people *with various salary levels* into households *with various household income levels*. Now the multiplication is more difficult:



The difficulty this presents is that there are a multitude of ways that people can sort themselves into households: two high-salaried workers will form one household; another household has only one salaried worker in it; yet another has one low- and one high-salary worker. There's no way to know how one individual worker will form a household. The model used for this analysis addresses this problem by ignoring individual workers and focussing on *distributions* of workers. We may not know what kind of household one person earning $50,000

[2] The statistics that people are usually aware of is the jobs-per-household ratio. However, the estimation in this project is from jobs to households, so we need the inverse of the jobs-per-household ratio (the households-per-job ratio).

per year will form, but we can say that some percentage of people earning $50,000 per year will be the sole earner in their households, some percentage will form a household with another $50,000 earner, and so on.

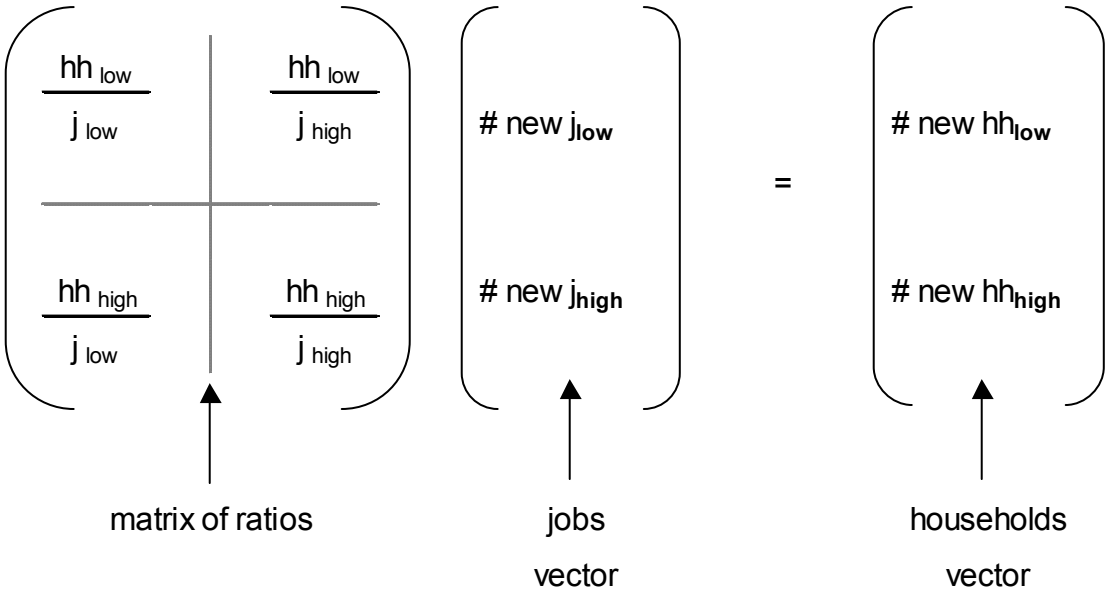
Using large Census samples, we can observe these distributions over time and from place to place. It turns out that, while the jobs-per-household ratios fluctuate over time and from place to place due to changing economic conditions, the distribution of people with various salary levels sorting themselves into households has been fairly stable. We can use those historically observed ratios to predict a distribution of households from a distribution of jobs, and then adjust the overall number of households using current estimates of the jobs-per-household ratio.

Calculations

The distributions of jobs into households are collected in matrix form, and the actual estimation of households from jobs is performed by matrix multiplication. To show a simplified example, imagine that you have jobs (j) and households (hh). Both j and hh have two categories: low and high (for jobs that means low and high salary; for households, low and high household income). Using historical data, we can find four ratios that represent all possible household per job combinations:

1. low income households per high wage jobs (hh_{low} / j_{high})
2. high income households per high wage jobs (hh_{high} / j_{high})
3. low income households per low wage jobs (hh_{low} / j_{low})
4. high income households per low wage jobs (hh_{high} / j_{low})

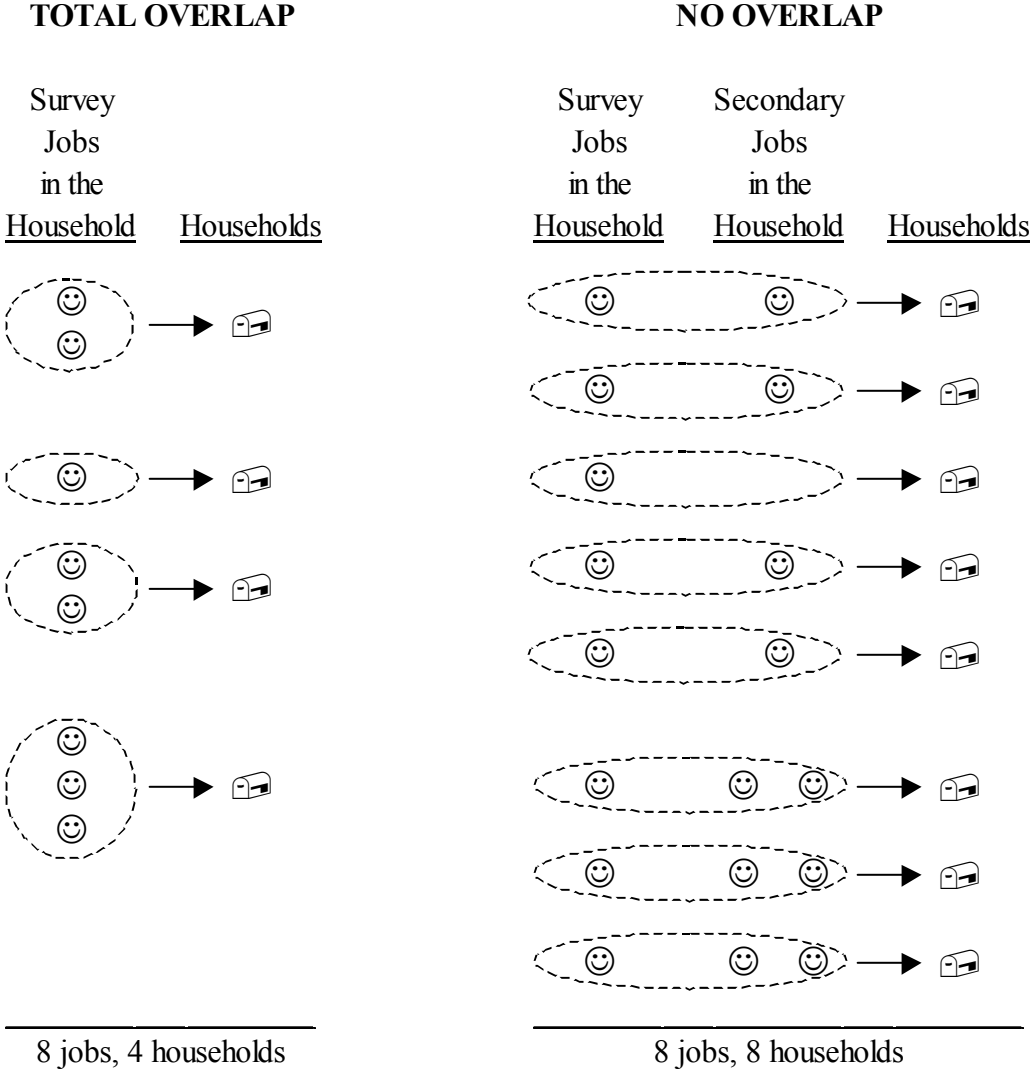
Arranging these ratios in a matrix, they can then be multiplied by a vector of new jobs in the two categories to get an estimate of the new households they will form, and in which categories:



The information in the matrix is basically a group of sorting ratios, showing how people with jobs at certain salary levels sort themselves into households together.

Two Variants

In the analysis, two variants of the jobs into households calculation are presented. In the minimum variant, we imagine total overlap of the jobs into the households. In the maximum variant, we imagine no overlap. To contrast the two, imagine that our survey gives us information on eight new jobs. The total overlap scenario imagines that these survey jobs will be filled by people moving to Dublin together as pre-existing households. The no overlap scenario imagines that households move to Dublin so that the main wage earner can take one of the new survey jobs and that any other salaries in those households will be secondary and will come from jobs the spouse/partner/roommate had from somewhere else. Using the salary distributions in households data discussed previously, we can estimate how they will sort them into households. Schematically, it looks something like this:



The matrices used are different, but they represent the same information about how people of different income levels sort themselves into households.

Data

The data to calculate the matrices comes from the Integrated Public Use Microdata Samples (IPUMS). These are representative samples of individual people's Census long forms. For the purposes of creating the households per jobs matrices, I took all of the available long form samples from Alameda County for the 1990 Census, a sample of 25,658 persons in 15,327 households. People living in group quarters were excluded. The relevant data is the household's total income, and the salary contribution of each working member of that household. (All dollar values were inflated up to February 2001 levels using the CPI-U for the San Francisco-Oakland-San Jose area, making them roughly compatible with the salary levels obtained in the employer survey.) Both variants are shown below.

TOTAL OVERLAP

		Job Salary Range						
		< 20	20 - 40	40 - 60	60 - 80	80 - 100	100 - 150	> 150
Household Income Range	< 20	0.17	0.00	0.00	0.00	0.00	0.00	0.00
	20 - 40	0.11	0.25	0.00	0.00	0.00	0.00	0.00
	40 - 60	0.09	0.11	0.31	0.00	0.00	0.00	0.00
	60 - 80	0.06	0.09	0.09	0.35	0.00	0.00	0.00
	80 - 100	0.03	0.06	0.10	0.09	0.36	0.00	0.00
	100 - 150	0.04	0.05	0.11	0.17	0.21	0.46	0.00
	> 150	0.02	0.02	0.03	0.06	0.10	0.23	0.69
	Column Sum	0.52	0.59	0.64	0.67	0.67	0.68	0.69

NO OVERLAP

		Job Salary Range						
		< 20	20 - 40	40 - 60	60 - 80	80 - 100	100 - 150	> 150
Household Income Range	< 20	0.57	0.00	0.00	0.00	0.00	0.00	0.00
	20 - 40	0.28	0.50	0.00	0.00	0.00	0.00	0.00
	40 - 60	0.09	0.27	0.45	0.00	0.00	0.00	0.00
	60 - 80	0.04	0.15	0.21	0.44	0.00	0.00	0.00
	80 - 100	0.01	0.05	0.20	0.18	0.42	0.00	0.00
	100 - 150	0.01	0.03	0.13	0.34	0.42	0.60	0.00
	> 150	0.00	0.00	0.02	0.04	0.16	0.40	1.00
	Column Sum	1.00	1.00	1.00	1.00	1.00	1.00	1.00

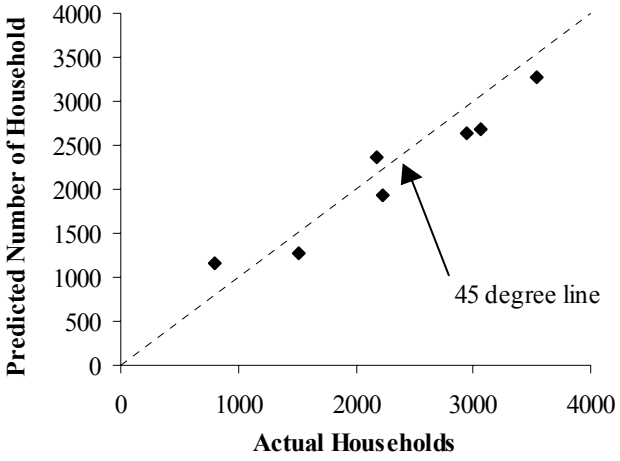
Each entry of the matrix is the sorting factor for the households of income category to the left and job of salary category above. We can see that the column sums add to one in the no overlap matrix because we are sorting one job into one household. For the total overlap matrix, the column sums are less than one. Using this matrix, each job makes up less than one household.

Testing of Methodology

Before using this methodology, some proof of its predictive power is in order. One kind of proof would be to show that the estimated matrices on the previous page are fairly constant from place to place and from time to time. A check on this was done for the nine counties in the Bay Area between 1980 and 1990. The results were favorable in that the ratios were quite stable.

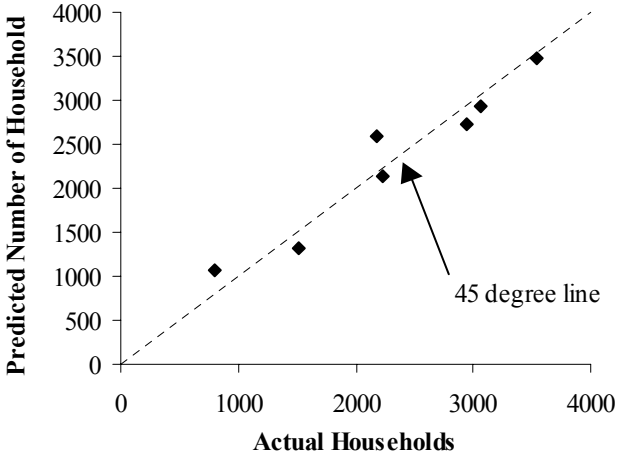
More important than showing the stability of the matrices is demonstrating their predictive power. The prediction of interest is of households in income ranges from jobs in salary ranges. This prediction is demonstrated by using the 1990 Alameda County matrix to predict the 1980 Alameda County household vector from the 1980 Alameda County job vector. For the total overlap variant, the results are as follows:

Household Income Range ($)	Alameda County, 1980 Households (# in Sample) ACTUAL	PREDICTED
< 20	1515	1262
20 - 40	2943	2632
40 - 60	3533	3282
60 - 80	3056	2690
80 - 100	2224	1932
100 - 150	2186	2370
> 150	795	1161



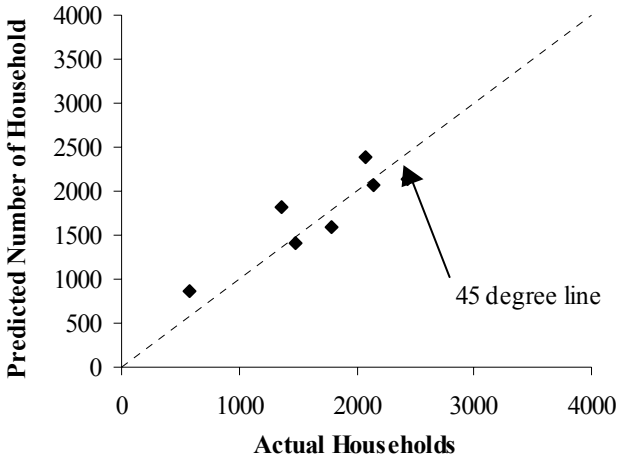
The graph on the right shows the extent to which the prediction matches the number of households in the household income categories actually observed in the data. The same analysis for the no overlap variant is as follows:

Household Income Range ($)	Alameda County, 1980 Households (# in Sample) ACTUAL	PREDICTED
< 20	1515	1316
20 - 40	2943	2718
40 - 60	3533	3486
60 - 80	3056	2940
80 - 100	2224	2145
100 - 150	2186	2583
> 150	795	1064



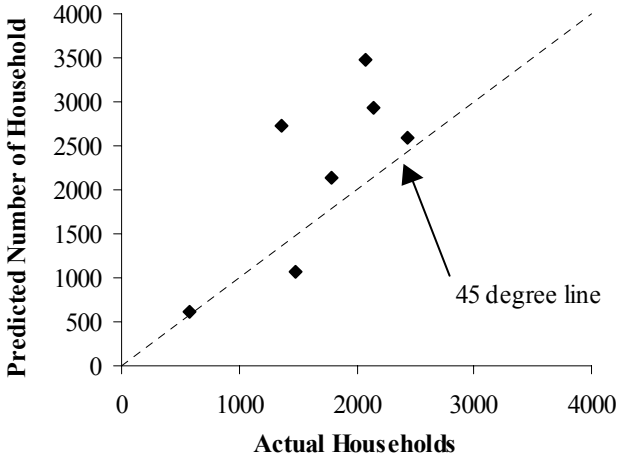
As another test, we can use the matrix to predict Contra Costa County's households from its jobs and see how that lines up with the actual household data. For the total overlap variant, the comparison is as follows:

Household Income Range ($)	Contra Costa, 1990 Households ACTUAL (# in Sample)	PREDICTED
< 20	571	859
20 - 40	1362	1807
40 - 60	2078	2396
60 - 80	2141	2059
80 - 100	1793	1597
100 - 150	2438	2138
> 150	1480	1404



Again, the predictions line up very close to the 45 degree line, indicating a good prediction. The no overlap variant, however, does not recommend this method quite so much:

Household Income Range ($)	Contra Costa, 1990 Households ACTUAL (# in Sample)	PREDICTED
< 20	571	622
20 - 40	1362	2718
40 - 60	2078	3486
60 - 80	2141	2940
80 - 100	1793	2145
100 - 150	2438	2583
> 150	1480	1064



So, a first pass at testing the matrix seems to indicate that it makes decent predictions. Further testing should be done to confirm. The best test will be when microdata samples are available from the 2000 Census. Then we can see how closely the matrices matched over a period of great change in the Bay Area.