Regional Occupational and Industrial Structure:

Does the One Imply the Other?

Elisa Barbour
Public Policy Institute of California
500 Washington St. Suite 800
San Francisco, CA 94111 USA
415-291-4423
barbour@ppic.org

Ann Markusen
Project on Regional and Industrial Economics
Humphrey Institute of Public Affairs
University of Minnesota
301 S. 19th Avenue
Minneapolis, MN 55455 USA
612-625-8092
markusen@umn.edu

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Abstract

The product/profit cycle and new international division of labor theories hypothesize that establishments in a single industry may be undertaking different activities in different locations. Innovative and developmental activities will be anchored in regions of origin, while more routine production and service functions will be dispersed to lower cost and downstream consuming regions. Disparities in occupational composition offer a test of these theories. In this paper, we test whether a region's occupational structure can be read off its industrial structure. Using a data set created for eleven California metropolitan areas for 1997, we explore the extent to which the occupational mix within a specific metropolitan industry is dissimilar to the mix found for that same industry in other metros. We find that estimating a metro's occupational mix by assuming that its industries mirror the national occupational structure for those industries often provides a reasonable approximation for local-serving and more mature export base industries. However, this does not hold for the more innovative industries and occupations, particularly those in high-tech and business service activities. In such cases, pursuing industrial targeting will not achieve the same consequence as pursuing occupational targeting.

I. Introduction[1]

No one ever "sees" a regional economy. Instead, we have mental maps based on conceptual categories that often showcase certain decision-makers as key to economic development. The two most common typologies used to depict regional economies have been grouping jobs by industry or grouping them by occupation (Harrington, 1999). However, the industrial conception of a regional economy is older and much more heavily used. This has been reflected in regional economic analysis and economic development practice geared to firms as drivers of economic growth.

In recent decades, scholars have been increasingly interested in the occupational aspect of regional employment (Thompson and Thompson, 1985 & 1993; Feser, 2002; Markusen, 2004). This reflects, among other factors, a growing appreciation for the role of human capital in economic development (Mather, 1999; Markusen, 2006). In addition, increasing mobility by both workers and firms during recent decades has coincided with a growing separation of functions across space within firms and industries – a spatial division of labor that may relate to occupational distinctions among regional workforces (Frobel et al, 1979; Massey, 1984; Markusen, 1985; Saxenian, 1994).

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In this paper, we explore this possibility and test the extent to which occupational and industrial structures dovetail across regions. We test whether a region's occupational structure can be read off its industrial structure (or vice-versa). In other words, does industry X in a region possess an occupational mix similar to that of the same industry in other regions or in the state or nation as a whole?

This question is important for practical reasons. Because industrial data are presently easier to procure and analyze than occupational data, planners and policymakers would be justified in using industrial mix to estimate occupational mix for a region if the variation among jurisdictions is very low. But if industries' occupational compositions vary across regions, use of such a two-step methodology could result in poorly targeted workforce and economic development programs. The question also has theoretical implications for understanding regional economies. If industry structure proves to be a poor predictor of occupational structure – and especially if the relationship is shown to be growing weaker over time – then new research approaches may be needed that employ an occupational lens parallel to rather than subordinated to an industrial framework.

Using a data set developed for eleven California metropolitan areas for 1997, we explore the extent to which occupational mix maps neatly onto industrial mix using national data on occupational employment by industry. We show where the two are coterminous and where they are not. In the latter case, it means that the occupational mix within a specific metro industry is dissimilar to the mix found for that same industry in other metros. In such cases, pursuing industrial targeting will not achieve the same consequence as pursuing occupational targeting. We find that estimating a metro's occupational mix by assuming that its industries mirror the national occupational structure for those industries is often a good approximation for local-serving and more mature export base industries. However, in support of our theory, this does not hold for the more innovative industries and occupations, particularly those in high-tech and business service activities.

II. Within-Industry Spatial Divisions of Labor

Regional corollaries to product/product cycle theories posit that spatial divisions of labor and distended commodity chains will emerge in industries as they move from innovative commercialization and business-building stages through more mature, market-oriented stages (Frobel et al, 1979; Massey, 1984; Markusen, 1985; Gereffi and Korzeniewicz, 1994). The product/profit cycle theories argue that firms' preoccupations, and thus their spatial requirements, vary across stages of development, with agglomeration factors (including access to information, unique skills, and innovating other firms) dominating in earlier stages while cost and market access factors induce dispersion in later stages. One inference is that although industries may be quite widely distributed across regions, what occurs in flagship regions' establishments may be quite different from what occurs in others.

Over the past twenty years, scholars have documented empirically an increasing spatial separation of functions within particular production processes, industries or commodity chains to take advantage of differential agglomeration, cost and market advantages in various regions. Saxenian (1980) showed that by the late 1970s, the US semiconductor industry's headquarters and R&D functions remained clustered in Silicon Valley while its advanced manufacturing had dispersed to other US locations such as Phoenix and Colorado Springs and its routine assembly functions had been relocated overseas. Establishments in these latter locations would be classified as electronics manufacturing, but the jobs associated with each would be quite different from that in Silicon Valley.

Christopherson and Storper (1986) found a similar spatial division of labor for the motion picture industry, as did Gray (2002) for biotech and pharmaceutical activity in the US.

In addition, urban agglomeration theory posits that in larger conurbations, there will be a tendency towards greater vertical disintegration, because certain functions can be outsourced to specialist firms in the environs (Scott, 1988; Storper, 1989). A manufacturing establishment, then, in a large metropolitan area might be outsourcing more of its parts, service, marketing, maintenance and clerical work to local firms than would an establishment producing a similar product in a smaller city. Both types of establishments would be allocated to the same industrial code, but the occupational structure of each would look quite different.

In this paper, we use an occupational lens to explore the inter-regional division of labor. To the extent that such spatial divisions of labor and differentials in vertical integration exist, we should not expect that an establishment classified as belonging to a particular industry in one region will employ the same mix of occupations as one elsewhere. If industries' occupational compositions vary substantially across regions, misplaced assumptions based on industry analysis alone could result in poorly targeted workforce and economic development programs. Similarly, regional economic analysis may need to be reframed to include new tests of developmental or structural hypotheses using occupation in addition to industry.

Occupational analysis as a means of studying regional economies has gained stature since Thompson and Thompson's (1985) pioneering work. Several techniques for exploring occupational structure (Harrington, 2002; Markusen, 2004) and identifying occupational clusters (Feser and Koo, 2001; Feser, 2002) have been proposed as tools for economic development planners and policymakers in shaping regional economies. In fact, industry and occupation are only the most prominent among a variety of typologies that can be used to depict the character of regional economies (Harrington, 1999). These classifications are conceptual artifacts, and neither "causes" or "explains" the other. Jobs reported by industry are grouped according to similarities in their product or service outcomes. Reported by occupation, jobs are grouped by the similarity of workers' skills and activities on the job. Although the industrial conception of a regional economy is older and more heavily used,[2] neither conception is in any way theoretically prior to the other. In practice, economic development planners tend to rely on industry depictions while workforce development planners rely primarily on occupational characterizations. Preference for an industrial approach is encouraged by the fact that data on industry are more user-friendly than data on occupations, especially if comparability over regions and time is desired.

If occupations map neatly and consistently onto industries across space, then it is not particularly important to analyze occupational composition in its own right. Industrial

[2] In the US, governments at the state and federal levels have been creating data sets for decades that permit quite detailed perusal of occupational and industrial employment at the state, metropolitan and county levels. Until the 1940s, the Census Bureau did not classify occupations on the basis of what workers did but rather on the basis of industry, as in "forestry workers," "bank workers." Beginning in the 1940s, a detailed occupational code was developed for the census to classify jobs more closely on the basis of what people did, i.e. the nature of their work tasks rather than the product they produced. Elsewhere in the government, agencies created their own codes to suit their particular needs. According to McKee and Froeschle (1985) agency isolationist attitudes gave rise to a myriad of unrelated coding systems that confounded occupational analysis until 1977, when the federal government adopted the Standard Occupational Classification system. However, further development and adoption of the SOC system was slow. It was not until 1999 that all federal statistical agencies – including the Occupational Employment Statistics (OES) program, BLS' primary program to gather detailed data on occupational employment– began officially adopting the SOC system. According to the BLS, "the SOC system … incorporates structural features that free occupational classification from its previously industry-rooted structure" (Bureau of Labor Statistics, 2001).

employment could be used as a proxy for occupations – a planner or regional economist would simply assume that the state or national occupational mix for an industry holds in his/her local economy and estimate occupational structure in this manner. Most existing regional input-output models infer occupational composition from industrial composition, as do national models. Census and BLS economists modeling the occupational impact of the 1980s defense build-up assumed that the occupational structure in defense segments of defense-related industries (aircraft, electronics, instrumentation) would mirror that of the wider industries as a whole (Henry and Oliver, 1987). But using the National Science Foundations' Survey of Scientists and Engineers, Markusen and Yudken (1992) showed that this method underestimated the shares of physicists and aeronautical and electrical engineers by 300% and 100% respectively. Defense-related segments of these industries were much more research and innovation-intensive than civilian establishments in the same industry. At the local level, pioneering efforts to match an under-employed workforce with evolving industry demand have also used state or federal occupation-by-industry matrices to infer local occupational demand (McKee and Froeschle, 1985; Ranney and Betancur, 1992; Thompson and Thompson, 1993; Balfe and McDonald, 1994; Theodore and Carlson, 1998).

Even though the federal government designs industry codes on the basis of what firms produce and occupational codes on what workers do (in the famous Thompson and Thompson, 1985, formulation), researchers expect a predictable correspondence between classifications of employment by occupation and industry, because they have emerged as related concepts. Indeed, it appears that some new industries, as statistical categories, are created by the Department of Commerce by grouping together what are essentially occupationally-based activities. For instance, business services as an industry grouping emerged after accountants and software engineers and programmers moved out of larger manufacturing and finance firms and established their own companies around an occupational core. Since every establishment must be assigned to an industry group, these became the accounting and software services industries respectively. The belated creation of new industry categories, then, tends to introduce more congruence between the two sets of categories. In the carefully conceived mid-1990s industry and occupational recoding exercise, government social scientists made an effort to reconceptualize industries more along lines of their production process rather than end products, although the results were a compromise (Hecker et al, 2001).

If our hypotheses are correct, we believe that regional scientists should begin to research industrial/occupational agglomerations, not just industrial ones. Industrial targeting efforts and cluster analysis, the most recent incarnation of industrial complex analysis, could benefit from companion occupational analyses, especially since these would support the growing trend towards merging economic and workforce development agencies at the state and local level.

III. Testing for Coherence Between Occupation and Industry

To what extent can metropolitan occupational structure be inferred from industry structure, based on national averages for the occupational distribution of jobs within industries? In other words, how similar are metropolitan occupational structures within California to the national norm, when industry structure is held constant? How much of the difference might be attributed to characteristics shared by California metropolitan regions that distinguish them from others in the nation?

We compare employment by occupation for eleven California metropolitan areas in 1997 to the national average, holding industry structure constant. More specifically, we simulate what employment for California metropolitan areas would have been if the breakdown by occupation within local industries matched the national average for the same industries. We then summed total employment by occupation across all industries and compared expected employment based on this measure to actual employment. The procedure is symbolized as follows:

$$\left(\sum_{i} \left((E_{io}/E_i) * R_i\right) - R_{io}\right) / R_o$$

E = National Employment
R = Regional Employment
i = Industry
o = Occupation

We also construct a summary measure of overall correspondence between actual and expected values: the sum across occupational categories of the absolute value of the difference between actual and expected employment by occupation, as a share of total employment, then divided by two to avoid double-counting (unexpected employment deficits in one occupational category appear as unexpected surpluses in others). The summary measure is symbolized as:

$$\left(\left(\sum_{o} \text{abs}\left(\sum_{i} \left((E_{io}/E_i) * R_i\right) - R_{io}\right)\right) / R\right) / 2$$

Wide disparities between expected and actual employment would indicate that occupational distributions within industries are dissimilar for different areas, and/or that they differ among these California metropolitan areas as a group when compared to the nation as a whole. This could suggest that industry structure – at least on its own – is not a reliable estimator of metro employment by occupation.

The data used for this exercise come from two main sources – the California Employment Development Department's *Industry-Occupation Matrix* data, and the US Bureau of Labor Statistics' *National Historical Industry-Occupation Matrix Time Series (NTS), 1983-1998*. The data were developed as part of a larger project to compare occupational profiles over time among California metropolitan areas and with the nation as a whole. The demands of the larger project dictated many aspects, including the selection of metropolitan areas (Table 1), the selection of a single year, 1997, the need to employ only 93 occupational categories and 181 industry categories, and the construction of aggregate occupational categories. For more about these issues, see Markusen and Barbour, 2003.

It would be useful to extend this work to include analysis over time and across states with more detailed occupational information. However, the challenges are formidable. Data of the sort we employ was available for California metropolitan areas with a consistent classification system only for the period from 1993 to 1999, making it difficult to compare results over a period long enough to detect structural shifts. Starting in 1999, state and federal agencies began shifting to new classification systems – the Standard Occupational Classification (SOC) system and the North American Industry Classification System (NAICS) - hampering efforts to compare recent occupational data from any available source to that for earlier years.[3] Publication schedules for national and state-produced data do not always

[3] An alternative would be to use self-reported individual industry and occupational data from the recent Census years to test this hypothesis more broadly at the national level. There are industry and occupational crosswalks that help bridge between the 1990 and 2000 industry and occupational coding changes. The Census may be a less reliable source of industry by occupation profiles since individuals answer questions about their own

coincide. Across-state comparison is frustrated by differences in data collection and dissemination methods used among state employment departments. Given the obstacles, California is a uniquely attractive state for studying differences among metropolitan areas because it contains a significant number of metro areas of different size and vintage. Below, we speculate on how California's metros differ from the larger set of national and international metros.

IV. Findings on Employment by Occupation and Industry

Our results show that in general, industry structure weighted by each industry's national occupational profile does yield a close estimate of metropolitan occupational structure for eleven California metropolitan areas in 1997 (Table 2). Even at the most disaggregated level of occupational analysis possible, the share of employment by occupation not predictable by industry structure for our entire sample is fairly small, at 5% of total employment. Nevertheless, this represents a substantial number of jobs – 585,000. At a broader level of aggregation – using only the six occupational categories shown in Table 2 – the discrepancy between actual and expected employment is even smaller, at 3%.[4] However, results vary by occupational category. Disparities are highest for manual workers, professional workers, and service workers. They are especially low for sales-related workers.[5]

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occupation and industry with very little guidance; in contrast, the data used here are based on employer reporting. The establishment-based data are also available on a much more timely basis.

[4] We also tested the relationship just for the six largest metropolitan areas, to determine if the greater level of occupational detail afforded in this comparison would influence the results. For the six largest metropolitan areas, data for 125 occupational categories were available for all areas. The outcome was similar, with the unexplained share at 6% of total employment.

[5] Farming, forestry, and fishing occupations were excluded from our analysis because of data constraints.

California's metropolitan areas differ substantially in the degree to which their occupational structures can be gauged by their industry mix (Table 3). At the more detailed level of occupational breakdown – with 93 categories employed – the disparity between expected and actual employment ranges from a high of 9% in the San Jose metro area to a low of 4% in the Los Angeles metro area. This discrepancy between a region of new economic activities and a more mature regional economic center may offer some fuel for the hypothesis that in more innovative portions of the economy, industrial structure will be less congruent with occupational structure.

To what degree do these divergences from the national norm reflect characteristics shared among California metros? The breakdown by occupational category in Table 3 helps to pinpoint what these shared characteristics are. California metros tend to have higher shares of clerical workers and lower shares of service and sales workers than the national norm for occupational distribution by industry.

However, the California metros demonstrate a considerable degree of diversity in spite of these shared tendencies. In some cases, the differences follow an apparent pattern that distinguishes central from outlying areas. For example, disparities between expected and actual employment across the metropolitan areas are especially wide for managerial/professional and manual workers. Industries in the larger, more central areas employ more managers and professionals than expected. For example, San Jose metro area employers employ one-sixth (17%) more such workers than would be suggested by its industry structure alone. Neighboring San Francisco Bay Area metropolitan areas – Oakland and San Francisco – show similar propensities, as did the Sacramento metro area. Less central metropolitan areas – specifically Riverside/San Bernardino, Redding, and Fresno – show the opposite tendency, employing substantially fewer managerial and professional workers than would be expected from their industry structures alone.

The pattern in manual, precision, and service employment is the mirror opposite of that for managerial and professional workers: smaller, more outlying metropolitan areas tend to have more workers than expected in these occupational categories, while the larger metropolitan areas tend to have fewer. Similarly, less central metropolitan areas are somewhat more likely to host clerical jobs than their industrial mix would predict, although the disparities are smaller and less consistent with the center-periphery distinction than for the other categories. This pattern suggests an intra-metropolitan division of labor in many industries, where command and control functions are core-based, providing access to pools of skilled labor, while more routine functions are suburbanized.

In some cases, however, the findings are less easily ascribed to a pattern distinguishing central from peripheral metropolitan areas. For example, Los Angeles County (the core primary metropolitan statistical area) hosts over-representations of manual and clerical workers and under-representations of managerial and professional workers. This pattern is similar to that prevailing in smaller, outlying areas. Industries in neighboring Orange County metropolitan area employ disproportionate shares of clerical workers. This suggests a division of labor between the two neighboring metros' industries not clearly associated with the traditional division of labor hypotheses.

Thus, our findings indicate that California metropolitan areas possess occupational structures that operate to some degree independently from their industry structures. A test of correlations between location quotients – a measure of occupational specialization in a metro economy relative to the national norm – and employment shares unexplained by industry structure shows a very strong relationship in most cases.[6] In some cases, the patterns reflect a spatial division of labor distinguishing central and outlying metro areas. But in other cases, the differences appear to be associated with regional specialization.

V. High-Technology Occupations

To test whether innovative sectors are more prone to inter-regional dispersion in occupational structure than mature ones, we chose to examine more closely a cluster of high-tech and business service occupations. Both groups are widely acknowledged to have undergone significant growth and restructuring over recent decades, and industries with larger concentrations of them are a frequent focus of economic development strategies.

The high-tech occupational set consists of computer/information technology professionals, selected engineers, and natural scientists.[7] Measures of specialization for these occupations are presented in Table 4 for the six largest metropolitan areas in the state. The San Francisco Bay Area's dominance in high-tech occupations, as expressed in occupational location quotients, is evident in the findings. Location quotients were quite high in 1997 for each of these sectors in each of the three Bay Area metros – San Francisco, San Jose and

[6] Location quotients measure the ratio of each occupation's share of total employment in the local economy to the share in the national economy. The correlation of location quotients and unexplained shares was: managerial/professional workers (.95); sales workers (.81); clerical workers (.51); service workers (.70); precision workers (.84); and manual workers (.72).

[7] "Selected engineers" include chemical engineers, civil engineers, electrical and electronics engineers, and mechanical engineers. This group comprises the vast majority of engineers. Due to data limitations, aeronautical and astronautical engineers, industrial engineers, metallurgists, mining, and petroleum engineers are excluded. "Computer/information technology professionals" include computer engineers, systems analysts, database administrators, computer support specialists, computer programmers, computer programmer aides, programmers, (numerical, tool, and process control) and all other computer scientists. "Natural scientists" include agricultural and food scientists, biological scientists, conservation scientists and foresters, medical scientists, all other life

Oakland. High tech occupations have been found elsewhere to be highly skewed across the thirty largest US metropolitan areas (Markusen and Schrock, 2006).

Is the observed over-representation of high-tech-related occupations in the San Francisco Bay Area merely a function of industry mix, i.e. of high-tech establishments' greater likelihood of being located in these counties? Our answer is no. The presence of one-third or more of computer professionals in each of the three Bay Area metropolitan areas cannot be attributed to industry structure alone (the "unexplained share"), based on national averages for occupational composition by industry. Unexplained shares for scientists and engineers also were quite high. In the three Bay Area metros in 1997, about 35,000 more computer professionals were employed than if Bay Area high-tech industrial establishments' occupational composition had conformed to national norms. For the three occupational sectors studied, over 53,000 jobs were similarly unexplained.

These findings provide strong evidence that employment growth in the region over the period was skewed, relative to national averages, in favor of high-tech occupations associated with research and development. This same phenomenon did not hold for Los Angeles or Orange Counties, however. The San Diego metro economy showed a slight propensity toward higher shares of employment in these occupations but not nearly as dramatic as in the Bay Area.

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scientists, geologists, geophysicists, and oceanographers, physicists and astronomers, chemists, atmospheric scientists, and all other physical scientists.

What if we examine information technology industries exclusively?[8] We find even stronger confirmation that industry presence does not dictate occupational composition (Table 5). Information technology industry employment in the three Bay Area metros is highly skewed toward professional employment and away from employment in other occupational categories – notably service, precision, and manual workers. In business services in the Bay Area, unexplained shares generally range from one-third to one-half of all workers in the occupational categories listed. This discrepancy is less evident in other metropolitan areas. These findings suggest that a spatial division of labor has emerged in which high-tech occupational agglomerations – based on certain functional components of firms' production processes – are operating in certain regions and do not closely dovetail with industrial composition.

Does the over-representation in the San Francisco Bay Area of the three research and development occupations we have examined (computer professionals, selected engineers, and natural scientists) extend beyond the high-tech industry sector? If so, this would lend support to the notion that an occupational agglomeration is operating across a variety of industries in the region. To test this, we estimated the shares of employment unexplained by industry structure in the three high-tech-related occupations, after removing employment in information technology and business services from consideration. The results, shown in Table

[8] In this analysis, the information technology sector consists of the following categories from the Standard Industrial Codes: all employment in SIC 357 (computer and office equipment), SIC 36 (electronic equipment), SIC 38 (instruments and related products), SIC 871 (engineering and architectural services), and SIC 873 (research and testing services). Our definition of information technology industries derives from Daly (2001). However, because data limitations prevented us from distinguishing one component of the information technology sector – computer and data processing services, or SIC code 737, which includes software development – from its larger category, business services, we have computed the results for the business services industry separately.

6, suggest that even after discounting employment in information technology and business services, the three high-tech occupations studied are still highly over-represented in the San Francisco Bay region. Computer/IT specialists are particularly over-represented in the counties peripheral to the San Jose metro area, the heart of Silicon Valley. Figure 1 shows the results graphically. Although location quotients for the three high-tech occupations decline substantially after discounting employment in information technology and business services, the shares of employment unexplained by industry structure remain high. Rather than relying on an industrial characterization alone, it would be more accurate to characterize the Bay Area economy as possessing a unique high-tech industry/occupational agglomeration.

VI. Conclusion

Our findings demonstrate that estimating occupational composition from national industry-by-occupational structure produced a fairly reasonable approximation of actual employment by occupation at the state level in California in 1997. This suggests that planners might proceed with a certain degree of confidence in estimating overall statewide occupational demand from national industrial demand, at least in states resembling California. However, we find that certain occupations associated with innovative industries (specifically high-tech occupations) diverge markedly from expected outcomes in some metros. We also detect a division of labor by occupation between central and peripheral metro areas suggesting a hierarchy of intra-firm functions (management, technical, and professional labor on the one hand, and manual, precision, and service, on the other). These findings should raise concern among economic development practitioners about the accuracy of predicting high-tech occupational employment based on industry structure alone. Local practitioners should also consider central-peripheral relationships before assuming that occupational distribution can be easily read off industry distribution.

To what extent can our California metro findings be generalized to the rest of the US and elsewhere? Industries in the California metros studied exhibit some in-common divergence from the national occupation-by-industry structure. However, we also believe that the center-periphery and high-tech agglomeration features we noted might well apply in other states and parts of the country, in spite of the California-specific distinctions. In general, we hope researchers nationally and in other states will examine metropolitan regional occupational structures to determine whether and what state-level distinctions, center-periphery distinctions, and occupational agglomerations such as those we have noted are replicated elsewhere.

Among broad occupational categories, we found that retail sales workers were most evenly dispersed among California regions, and most closely matched the national distribution, after controlling for industry differences. We expect that this relationship might hold nationally. Even where one could argue, as with the Mall of America in the Twin Cities, that retailing is an export base function, the structure of employment in the retailing sector is apt to be very similar to that of the nation.

However, even local-serving industries may exhibit different structures of work in response to differences in consumption patterns. Our findings show that service industries were less evenly distributed across California regions, for example, and less closely matched the national distribution, than was the case for retail. Health care provides one example why this might be so. Regions with disproportionately aged populations (from either net migration or differential fertility rates) may require more and different forms of health care than regions with more youthful profiles.

We believe that the substantial discrepancy between expected and actual employment found in high-tech occupations in the Bay Area may reflect a broader tendency in industries in initial, fast-growth stages of their product/profit cycles. In other words, a spatial division of labor may be strongly reflected among establishments in innovative industries. Industries that are investing strongly in product and service innovation may be more likely to hire proportionally more highly skilled workers and locate them in higher cost urban locations while dispersing more routinized work elsewhere. This pattern was observed in Silicon Valley and California as a whole as far back as the 1970s (Saxenian, 1980; Markusen, 1985).

We surmise that researchers elsewhere may also find large discrepancies in some sectors when gauging occupational structure from industry structure, though the particular occupations incorrectly estimated could be different than in our analysis. For example, while high-tech occupations in the Boston, Minneapolis/St. Paul and Seattle regions might be underestimated as in our Bay Area findings, other regions might possess occupational structures for these same industries either below or similar to the nation's. Employment in science and engineering occupations in the pharmaceutical industry, for instance, might be under-estimated in central New Jersey but over-estimated elsewhere, since most of the leading edge research, product development, testing and marketing of drugs is concentrated in that region while routine production is decentralized elsewhere (Gray, 2002).

Such discrepancies may not be confined to high-tech and business service sectors elsewhere. Apparel industry employment in New York and Los Angeles, because of high fashion content, might be expected to support more designer jobs than apparel establishments in lower cost southern locations (Currid, 2006). Even in a mature industry like steel, occupational composition in older fully-integrated steel operations in places like Baltimore and Gary could be expected to differ substantially from newer steel-making in decentralized mini-mills around the US. As yet another example, labor-intensive underground coal mining in Virginia is quite different in character from highly capital-intensive strip mining in Montana. A similar distinction in production methods holds for agriculture across regions. Indeed, for some of these industries, regional occupational profiles might vary by much more than we have detected in the large and diverse set of California metros.

Especially for industries that comprise important segments of the trade specializations of regions, and those undergoing rapid change, local occupational structures may diverge from profiles derived from industry-by-occupational profiles at a larger geographical scale. These are precisely the sectors that are of central importance to economic development practice. Furthermore, industries on the innovative wave, such as medical instruments, electronics and biotechnology, are often those most sought by states and localities that do not yet host them. Major miscalculations could result from estimating future occupational composition of regional employers on the basis of these industries' profiles nationally.

For a region that aspires to an innovative or "high road" future, then, or one trying to cope with intense challenges to an existing economic base sector, occupational analysis should be conducted in its own right. We advise that regional analysts and planners conceptualize their economies as occupational as well as industrial portfolios and study the particular intersection between the two.

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Table 1. California Metropolitan Areas Covered in this Study

Metropolitan Area	Counties Included	Employment 1997
Major Metros		
Los Angeles/ Long Beach	Los Angeles	3,849,966
San Francisco*	San Francisco, San Mateo	875,969
Oakland	Alameda, Contra Costa	941,195
San Diego	San Diego	1,044,149
Suburban Metros in Large Conurbations		
Orange County	Orange	1,218,492
San Jose	Santa Clara	921,357
Riverside/ San Bernardino	Riverside, San Bernardino	833,630
Stand-Alone Metros		
Bakersfield	Kern	178,152
Fresno*	Fresno	247,589
Sacramento*	Sacramento	498,106
Redding	Shasta	54,763
US Economy		121,839,796

Sources: California Employment Development Department, *Occupational Employment Projections*, U.S. Bureau of Labor Statistics, *National Historical Industry-Occupation Matrix Time Series (NTS), 1983-1998*

* These metropolitan areas are only partially represented due to data limitations; only central counties are included.

Table 2. Differences between Actual and Industry-Based Estimates of Employment by Occupation Across Eleven California Metropolitan Areas, 1997

	Summary Measure of Difference Between Actual and Industry-Based Estimate, for 11 Metro Areas*	Standard Deviation of Unexplained Difference Across Metro Areas
Total Employment		
Disaggregated Level (93 categories)	5%	
Aggregated Level (6 categories)	3%	
Occupations at Aggregated Level:		
Managerial/Professional workers	7%	0.10
Sales and related workers	2%	0.02
Clerical and administrative support workers	5%	0.04
Service workers	7%	0.08
Precision workers	4%	0.06
Manual workers	8%	0.12

Sources: Authors' calculations based on data from California Employment Development Department, *Industry-Occupation Matrix, 1997,* and Bureau of Labor Statistics, *National Historical Industry-Occupation Matrix Time Series, 1983-1998*

* The summary measure for total employment is calculated as the sum across occupational categories and metropolitan areas of the absolute values of differences between actual and expected employment, as share of total employment, divided by two. The measures for separate occupational categories are calculated as the sum across metropolitan areas of the absolute values of differences between actual and estimated employment, as a share of total employment within each occupational category.

Table 3. Differences Between Actual and Industry-Based Estimates of Occupational Employment, as Share of Total Employment, for Eleven California Metropolitan Areas, 1997

Occupation	Total for MSAs Combined	Oakland	Fresno	Bakersfield	Los Angeles	Orange	Riverside/ San Bernardino	Sacramento	San Diego	San Jose	San Francisco	Redding
Summary Measure for Total Employment*												
Disaggregated Level	4	6	5	7	4	6	5	8	5	9	7	8
Aggregated Level	2	3	2	2	2	3	3	6	1	6	5	3
Aggregated Level:**												
Managerial/Professional work	4	9	-7	-5	-2	4	-11	14	4	17	14	-9
Sales and related workers	-2	1	0	-4	-4	-1	1	0	0	-6	0	2
Clerical, admin support	4	0	3	2	8	7	4	6	0	-5	0	5
Service workers	-7	-14	-3	2	-8	-3	0	-24	-3	-13	-8	2
Precision workers	-2	-1	4	3	-2	-7	4	-5	2	-6	-10	9
Manual workers	-4	-6	4	4	3	-9	7	-25	-8	-20	-25	-5

Source: Authors' calculations based on data from California Employment Development Department, *Industry-Occupation Matrix, 1997* , and Bureau of Labor Statistics, *National Historical Industry-Occupation Matrix Time Series, 1983-1998*

* The summary measures for total employment are calculated as in Table 2.
** The measures for separate occupational categories are calculated as the difference between actual and expected employment by occupational category as a share of total employment in the category.

Table 4. Incidence of Three High-Tech-Related Occupations in Six California Metropolitan Areas, 1997

	San Francisco	San Jose	Oakland	Los Angeles	Orange	San Diego
Computer/IT Professionals						
Location Quotient	2.0	3.3	1.7	0.9	1.3	1.3
Employment Share Unexplained by Industry	32%	38%	33%	-25%	2%	11%
# Jobs Unexplained by Industry	8,961	18,348	8,448	-13,433	572	2,277
Selected Engineers						
Location Quotient	1.2	4.6	1.7	0.9	1.5	1.7
Employment Share Unexplained by Industry	10%	37%	28%	-6%	10%	21%
# Jobs Unexplained by Industry	623	9,888	2,755	-1,383	1,104	2,274
Natural Scientists						
Location Quotient	1.8	1.7	1.9	0.8	0.9	1.8
Employment Share Unexplained by Industry	33%	18%	37%	-12%	-4%	3%
# Jobs Unexplained by Industry	1,504	756	1,872	-1,023	-125	142

Source: Authors' calculations based on data from California Employment Development Department, *Industry-Occupation Matrix,* and Bureau of Labor Statistics, *National Historical Industry-Occupation Matrix Time Series, 1983-1998*

Table 5. Share of Occupational Employment Unexplained by Industry Structure in Information Technology and Business Services, for Six California Metropolitan Areas, 1997

	San Francisco	San Jose	Oakland	Los Angeles	Orange	San Diego
Information Technology Industries, Excluding Computer and Data Processing Services						
Managerial/Professional Workers	10	21	15	12	5	8
Computer/IT Professionals	-11	21	1	11	-6	17
Selected Engineers	4	36	19	3	7	-3
Natural Scientists	48	12	35	7	19	6
Sales and related workers	3	-8	27	-22	24	-47
Clerical and administrative support	-18	-4	-2	8	11	-13
Service workers	-45	-43	-29	9	-24	-36
Precision workers	-21	-29	-8	-8	8	-16
Manual workers	-25	-34	-41	-25	-20	-1
Total Employment	35,532	214,907	50,089	153,605	87,690	74,513
Business Services (Includes Computer and Data Processing Services)						
Managerial/Professional Workers	35	38	28	-8	2	17
Computer/IT Professionals	39	57	40	-51	1	9
Selected Engineers	43	61	34	-167	-35	52
Natural Scientists	-30	-89	55	-32	-8	14
Sales and related workers	7	-44	-18	16	-33	-19
Clerical and administrative support	-3	-33	-14	-6	20	4
Service workers	-42	-56	-48	6	-5	-5
Precision workers	-118	28	-45	1	0	-18
Manual workers	-68	-15	14	1	-30	-28
Total Employment	111,411	128,230	93,027	353,245	123,314	90,357

Source: Authors' calculations based on data from California Employment Development Department, *Industry-Occupation Matrix,* and Bureau of Labor Statistics, *National Historical Industry-Occupation Matrix Time Series, 1983-1998*

Table 6. Concentration of High Tech Occupations in California Metropolitan Areas, 1997, With and Without Employment in Information Technology and Business Services Industries

	San Francisco Bay Area Metros*		Other Largest Cal Metros**		San Francisco Metro Area		San Jose Metro Area		Oakland Metro Area	
	With BS/IT	No BS/IT	With BS/IT	No BS/IT	With BS/IT	No BS/IT	With BS/IT	No BS/IT	With BS/IT	No BS/IT
Location Quotient										
Engineers	2.5	1.3	1.1	1.1	1.2	0.8	4.6	1.4	1.7	1.6
Scientists	1.8	1.4	1.0	0.8	1.8	1.2	1.7	1.4	1.9	1.7
Computer/IT	2.4	1.5	1.0	1.0	2.0	1.8	3.3	1.2	1.7	1.5
Employment Share Unexplained by Industry Structure										
Engineers	31	26	5	12	10	-1	37	28	28	37
Scientists	30	31	-6	-16	33	22	18	34	37	35
Computer/IT	35	26	-11	-7	32	29	38	11	33	32

Source: Authors' calculations based on data from California Employment Development Department, *Industry-Occupation Matrix*, and Bureau of Labor Statistics, *National Historical Industry-Occupation Matrix Time Series, 1983-1998*

* Includes the three metro areas listed

** Includes Los Angeles, Orange, and San Diego metro areas

Figure 1. Location Quotients and Employment Shares Unexplained by Industry Structure for Three High-Tech Occupations, With and Without Employment in Information Technology and Business Service Industries, for Major San Francisco Bay Area Counties in 1997