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Author
Cervero, Robert

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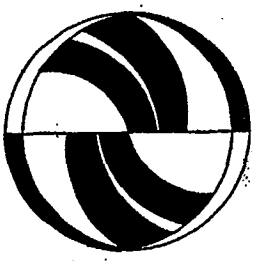

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Robert Cervero

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University of California Transportation Center

108 Naval Architecture Building
Berkeley, California 94720
Tel: 510/643-7378
FAX: 510/643-5456

Land-Use Mixing and Suburban Mobility

Robert Cervero

Department of City and Regional Planning
University of California at Berkeley
Berkeley, CA 94720

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Land-Use Mixing and Suburban Mobility

ROBERT CERVERO

Robert Cervero is Associate Professor of City and Regional Planning at the University of California, Berkeley. He recently completed a monograph, titled America's Suburban Centers: A Study of the Land Use—Transportation Link, *from which this article is drawn. Professor Cervero is presently conducting research on the affects of competitive contracting on public transit agencies and working in Indonesia on a rural economic development project.*

SUBURBAN traffic congestion has emerged as one of the most pressing problems in the transportation field today and, most probably, will hold center stage in the transportation policy arena for years to come. Most accounts link the suburbanization of congestion to the suburbanization of jobs during the 1980s.[1] Indeed, recent surges in suburban office employment have fundamentally altered commuting patterns, giving rise to far more cross-town, reverse-direction, and lateral travel movements than in years past. This dispersal of jobs and commuting has been a mixed blessing of sorts. While on the one hand it has relieved some downtowns of additional traffic and brought jobs closer to some suburbanites, on the other hand it has flooded many outlying thoroughfares with unprecedented volumes of traffic and seriously threatened the very quality of living that lured millions of Americans to the suburbs in the first place.

The way suburban workplaces are being designed, it could be argued, bears some of the blame for worsening congestion. In particular, the emergence of many suburban job centers that have a single dominant use, usually offices, could be inducing many employees to drive their own cars to work. These single-use office centers stand in marked contrast to traditional downtowns, most of which feature a

1. Robert Cervero, "Managing the Traffic Impacts of Suburban Office Development," *Transportation Quarterly* 34, 3 (1984): 533–550; Robert Cervero, *Suburban Gridlock,* (New Brunswick, NJ: Center for Urban Policy Research, 1986); C. Kenneth Orski, "Suburban Mobility: The Coming Transportation Crisis?" *Transportation Quarterly* 39, 2 (1985): 283–296; C. Kenneth Orski, "Toward a Policy for Suburban Mobility," *Urban Traffic Congestion: What Does the Future Hold?* (Washington, DC: Institute of Transportation Engineers, 1986).

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rich variety of offices, shops, restaurants, banks, and other activities intermingled amongst one another. While downtown workers can easily walk to a restaurant or a merchandise store during lunch, those who work in many campus-style office parks are almost stranded in the midday if they don't drive their own car to work. The problem has been less one of these workers clogging roadways during the noon hour and more one of regional thoroughfares being jammed during peak periods by those who feel compelled to drive so that they have an auto readily available during and after work.

This article examines the potential mobility benefits of developing mixed-use suburban workplaces, ones where offices, shops, banks, restaurants, and other activities are built side-by-side. The affects of current land-use mixes on the commuting choices of suburban workers are also studied based on an empirical analysis of some of the largest suburban employment centers in the United States. The article concludes with suggestions on how mixed-use developments could be encouraged in suburbia through various zoning and tax policy initiatives.

ADVANTAGES OF MIXED-USE DEVELOPMENTS

Mixed-use developments (MXD) can improve suburban mobility and reduce local traffic congestion in at least four ways: by reducing motorized travel; by spreading trips out more evenly throughout the day; by encouraging more workers to carpool and vanpool; and by allowing shared-use parking arrangements to be introduced.[2] Each of these benefits is discussed below.

Reductions in Motorized Travel

In many single-use environments, such as office parks, an automobile becomes almost indispensible for circulating within projects and accessing restaurants, banks, and other consumer services that are off site. A suburban job center with a lively mixture of activities, on the other hand, can internalize trips that would otherwise be made on areawide roads. Notably, significant shares of trips end up as foot traffic within individual buildings or between groups of buildings in mixed-use environments.[3]

2. The abbreviation MXD has been adopted by the Urban Land Institute and is used in this article. For a detailed discussion of MXDs, see: Dean Schwanke, Eric Smart and Helen J. Kessler, "Looking at MXDs," *Urban Land* 45, 12 (1986): 20–25.

3. Cervero, *Suburban Gridlock*, pp. 71–88.

MXDs reduce motorized travel and congestion levels in two key ways. First, since land uses have different trip generation rates, a given amount of floorspace spread among multiple activities will normally produce fewer trips than the same floorspace devoted to a single, more intensive use, such as office. Secondly, more travel is made by foot and bicycle, particularly during noon hour, and to the extent that workers are able to reside on-site or nearby, some motorized travel during morning and evening peak periods will also be replaced by walk and cycle trips.

Take a 100,000 square-foot office development, for example. Using a trip generation rate of 12.3 weekday trips per 1,000 gross square feet of general office space from the Institute of Transportation Engineers' (ITE) *Trip Generation* manual, this project could be expected to produce 1,230 daily vehicle trips, many of which would occur within a concentrated peak period.[4] If this same floor area was split into 25,000 square feet of general office space, 25,000 square feet of R&D space, 40,000 square feet of multi-family apartments (assuming an average of 1,600 square feet per unit), and 10,000 square feet of specialty retail, based again on ITE rates, the daily trips would fall to 1,000, and spread much more evenly throughout the day.[5] That is an 18.7 percent drop in daily traffic volume. Peak-hour volumes would likely fall even more since many retail trips occur throughout the day.

By allowing people to walk between nearby activities, MXDs further reduce vehicular traffic. For instance, office workers are more likely to spend their lunch hour at shops and restaurants located within the development rather than driving to an off-site shopping center when they work in a mixed-use setting. One study of MXDs in the greater Denver area estimated that mixed uses could reduce vehicle trip generation rates of individual uses within a development by as much as 25 percent.[6]

4. Institute of Transportation Engineers, *Trip Generation,* 4th ed. (Washington, DC: Institute of Transportation Engineers, Seminar Workbook, 1987).

5. ITE daily trip rates are: 5.3 weekday trips per 1,000 gross square feet of R&D, 6.1 trips per apartment unit, and 40.7 trips per 1,000 gross square feet of specialty retail. Thus, for this scenario, the trip volume can be calculated as: (25,000 office sq. ft. @ 12.3 trips/1,000 office sq. ft.) + (25,000 R&D sq. ft. @ 5.3 trips/1,000 sq. ft. R&D) + (40,000 sq. ft. apartments @ 1,600 sq. ft./apartment unit @ 6.1 trips/apartment unit) + (10,000 sq. ft. specialty retail @ 40.7 trips/1,000 sq. ft. specialty retail) = 999.5 daily trips.

6. Institute of Transportation Engineers, *Trip Generation,* pp. 27–29; Colorado/Wyoming Section Technical Committee, "Trip Generation for Mixed Use Developments," *ITE Journal* 57, 2 (1987): 27–32.

Spreading Out Demand

With a combination of office, retail, recreational, and other land uses on a site, trips tend to be spread more evenly throughout the day and week. In contrast, with a single function, such as office enterprises, many trips are concentrated in the morning and evening peak hours. If anything, then, the diversification of activities would help lessen the peak-hour crunch experienced by many large-scale suburban work centers.

This point is often overlooked by critics who condemn MXD proposals at public hearings in fear that their suburban communities will become inundated by traffic and transformed into urban-like places. While retail, hotel, restaurant, and other consumer land uses average far higher daily trip generation rates than office functions do on a square footage basis, most trips to such establishments occur in the evening, on weekends, and during lunch time when capacity is readily available. Thus, adding such activities into a development will normally add hardly any traffic to the morning rush hour and far less to the evening rush period than a comparable amount of office space would. By spreading out trip-making, MXDs in a way accomplish what flex-time and staggered work-hour programs accomplish without disrupting the work schedules of a private business. Moreover, by spreading out demand, MXDs allow available infrastructure to be efficiently used throughout the day, thus tempering the need to expand roads serving suburban job centers.

Inducement to Ridesharing

MXDs can also be a boon to ridesharing. Unless restaurants, shops, and banks are located nearby, most workers will find it necessary to drive their own cars in order to reach lunch-time destinations and run midday and after-work errands. From a mobility standpoint, the addition of noon-hour traffic usually poses few problems. Rather, problems are encountered during the peak hours because of the surfeit of automobiles with a single occupant who drives in order to have a car available during the day and after work.

Several recent surveys reveal how important an automobile can be to suburban workers for taking care of personal business. The top two reasons given by 17,000 surveyed employees of the Warner Center office complex in Los Angeles's San Fernando Valley for commuting alone were the need for a car after work (36 percent of respondents)

and for running midday errands (32 percent of respondents).[7] Another survey of employees working at Orange County's massive South Coast Metro development found that 83 percent felt they needed their cars at least once a week for personal business and 44 percent needed them at least three times a week.[8] Lastly, a recent study of suburban activity centers in the greater Houston area found that suburban employees are 1.6 times more likely to leave the immediate area for lunch than their downtown counterparts, in large part because of the dearth of on-site eateries and other consumer services near most suburban workplaces.[9]

Shared-Parking Possibilities

Mixed-use projects also create opportunities for shared-parking arrangements that can reduce the scale of a project and create a more pedestrian-friendly environment. In most instances, the parking demands of different land uses peak at different time periods. The same parking facility used by office workers from 8–5 on Mondays through Fridays could serve restaurant and movie goers during the evening and on weekends. It could serve as overflow parking for weekend shoppers as well. For multi-purpose trips, such as a work-shop-movie trip, only one parking space might be necessary if offices, stores, and theaters lie in reasonable proximity to one another. One study, for instance, found 28 percent of employees of MXDs patronized the same or nearby development, while only 19 percent of workers from single-use sites did so.[10]

An often overlooked mobility benefit of MXDs is that they lower the total parking requirements for a site far below what would be the sum of individual office, retail, and recreational uses. Developers of Los Angeles's Warner Center, for instance, were able to reduce parking in a central garage from 1,400 to 1,100 spaces because of land use mixing, saving over $3 million (1980 dollars) in the process.[11]

7. Commuter Transportation Services, "Warner Center Transportation Survey Results," (Los Angeles: Agency report, 1987).

8. Ruth and Going, Inc., "South Coast Metro Area Pilot Transportation Management Program" (San Jose, CA: Report prepared for the Orange County Transportation Commission, 1983).

9. Rice Center, *Houston's Major Activity Centers and Worker Travel Behavior* (Houston: Report prepared for the Houston-Galveston Area Council, 1987).

10. Barton-Aschman, Inc., "Shared Parking Demand for Selected Land Uses," *Urban Land* 42, 9 (1983): 12–17.

11. Ibid., p. 14.

Such a reduction in parking area can dramatically shrink the scale of a project and reduce the separation between buildings, thus inviting more foot travel. Today, many office parks devote more space to parking than they do to buildings. At the usual suburban standard of four parking spaces per 1,000 square feet of building space, with each stall measuring approximately 325 square feet in size, 1,300 square feet or more of asphalt is paved for every 1,000 square feet of office space.[12] Thus, more land is often used for the unproductive purpose of housing cars than for the productive purpose of housing office workers. To the extent that mixed-use projects allow the number of parking spaces to be reduced 20 to 30 percent, the overall dimensions of a project might be scaled down at a commensurate level, thus helping to contain sprawl and encourage more walk trips.

Benefits Beyond Transportation

Besides these transportation benefits, MXDs also add life to what sometimes are rather undistinguishable suburban work environments. By replacing vehicle trips with people trips, a far more active and socially interesting milieu can be created. A setting with an after-work night life can also entice more employees to live near their workplace, cutting down on vehicular traffic even more. A common complaint voiced by suburban businesses today is that their employees, especially those who have been reassigned from downtown, are disenchanted by the barreness and lack of urban amenities around their workplaces. For this and other reasons, MXDs appear to be becoming increasingly attractive to high-end tenants and are perceived by a growing number of developers as providing a competitive market advantage. Based on a recent Urban Land Institute report, MXDs appear to be gaining in popularity—61 percent of more than 200 MXDs studied had broken ground since 1980.[13]

LAND-USE COMPOSITION OF AMERICA'S SUBURBAN JOB CENTERS

As part of a larger study of how land-use patterns and site designs affect commuting choices in suburban areas, data were gathered in late-1987 on the land-use activities of 57 of the largest suburban

12. W. Paul O'Mara and John A. Casazza, *Office Development Handbook* (Washington, DC: Urban Land Institute, Community Builders Handbook Series, 1982).

13. Schwanke et al., "Looking at MXDs," p. 20.

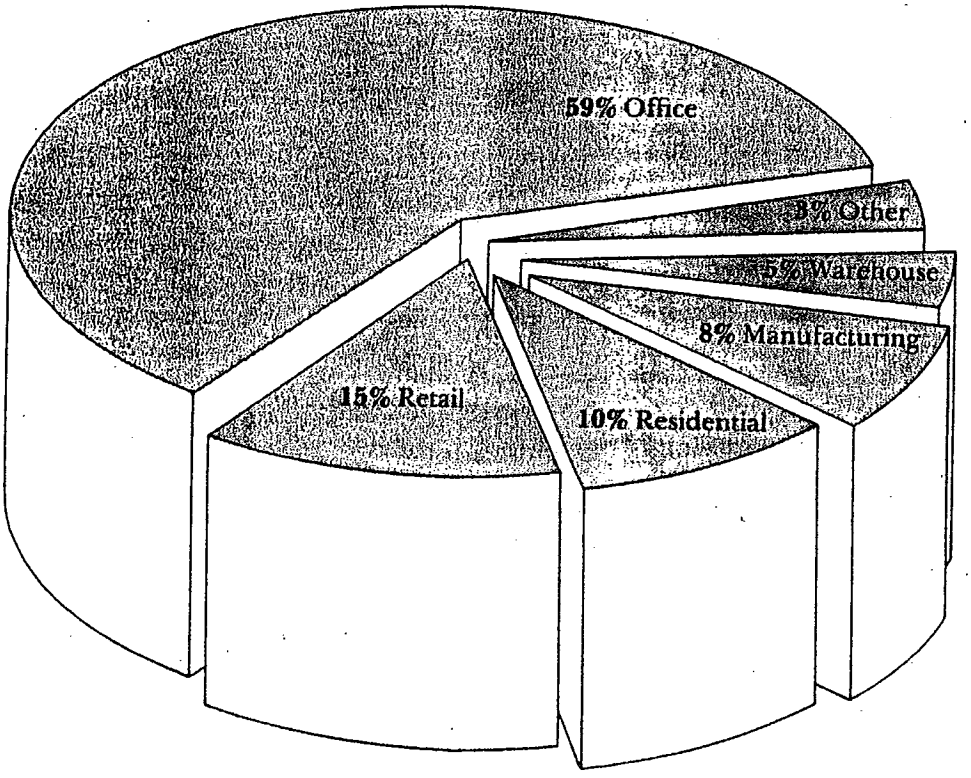

Figure 1. Percent of floorspace in land-use categories for 57 large suburban employment centers in the United States

employment centers in the nation.[14] Combining survey responses from office developers and various secondary sources, land-use data were compiled for suburban centers in 26 of the nation's largest metropolitan areas with at least one million square feet of office floorspace and 2,000 or more workers. Such notable suburban job centers as Post Oak and Greenway Plaza near Houston, Bishop Ranch and Hacienda Business Park east of San Francisco, Warner Center and South Coast Metro near Los Angeles, Tyson's Corner outside of Washington, Schaumburg Village and Oak Brook west of Chicago, the Meadowlands and downtown Stamford near New York City, the Denver Technological Center, and the North Dallas Parkway were included in the study.

Figure 1 and Table I indicate just how mixed the land-use activities are in the largest suburban employment centers in the nation. Among the 57 sites surveyed, the preponderance of floorspace

14. Robert Cervero, *America's Suburban Centers: A Study of the Land Use-Transportation Link* (Houston: Report prepared for the Urban Mass Transportation Administration, Rice Center for Urban Mobility Research, 1988).

TABLE I—LAND-USE AND MIXED-USE CHARACTERISTICS OF SUBURBAN EMPLOYMENT CENTERS IN THE UNITED STATES

	Mean	*Std. Dev.*	*Min.*	*Max.*	*No. Cases*
Land-Use Composition					
Percent of floorspace in					
Office use	59	23	10	99	56
Retail use	15	11	1	40	56
Consumer Services					
Number of on-site					
Restaurants/eateries[a]	19.6	27.3	0	89	18
Banks[a]	4.5	6.6	0	29	18
Shopping clusters and retail centers[b]	4.4	8.0	0	47	50
Employees/on-site restaurant[a]	3,715	7,335	281	30,000	18
Employees/on-site bank[a]	6,784	9,273	862	41,000	18
Employees/on-site retail center[b]	8,640	11,097	550	64,700	50
Square footage of retail space (millions) within 3 radial miles of suburban center[b]	1.92	2.10	0.02	8.0	45
Square footage of nearby retail space/employee[b]	170	329	12	2,215	45

a. Exclusive of corridors, consisting mainly of master-planned projects.
b. Exclusive of corridors, consisting mainly of well-defined clusters.

is being devoted to office uses. Retail is the second most prevalent activity, followed by housing, manufacturing, warehousing, and other uses (i.e., mainly consumer services, such as restaurants, hotels, and banks). Looking at the minimum and maximum ranges for shares of office and retail floorspace in Table I, it is apparent that the surveyed job centers vary considerably in their degree of land-use mixtures.

Table I also reveals the average number of restaurants and banks—important ingredients of any suburban mixed-use environment—within those suburban employment centers which are either master-planned or highly concentrated. Among the 18 cases for which data were available, there is, on average, approximately 20 eateries (ranging from restaurants to private delis, but exclusing company cafeterias) and 4 to 5 banks or savings institutions. The South Coast Metro in Orange County holds the distinction of having the most of both among the case sites—89 restaurants and 29 banks.

A larger subsample of fifty cases was available for studying the number of distinct retail centers within case sites. The average is in the 4-to-5 range, with the 2,600-acre Schaumburg Village, northwest of Chicago, featuring the most—47 centers. Additionally, the average number of shopping centers with over 100,000 square feet of gross floorspace within three radial miles of a suburban employment center

was found to be 3.6. These nearby shopping centers averaged around 170,000 square feet of retail space—an area comparable to a supermarket connected by around ten medium-size specialty stores.

Of course, the number of consumer establishments within a suburban job center is most relevant when compared to the number of on-site employees. Table I summarizes several retail intensity statistics. For the subsample of 18 cases, on average there are around 3,700 employees per eatery and 6,800 employees per bank, with considerable variation among sites. South Coast Metro earns top honors for having the highest level of retail intensity among suburban job centers, featuring a restaurant and a bank for every 281 and 862 employees, respectively.[15] Additionally, these large-scale suburban job centers were found to average around 8,600 workers for every on-site retail center and 170 square feet of areawide shopping space per employee.

Overall, it is apparent that the nation's largest suburban employment centers vary considerably in their degree of land-use mixture. While many have over 90 percent of floorspace devoted exclusively to office use, others feature a balance of office, commercial, and institutional activities. It is because of such variation that one could expect appreciable differences in the commuting behavior of workers among these study sites.

AFFECTS OF SUBURBAN LAND-USE MIXES ON MODE CHOICE

In order to study how the degree of land-use variation influences the modes that suburban workers choose, a series of stepwise regression models were developed. A host of variables measuring the size, density, land-use composition, and other site characteristics of each of the 57 cases were used, along with variables measuring the price and supply of transportation services (e.g., parking, road facilities, bus transit) available to workers. By using stepwise regression, the emphasis is placed on uncovering those combinations of variables that best account for variation in the dependent variable, in this case, the percentage of work trips made by various modes. Thus, although stepwise results do not provide insight into the influences of all variables of interest, they do offer a foundation for understanding the unique influences of those few variables that do enter into the analysis.

15. A high retail intensity level means a low value for the ratio of employees to retail establishments.

TABLE II—STEPWISE REGRESSION RESULTS ON FACTORS INFLUENCING PERCENTAGE OF WORK TRIPS BY DRIVE-ALONE MODE

Dependent Variable: DRIVALON[a]

Variable	*Beta Coefficient*	*Standard Error*	*t Statistic*	*Probability*
OFFICE[b]	0.12073	0.04973	2.428	.0200
VANSRUN[c]	−0.09058	0.02762	−3.279	.0022
EMP/INTC[d]	−0.00053	0.00019	−2.713	.0100
RIDECOOR[e]	−3.36511	2.32610	−1.446	.1562
Intercept	82.24903	3.70500	22.200	.0000

Summary Statistics:
Number of observations = 46
R-Squared = .436
F Statistic = 7.345
Probability = .0002

a. DRIVALON = Percentage of work trips by drive-alone mode.
b. OFFICE = Percentage of total floorspace in office use.
c. VANSRUN = Number of company vans in daily operation.
d. EMP/INTC = Employees per freeway interchange within a 5-mile radius.
e. RIDECOOR = Rideshare coordinator in suburban center: 1 = yes, 0 = no.

Below, the best-fitting models for predicting the share of work trips made by driving alone, ridesharing, and walking-cycling are presented.

Drive-Alone Models

Table II summarizes the stepwise results for the dependent variable DRIVALON—percentage of work trips made by individuals who drive alone to their suburban job. For the 46 cases with complete data, a model with reasonably good predictive powers was obtained, explaining over 43 percent of the variation in DRIVALON. Three "supply-side" variables and one "land-use" variable entered the stepwise equation. On the supply-side, the model indicates that the share of work trips to SECs by solo-commuters declines as the number of vans in operation (VANSRUN) increases and the relative number of site access points decreases (i.e., EMP/INTC rises), all else equal.[16] The equation also suggests that, *ceteris paribus,* drive-alone shares fall around 3.4 percent if there is a designated rideshare coordinator at the suburban workplace (RIDECOOR).[17] Promotion

16. High values of EMP/INTC represent low levels of site access. Thus, the negative sign on EMP/INTC suggests that as site access improves (i.e., EMP/INTC rises), then the percent of trips by solo-commuters drops off.

17. RIDECOOR is a dummy variable. If it takes on values of 1 (i.e., a rideshare coordinator position exists at the suburban center), then DRIVALON rises by 3.36 percent.

and support of ridesharing, thus, clearly seems to be paying off in large suburban work centers. According to the model, a suburban center with twenty vans in operation and a rideshare coordinator could be expected to reduce the share of work trips made by solo commuters by about 5 percent over a suburban center with no vanpools or coordinator position.

The sole land-use variable that entered the equation was OFFICE—the percent of floorspace in office use. Based on the sign on the variable OFFICE, as suburban workplaces become more office-oriented, the share of solo-commute trips can be expected to rise. All else equal, a suburban center with a share of total floorspace in office use that is 20 percent higher than an otherwise comparable center can be expected to have a 2.4 percent higher share of work trips made by solo commuters. This finding clearly supports the proposition that single-use office environments induce vehicle commuting. By inference, then, mixed-use work environments should reduce auto dependency and encourage workers to seek out other commute options.

The analysis of site factors that influence solo commuting generally ignores the affects of larger regional influences, such as the quality of regional bus services, on mode splits. These regional factors can be controlled for by taking the difference between drive-alone shares for each suburban work center and drive-alone shares for the entire region in which the center lies. The variable that measures these differences, DRIVDIFF, takes on a positive value when a larger share of employees at a suburban center solo commute than at the "typical" workplace in the region.[18] The stepwise results of modeling DRIVDIFF for 37 case sites from which data were available are shown in Table III. These results are fairly similar to those of the previous model, except two "land-use mixture" variables, and only one supply-side variable, entered this model. A reasonably good fit of the data was obtained and all of the variables that entered the model have coefficients that match *a priori* expectations.

Table III shows, as before, that the introduction of a modal competitor, namely vanpools, decreases the dominance of the private automobile in suburban employment centers. Every twenty vans

18. The magnitude of this percentage point difference reflects roughly just how much more suburban workers appear to be auto dependent than all other workers in the region. Since mode shares for both worker groups are influenced by the quality of regional transit services, the cost of automobile usage, and other factors, these influences are controlled for when differences are taken between the two percentages.

TABLE III—STEPWISE REGRESSION RESULTS ON FACTORS INFLUENCING DRIVE-ALONE COMMUTING AT SUBURBAN WORKPLACE RELATIVE TO REGIONAL AVERAGE

Dependent Variable: DRIVDIFF[a]

Variable	*Beta Coefficient*	*Standard Error*	*t Statistic*	*Probability*
OFFICE[b]	0.13623	0.05803	2.347	.0255
RSFT/EMP[c]	−0.00969	0.00427	−2.269	.0304
VANSRUN[d]	−0.09665	0.03141	−3.077	.0043
Intercept	0.09738	0.03897	0.028	.9402

Summary Statistics:
Number of observations = 37
R-Squared = .373
F Statistic = 6.145
Probability = .0021

a. DRIVDIFF = Drive-alone work trip percentage minus regional drive-alone percentage.
b. OFFICE = Percentage of total floorspace in office use.
c. RSFT/EMP = Retail square footage within 3-mile radius of suburban center per on-site employee.
d. VANSRUN = Number of company vans in daily operation.

reduces the share of trips made to a suburban center by solo commuters by about 2 percent over the share of a typical workplace in the region. And as before, office environments seem to increase the relative dependency of suburban workers on their automobiles (i.e., relative to the "typical" worker in the region). The additional land-use variable that has entered this second model gauges the relative amount of retail space nearby (RSFT/EMP). The negative sign on this variable suggests that the relative automobile dependency of suburban workers declines as the amount of retail space per employee in reasonable proximity to a suburban center increases. As an indicator of land-use diversity, it is clear that nearby retail and other mixed-use offerings encourage workers to choose other commuting options to driving alone.

In sum, land-use composition emerged as the primary site factor that influences the level of solo commuting among workers of large suburban centers. Specifically, the share of space in office use and the relative availability of nearby retail activities appear to have a significant affect on the share of work trips that are driven alone. Overall, then, more varied land uses appear to offer a reasonably good potential for reducing auto dependency in suburban employment settings.

Rideshare Model

Solo commuting constitutes over 80 percent of all work trips made to the overwhelming majority of suburban employment centers studied. The only serious competitor in most instances is vehicle-pooling, whether by private automobile or van. Table IV presents the best model obtained for predicting RIDESHAR—the percent of work trips by vanpool or carpool. The model, which explained one-half of the total variation in RIDESHAR, offers a slightly different perspective on the mode choices of suburban workers from the two prior ones.

The two supply-side variables that entered the equation reinforce what was learned from the prior models. The share of work trips by vanpools or carpools rises as more vans are sponsored by companies and the relative number of access points to the site falls (i.e., the variable EMP/INTC rises). Both variables are statistically significant at the .05 probability level.

The variable OFFICE further confirms the importance of land-use mixing on commute choices. The equation suggests that as office uses become more dominant, ridesharing can be expected to slip in its share of the commuting market. It follows that unless other activities take place at a site—most importantly, consumer services, such as at

TABLE IV—STEPWISE REGRESSION RESULTS ON FACTORS INFLUENCING PERCENTAGE OF WORK TRIPS BY RIDESHARE MODES

Dependent Variable: RIDESHAR[a]

Variable	*Beta Coefficient*	*Standard Error*	*t Statistic*	*Probability*
VANSRUN[b]	0.15264	0.03618	4.218	.0002
EMP/INTC[c]	0.00044	0.00017	2.582	.0151
J/HAREA[d]	0.08632	0.04566	1.850	.0804
OFFICE[e]	−0.05686	0.03477	1.635	.1089
Intercept	11.10422	2.96415	3.746	.0008

Summary Statistics:
Number of observations = 35
R-Squared = .499
F Statistic = 7.226
Probability = .0004

a. RIDESHAR = Percentage of work trips by vanpool or carpool.
b. VANSRUN = Number of company vans in daily operation.
c. EMP/INTC = Employees per freeway interchange within a 5-mile radius.
d. J/HAREA = Ratio of on-site employees to estimated housing units within a 3-mile radius of suburban center.
e. OFFICE = Percentage of total floorspace in office use.

restaurants and banks—then suburban employees will be less inclined to participate in a vanpool or carpool program.

The inclusion of the other land-use variable in Table IV poses an interesting paradox, of sorts. The variable J/HAREA, which reflects the degree to which jobs and housing units are in balance, suggests that when there is a relative shortage of nearby housing, employees are more likely to live farther away and vehicle-pool. By extension, when housing is more plentiful nearby, relatively fewer commutes will be made in carpools or vanpools. Thus, jobs-housing balances tend to work against carpooling and vanpooling. For short distances, ride-sharing is unattractive because the time spent picking up other passengers en route is generally viewed as excessive. Thus, balancing jobs and housing growth cannot be expected to necessarily reduce solo commuting. It might even encourage some to drive to work. In a balanced environment, however, more commuters would be driving short distances on mainly local streets rather than mixing with through traffic on freeways. The other primary benefit of jobs-housing balances, of course, is that some employees may find it convenient to walk or cycle to work.

Walking-Cycling Model

While fewer than 3 percent of employees at all of the suburban centers studied walk or cycle to work, it is nonetheless instructive to explore whether mixed-use developments are associated with higher than normal rates of non-motorized commuting. After all, shaving the share of motorized trips just by a few percentage points can mean the difference between gridlock and more tolerable flow conditions in many congested corridors around the country.

Table V presents the best-fitting model for explaining the dependent variable WALKBIKE, the percent of work trips by walking or cycling for 36 of the case sites. The supply-side variable that entered the equation reflected the level of vanpool service (EMP/VAN). The sign on the variable EMP/VAN suggests that where there are few vans relative to the number of employees, the share of commutes made by foot or via bicycle increases, all things equal. This probably reflects less the fact that walking can serve as a substitute for vehicle-pooling and more the fact that balanced, mixed-use settings tend to have high shares of walking and relatively low shares of vanpooling. One can surmise, then, that factors like jobs-housing balance and land-use

TABLE V—STEPWISE REGRESSION RESULTS ON FACTORS INFLUENCING PERCENTAGE OF WORK TRIPS BY WALKING AND CYCLING MODES

Dependent Variable: WALKBIKE[a]

Variable	*Beta Coefficient*	*Standard Error*	*t Statistic*	*Probability*
EMP/VAN[b]	0.00009	0.00002	5.323	.0000
RETAIL[c]	0.05861	0.02363	2.480	.0190
EMPLOYMT[d]	0.00529	0.00303	1.746	.0910
Intercept	−0.01309	0.04455	−0.029	.9768

Summary Statistics:
Number of observations = 36
R-Squared = .663
F Statistic = 19.727
Probability = .0000

a. WALKBIKE = Percentage of work trips by walking or cycling.
b. EMP/VAN = Employees per on-site company sponsored van in operation.
c. RETAIL = Percentage of total floorspace in retail use.
d. EMPLOYMT = Size of full-time work force, in thousands.

mixtures are intervening influences on the relationship between walking and vanpooling.

The two land-use variables that entered the model are RETAIL and EMPLOYMT, tapping the "compositional" and "size" dimensions of suburban employment centers. Importantly, the equation suggests that walking and cycling trips are more likely to occur as the share of floorspace devoted to retail activities increases. The availability of on-site retail activities, one can infer, allows some workers to take care of personal business and other chores on foot, freeing them of the need to have an automobile available. The equation further suggests that as the employment base of a suburban center increases, so does the share of walking and cycling trips.

Summary of Mode Choice Models

Overall, the findings of this research confirm the hypotheses set forth regarding the affects of mixed-use environments on commuting. Single-use office settings seem to induce solo commuting, whereas work environments that are more varied generally encourage more ridesharing, walking, and cycling. Particularly important to ridesharing is the availability of consumer retail services. While the synchronization of job and housing growth around suburban centers could be expected to encourage more foot and bicycle travel, at the same time, ridesharing and vehicle occupancy levels could be expected to fall off

some. The benefits of jobs-housing balancing, therefore, relate more to the shortening of vehicular trips and the easing of local through-traffic conflicts than to inducing people to walk or cycle to work.

ENCOURAGING MIXED-USE SUBURBAN DEVELOPMENTS

From a mobility standpoint, a strong case can be made for diversifying activities in suburban workplaces of tomorrow. Future workplaces should be more like work centers of yesteryear when walking was the dominant mode of travel—ones with well-defined cores and a lively mixture of complementary activities. Offices, shops, banks, restaurants, and housing need to be built in close proximity to one another. Besides encouraging workers to commute in some other manner than the private automobile, mixed-use environments would spread trip-making more evenly throughout the day and allow for more space-saving shared-parking arrangements.

Among the instruments available for encouraging mixed-use developments, those which produce zoning and tax incentives would probably yield the most lasting mobility dividends. Inclusionary zoning, for instance, might be introduced to encourage the joint development of offices, housing units, and retail services in all master-planned business parks. Another way of diversifying projects is through conditional-use zoning, wherein conditions are set to allow land uses normally prohibited from a zone. Conditions might include allowing a new office project only if it is located within a specified radius of an existing high-density residential area or retail complex.

Incentive zoning could also be used to bring about a more heterogenous built environment. Developers, for instance, could be granted density bonuses that allow more intensive development in exchange for diversifying their projects. This is being done in the booming suburban center of Bellevue, Washington, some ten miles east of downtown Seattle. Under a "Floor Area Ratio Incentive System," those who build new projects in downtown Bellevue can add two square feet of office space for every square foot of retail space they provide. Bellevue's bonus system also encourages jobs-housing balances. For most downtown zones, developers can build four additional square feet of office space for every square foot of housing provided. This provision seems to be paying off. A 15-story residential tower was recently erected in downtown Bellevue and a number of other large-scale residential projects are in various stages of completion.

Through this bonus system, Bellevue officials aim to create a lively, mixed-use core that is active around the clock.

Another approach to diversifying land uses is through zoning swaps. Here, the zoning classifications of two different parcels within a community are switched to create a richer mixing of activities. The city of San Jose, California, for instance, recently instituted a zoning swap policy by rezoning an industrial area into residential at the northern end of the city while rezoning an equivalent residential land parcel to industrial usage. The intent of this zoning swap is to scatter employment growth, promote mixed-use developments, and eventually reduce commuting distances.

Tax concessions could likewise promote mixed-use projects. In recognition of the fact that developments with a mix of offices, shops, and residences will likely place less of a burden on public infrastructure than comparable-size single-use projects, consideration might be given to granting property tax credits to developers who diversify their projects.

Finally, performance standards might also be introduced to make the inter-mixing of offices, stores, and residences more attractive to developers. In Cupertino, California, for instance, a program has been instituted that encourages developers to commingle land uses. Prior to formal permit application, a developer is informed how many trip ends his project is allotted at a given time in the future. The developer can then propose whatever mixture of land uses will contain trip-making to within the allotted ceiling. Since the trip generation rates applied in making the projections are considerably lower for multi-use than single-use projects of comparable size, developers have a built-in incentive to add retail, restaurants, and housing components to their proposals.

In close, the reason why the land-use character of suburban workplaces is of such paramount importance is that many employment centers around the country are just beginning to take form. It is imperative that developers and planners seize the opportunity to coordinate transportation and land use while many projects are at a fairly embryonic stage and there is still time to take steps that will enhance future mobility. For once the vast majority of projects in an area are on the ground, the stage is already set for how workers will commute for years to come and the opportunities to build environments that promote certain commuting options will be quite limited.

As suburbia continues to become the destination of more and more travel, it is essential that policy makers carefully consider how the land-use make-up of suburban workplaces will affect travel behavior and traffic conditions. Future levels of mobility and overall quality of suburban living could very well depend on it.

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