The U.S. Context for Highway Congestion Pricing

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September 30, 2006

INTRODUCTION

If price does not ration, something else will. We also know that auto ownership and use respond to rising income and that congestion has become the default rationing mechanism on most of the world's roads and highways. Economists and others have pointed out that this is increasingly wasteful and have argued that time-of-day pricing should be implemented (see, for example, the recent collection of essays edited by Roth 2006). Modern monitoring and collection technologies suggest that this can now be done at low cost – although that assertion is challenged in a recent examination of the Stockholm road pricing trial, by Prud'homme and Kopp (2006).

Policy makers in the U.S., however, have for the most part been reluctant to go along, fearing the prospect (or the appearance) of regressive impacts – even though they are thereby foregoing a new and considerable revenue source. In Chapter X of this volume, Shoup argues that improved revenue targeting and sharing schemes could develop greater political support.

The world's best-known experiments with road pricing have been the area-pricing programs in Singapore (since 1975)[1] and London (since 2004). On a smaller scale, there have been scattered cases around various cities of the developed countries with moderately scaled pricing experiments on specific areas or on specific stretches of highways.

Recently, some writers have suggested that we are now near a tipping-point in the U.S., and that many more road pricing projects will soon be implemented (Poole and Orski 2006). What do we know about the modern U.S. urban transportation context? What does it suggest for further pricing projects in this country? This chapter is a survey of recently accumulated descriptive research findings and attempts to answer both questions.

There are two key results that emerge. First, in most major U.S. cities, trip origins and destinations of are dispersed. This makes London- or Singapore-style area-pricing impractical. An HOV-lane-to-HOT-lane conversion plan may be more appropriate. Second, the growth of non-work travel – many trips which are probably more responsive to dollar cost increases than commutes – at *all* times of the day makes the pricing alternative more attractive than had heretofore been thought. A look at the online TDM encyclopedia[2] which includes a summary of recently estimated transportation demand elasticities suggests that more specific knowledge in this area would be helpful. Our study of non-work travel also depicts the growth of *chained tours* that combine work trips with non-work trips. These are not likely to be done via transit or via carpools. This further strengthens the case for the HOT-lane approach.

DATA

Cities have been decentralizing for many years. In the U.S., the group of 75 largest cities gained population share until about 1940, but have been losing their proportionate importance ever since. The suburbanization of origins and destinations has been used to explain relatively benign commuting times in the U.S. – in spite of the absence of road pricing (Gordon, Kumar, and Richardson 1989; Crane and Chatman 2003). In fact *average* travel speeds on U.S. roads had been *increasing* to 1995. Less benign travel speed and time trends since 1995 have been explained by the prosperity of the late 1990s (more income, more cars, more errands by car, see below) coupled with a decline in road construction (Gordon, Lee, and Richardson 2004).

Our analysis begins where these well known fact leaves off, by considering trends for the smallest spatial units for which data are available to us and by considering employment as well as population locations.

We relied on two data sets. One was the 2000 Census Transportation Planning Package (CTPP) data, drawn from the decennial census journey-to-work survey. The CTPP is one of the few sources of employment data by place of work for small geographical units such as census tracts or traffic analysis zones (TAZs). It provides tabulations of households, persons and workers by place of residence, by place of work, and for journeys-to-work. These are all important information for grasping the extent of decentralization and dispersion of population and jobs in U.S. metropolitan areas.

We also worked with data from the 1990 and 1995 Nationwide Personal Transportation Surveys (NPTS) and the 2001 National Household Travel Survey (NHTS) for the study of work and non-work travel patterns. In the eleven-year interval, U.S.

population grew by 16 percent while the number of workers grew by 22 percent, household vehicles increased by 23 percent, person-trips by 34 percent and person-miles by 40 percent. Constant dollar per capita income over the eleven years grew by 21 percent.

The surveys, initiated in 1969 by the U.S. Department of Transportation (USDOT), provide detailed data on households, people, vehicles, and travel for all purposes by all modes. Thus, the NPTS/NHTS data series are one of the best data sources for the analysis of nationwide travel trends. Nevertheless, there are some comparability issues from one survey to another because the survey techniques changed between survey years. In particular, a travel diary (replacing memory recall) and household rosters have been used only since the 1995 survey. These changes have significantly improved interview responses. Hu and Young (1999) provides a method to adjust 1990 data for comparison with 1995 and 2001 results by estimating the impact of the two new techniques had they been used in the 1990 survey. Another problem is that, given what is known of work trip trends in the 1990s, the 1995 survey is believed to overestimate work trips. For these reasons, our trip-level analysis relies on the 1990 and 2001 data only. However, we did use 1995 and 2001 data for tour-level analyses because there was no information on trip-chaining behavior in the 1990 data.

CENTRALIZATION, DISPERSION AND DECENTRALIZATION

London- or Singapore-style area pricing schemes are effective in cities with highly centralized employment or sizable Central Business Districts (CBDs). For instance, the original congestion charging zone in Central London[3] – an eight-square mile area inside the Inner Ring Road – contained about 1.1 million jobs, or 27 percent of total employment in Greater London as of 2005 (Santos and Fraser 2006). Singapore's Restricted Zone covered an area of about 2.8 square miles including the CBD and 315,000 jobs, or about 20 percent of the city state's total employment were centralized in the zone as of 1990 (McCarthy and Tay 1993).

However, U.S. metropolitan areas are much more decentralized and dispersed. We were able to define and identify major employment centers and subcenters. In general, urban employment centers are defined as clusters of zones that have higher employment density than the surrounding areas. Two types of procedures have been popularly used in identifying density peaks, a minimum density procedure (Giuliano and Small 1991) and a nonparametric method (McMillen 2001). In a previous study (Lee 2007), we found that employment centers defined by the latter best reflect downtowns as we know them.

We identified CBDs and subcenters in 79 largest U.S. metropolitan areas using a modified version of McMillen's geographically weighted regression (GWR) procedure. Whereas he identified TAZs that have higher actual density than the estimated GWR surface, we compared two estimated employment density surfaces – one with a small window size (10 neighboring census tracts) and the other with a large window size (100 census tracts) (for detailed descriptions of the procedure, see Lee 2007). Among the identified employment density peaks, we qualified only those with more than 10,000 jobs as employment centers.

Table 1 shows CBD size and employment shares by location type in the largest U.S. metropolitan areas and average values in each metro size class. In every one of the major U.S. metro areas (those with population over 3-million), the largest share of employment was dispersed, outside of any identifiable center. Also in every one of the largest metro group, the CBD accounts for less than 10 percent of total metro employment. The Table also reveals similar tendencies for the smaller metros in our sample. Agglomeration opportunities come in many shapes and sizes but there are now many more Silicon Valleys than Manhattans. The dispersion tendency, of course, takes some congestion pressures away from centers but it also decreases the possible usefulness of the area pricing approach.

Table 1. Employment shares by location type and CBD size in the largest U.S. metropolitan areas, 2000

Metro name	Population (thousands)	Employment (thousands)	CBD Emp. (thousands)	CBD Area (sq.miles)	No. of Sub-centers	Share of employment (%) CBD	Share of employment (%) Sub-Centers	Share of employment (%) Dis-persed
New York	21,200	9,418	937.1	1.9	33	9.9	11.2	78.8
Los Angeles	16,370	6,717	190.1	2.5	53	2.8	28.8	68.4
Chicago	9,158	4,248	297.8	1.2	17	7.0	11.9	81.1
Washington	7,608	3,815	283.3	1.6	16	7.4	11.8	80.8
San Francisco	7,039	3,513	205.6	0.8	22	5.9	24.2	70.0
Philadelphia	6,188	2,781	239.7	2.4	6	8.6	4.5	86.9
Boston	5,829	2,974	238.1	1.7	12	8.0	8.0	84.0
Detroit	5,456	2,509	129.8	4.7	22	5.2	22.2	72.6
Dallas	5,222	2,566	126.0	4.7	10	4.9	15.8	79.3
Houston	4,670	2,076	165.5	4.1	14	8.0	20.8	71.2
Atlanta	4,112	2,088	166.9	3.9	6	8.0	10.7	81.3
Miami	3,876	1,624	121.0	4.0	6	7.5	15.0	77.5
Seattle	3,555	1,745	163.1	1.7	7	9.3	11.9	78.8
Phoenix	3,252	1,464	104.4	5.5	9	7.1	12.9	79.9
Averages by metropolitan area population size group								
3 million +					17	7.1	15	77.9
1 – 3 million					2.6	10.8	7	82.2
.5 – 1 million					0.9	12.2	5.2	82.6

Source: modification from Lee (2006).

Table 2 presents (one-way) commute times in 2000, by workplace location type. These data are for drive-alone commuters only so that mode mix changes do not perturb the results. It shows that the shortest commutes are for workers with destinations at dispersed locations. CBD workers spend significantly more time in commuting than other metro commuters especially in largest metro areas. CBD workers' commute time is almost twice longer than metropolitan average in New York and they spend 40 to 53 percent extra commute time in Philadelphia, Chicago, and Boston, which have relatively large CBDs. These older CBDs can still offer enough agglomeration economies to fund the wages that offset the longer commutes.

Table 2. Commute time by drive alone mode by location type, 2000

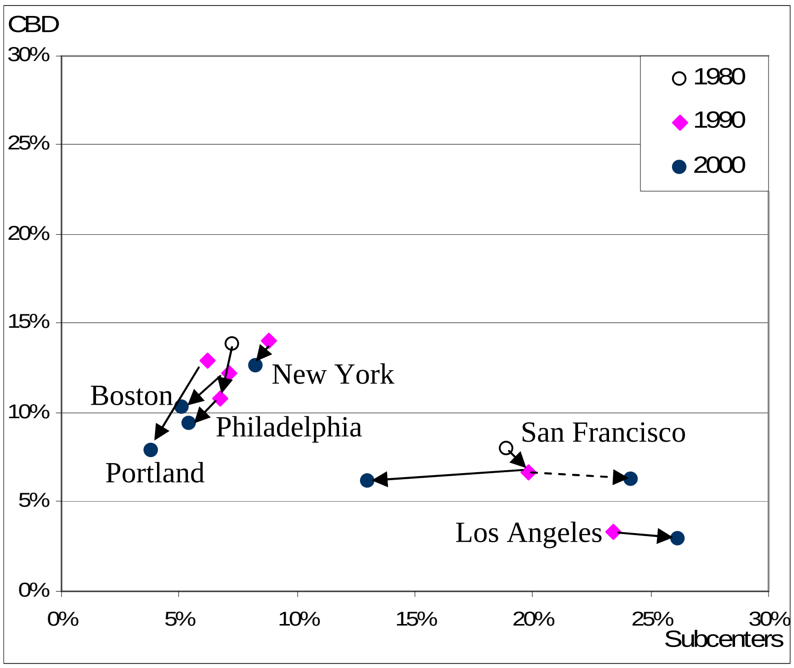
Metro name	Population (thousands)	Employment (thousands)	2000 Commute time by drive alone mode (min)			
			Metro	CBD	Sub-centers	Dis-persed
New York	21,200	9,418	28.5	55.6	30.2	27.8
Los Angeles	16,370	6,717	27.8	36.6	28.9	27.0
Chicago	9,158	4,248	28.9	41.8	32.1	28.0
Washington	7,608	3,815	30.3	40.2	30.2	29.8
San Francisco	7,039	3,513	28.4	39.3	29.3	27.8
Philadelphia	6,188	2,781	26.1	36.6	26.1	25.7
Boston	5,829	2,974	27.1	41.6	25.9	26.7
Detroit	5,456	2,509	26.2	31.0	27.7	25.4
Dallas	5,222	2,566	27.4	31.5	28.0	27.1
Houston	4,670	2,076	28.1	32.9	28.9	27.3
Atlanta	4,112	2,088	30.9	36.0	31.4	30.3
Miami	3,876	1,624	27.9	33.8	28.9	27.1
Seattle	3,555	1,745	26.2	30.7	26.3	25.8
Phoenix	3,252	1,464	25.4	31.1	24.7	25.0
Averages by metropolitan area population size group						
3 million +			27.8	37.1	28.5	27.2
1 - 3 million			24.1	26.9	23.4	23.8
.5 - 1 million			22.3	23.3	21.7	22.2

Source: modification from Lee (2006).

We were also able to describe changes in employment decentralization and dispersion over the last one or two decades. But, unfortunately, census tract level employment data conversion between census years was possible only for six metro areas. Figure 1 summarizes the results, in which X- and Y-axes represent the share of metro employment in subcenters and the CBD, respectively. Thus, we can read from the Figure that Los Angeles and San Francisco are more polycentric than the other four metropolitan areas in relative terms.

Employment decentralization occurred for the years shown in all six of these metro areas. The CBD's employment share shrank in each metro. Second, subcenters' employment share also fell in New York, Boston, Philadelphia, and Portland while significant subcentering occurred in the two western polycentric metros. It is interesting to find that more centralized places experienced increased dispersion. Nevertheless, either version of these spatial evolutions makes area congestion charging schemes even less attractive.

Figure 1. Trends of employment decentralization and dispersion, 1980 to 2000



Note: Employment density peaks in Silicon Valley were not identifiable after we converted 2000 data onto 1990 census tracts as we did for other metros. This is because there were many changes in census tracts boundary. Dotted line for San Francisco presents the 2000 result without the data conversion. Source: Lee (2007).

NON-WORK TRIPS

Much of the discussion of the "urban transportation problem" focuses on commuting, and commuting is thought to be a peak-hour problem. Both thoughts require some re-examination. In recent research, we found that most travel by Americans does not involve commuting. In fact, a large majority of peak period travel is not work-related.

In a recent paper, we investigated work and non-work travel patterns in terms of temporal variation (Lee, Gordon, et al. 2006). All trips in 1990 and 2001 were grouped by ten distinct periods of the week according to their departure time (Table 3). Non-work trips accounted for more than four-fifths of all trips in each year of the surveys, and were a sizeable majority in every one of the ten time-of-week periods including peak-hour periods (Table 4). They also grew more quickly between the 1990 and 2001 survey years than work trips (by 30 percent as opposed to 23 percent, while the U.S. population grew by 15.8 percent).

Table 3. Definitions of ten periods of the week

Time of day/week	Week	Departure time
Mon.-Thu. AM peak	Mon.-Thu.	6:00am-8:59am
Mon.-Thu. Day off-peak	Mon.-Thu.	9:00am-3:59pm
Mon.-Thu. PM peak	Mon.-Thu.	4:00pm-6:59pm
Mon.-Thu. Night off-peak	Mon.-Thu.	7:00pm-5:59am
Friday AM peak	Friday	6:00am-8:59am
Friday day off-peak	Friday	9:00am-3:59pm
Friday PM peak	Friday	4:00pm-6:59pm
Friday night off-peak	Friday	7:00pm-5:59am
Saturday	Saturday	0:00am-12:59pm
Sunday	Sunday	0:00am-12:59pm

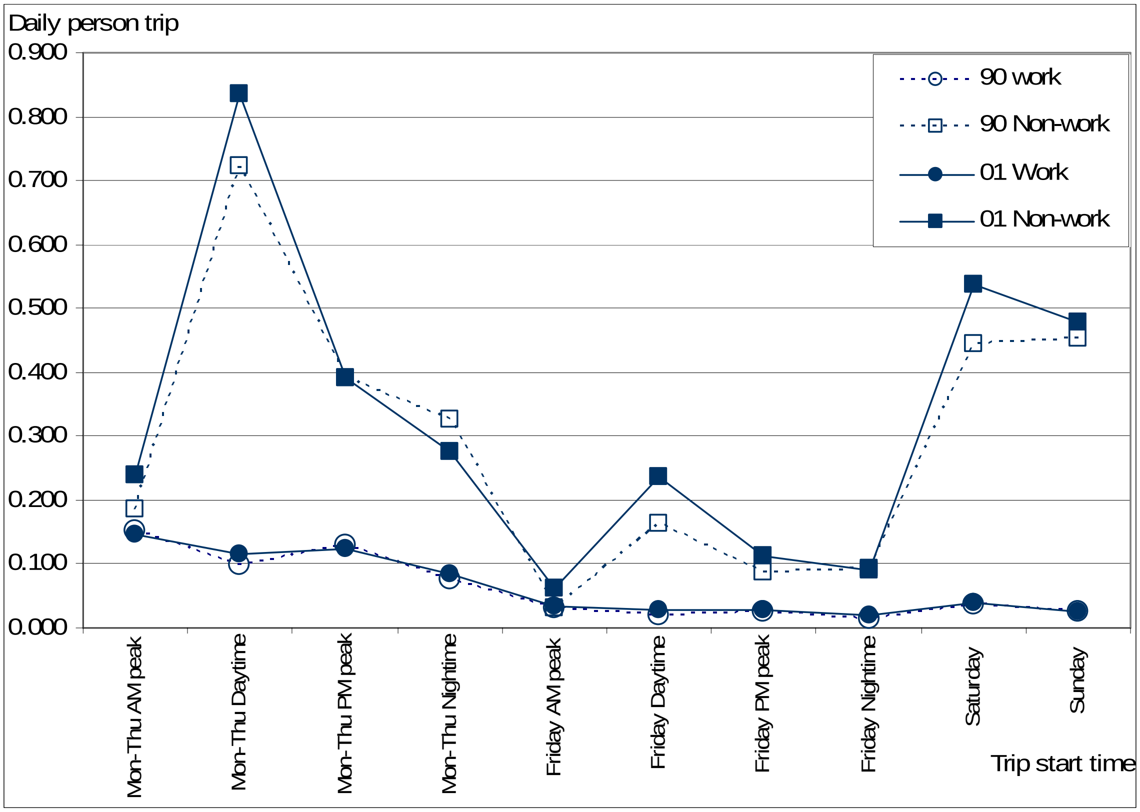
Table 4. Annual person-trips by trip purpose and by time of week, 1990 to 2001

	All		**Work**		**Non-work**		Family/ personal		School/ church		Social/ recreation	
		(%)		(%)		(%)		(%)		(%)		(%)
1990 All (millions)	284,551	100	49,327	17.3	235,224	82.7	130,770	46.0	27,848	9.8	76,605	26.9
Mon-Thu AM peak	27,272	100	12,227	44.8	15,045	55.2	6,700	24.6	6,968	25.5	1,377	5.0
Mon-Thu off-peak day	66,526	100	7,906	11.9	58,620	88.1	40,296	60.6	7,189	10.8	11,135	16.7
Mon-Thu PM peak	42,259	100	10,495	24.8	31,764	75.2	19,240	45.5	2,153	5.1	10,371	24.5
Mon-Thu off-peak night	32,709	100	6,152	18.8	26,557	81.2	11,897	36.4	1,853	5.7	12,807	39.2
Friday AM peak	5,068	100	2,536	50.0	2,532	50.0	1,198	23.6	1,113	22.0	221	4.4
Friday off-peak day	14,890	100	1,655	11.1	13,235	88.9	9,268	62.2	1,235	8.3	2,731	18.3
Friday PM peak	9,094	100	2,032	22.3	7,062	77.7	4,199	46.2	191	2.1	2,672	29.4
Friday off-peak night	8,723	100	1,233	14.1	7,489	85.9	2,957	33.9	184	2.1	4,349	49.9
Saturday all day	39,108	100	2,982	7.6	36,127	92.4	19,646	50.2	752	1.9	15,728	40.2
Sunday all day	38,902	100	2,109	5.4	36,793	94.6	15,368	39.5	6,211	16.0	15,214	39.1
2001 All (millions)	366,458	100	60,651	16.6	305,807	83.4	168,438	46.0	37,659	10.3	99,711	27.2
Mon-Thu AM peak	36,121	100	13,683	37.9	22,438	62.1	11,177	30.9	8,328	23.1	2,934	8.1
Mon-Thu off-peak day	89,124	100	10,724	12.0	78,400	88.0	53,182	59.7	8,589	9.6	16,629	18.7
Mon-Thu PM peak	48,367	100	11,712	24.2	36,655	75.8	19,648	40.6	3,573	7.4	13,434	27.8
Mon-Thu off-peak night	33,750	100	7,818	23.2	25,932	76.8	10,806	32.0	2,204	6.5	12,923	38.3
Friday AM peak	9,136	100	3,270	35.8	5,866	64.2	3,043	33.3	2,028	22.2	794	8.7
Friday off-peak day	24,927	100	2,712	10.9	22,215	89.1	15,333	61.5	1,898	7.6	4,984	20.0
Friday PM peak	13,240	100	2,679	20.2	10,561	79.8	5,745	43.4	625	4.7	4,191	31.7
Friday off-peak night	10,180	100	1,815	17.8	8,365	82.2	3,192	31.4	331	3.3	4,842	47.6
Saturday all day	54,218	100	3,786	7.0	50,431	93.0	27,420	50.6	1,686	3.1	21,325	39.3
Sunday all day	47,395	100	2,452	5.2	44,943	94.8	18,891	39.9	8,397	17.7	17,655	37.3
Growth 1990-2001 (%)	28.8		23.0		30.0		28.8		35.2		30.2	
Mon-Thu AM peak	32.4		11.9		49.1		66.8		19.5		113.1	
Mon-Thu off-peak day	34.0		35.6		33.7		32.0		19.5		49.3	
Mon-Thu PM peak	14.5		11.6		15.4		2.1		66.0		29.5	
Mon-Thu off-peak night	3.2		27.1		-2.4		-9.2		18.9		0.9	
Friday AM peak	80.2		28.9		131.7		154.1		82.2		258.9	
Friday off-peak day	67.4		63.9		67.9		65.4		53.7		82.5	
Friday PM peak	45.6		31.8		49.5		36.8		227.2		56.9	
Friday off-peak night	16.7		47.1		11.7		8.0		80.3		11.3	
Saturday all day	38.6		27.0		39.6		39.6		124.3		35.6	
Sunday all day	21.8		16.3		22.2		22.9		35.2		16.0	

1) 1990 data are adjusted to be comparable with 2001 data because new survey techniques such as travel diary and household rostering have been used since 1995 NPTS (Hu and Young, 1999).
2) Persons of age 0 to 4 are excluded from 2001 data because they were not surveyed in the 1990 survey.
3) Trips for which day of week or time of day are unknown are excluded.
4) The column of all trips does not equal to total person trips because it excludes trips for such purposes work-related, pleasure driving, and vacation.

Source: Lee, Gordon et al. (2006).

Figure 2. Average daily person-trips per person by trip purpose and by time of week, 1990 to 2001



Source: Lee, Gordon et al. (2006).

The Monday-Thursday AM peaks included the largest number and share of work trips, but these work trips were never the majority trip type. And their shares even fell significantly between survey years. The Friday AM peak showed a larger and increasing proportion of non-work trips. The only period showing a large increase in the proportion of work trips was the Monday-Thursday night off-peak period.

We found a stark contrast among growth patterns for work and non-work trips in terms of their temporal distribution across weekly periods. Whereas work trips became more spread out, extending to off-peaks, non-work trips grew faster in the morning peak. The spreading of work trips may be attributed to increasingly flexible work schedules while the growth in morning-peak non-work trips reflects the increased frequency of non-work trip-chaining into commute tours (see below). Both tendencies, increasing flexibility in work schedules and the prevalence of non-work trips in peak hours, make peak-hour pricing more attractive.

Trips for family or personal business (including shopping and doctor visits) accounted for the majority of non-work trips. Yet, there was also considerable growth in the school/church trips and the social/recreation trips categories. Non-work trip frequencies grew most in the Friday AM-peak period, perhaps the result of a trend towards early weekends.

This point is sharpened when we introduce a tour-level analysis which highlights the non-work trips that are parts of many commutes (Table 5). The tour analysis is the more interesting because it accounts for some of the growth in non-work travel. It makes sense that a growing labor force participation rate, especially among women causes more errands to be included in tours to and from work.

The Federal Highway Administration (FHWA) defines a trip chain as "a sequence of trips bounded by stops of 30 minutes or less" (McGuckin and Nakamoto 2004, p. 1). Any stop of more than 30 minute duration becomes either origin or destination of a tour. Thus, a tour denotes a single trip or chained trips bounded by two anchor destinations (of more than 30-minute dwell time). Unlike in previous research, the FHWA definition includes places other than home and workplace as anchor destinations that constitute either end of a tour. Thus, trip chain data sets for 1995 NPTS and 2001 NHTS classify all tours into nine tour types according to origin and destination place types: 1) home-to-home, 2) home-to-other, 3) home-to-work, 4) other-to-home, 5) other-to-other, 6) other-to-work, 7) work-to-home, 8) work-to-home, and 9) work-to-work. The home-to-work and work-to-home tours are apparently commute tours, whether direct or chained.

However, a commute tour in the general sense can be much more complex, possibly involving intervening stops of more than 30 minutes, such as a visit to a fitness center. To distinguish these kinds of commutes, we identified commutes with a stop of more than 30 minutes by connecting two pairs of continuing FHWA-defined tours in the categories home-to-other and other-to-work; and in the categories work-to-other and other-to-home. If, however, there are two or more intervening stops of more than 30 minutes en route to or from the workplace, we do not count the tour as a commute.

Our new definitions add to our point about the dominance of non-work travel because they emphasize the fact that not only are non-work trips the vast majority in each peak period but, once we re-define commute tours, we find that many of them (23 percent in the Monday-Thursday AM peak and 28 percent in the Monday-Thursday PM peak) also involve non-work trips. The proportion of chained commutes during both AM and PM peaks reflect a significantly increased trip-chaining tendency between survey years. This increase of chained tours in the morning peak may be an important factor behind the increased road congestion found for the late 1990s (Gordon, Lee, and Richardson 2004).

Trip-chaining is an individual level strategy to economize on travel times by combining multiple trips on various purposes into a tour and can be done most easily by car (Hensher and Reyes 2000; Lee, Gordon and others 2006). Therefore, the increasing tendency toward trip-chaining further strengthens the case for the HOT-lane approach over other approaches for coping with road congestion.

Table 5. Direct and chained tours by period of the week, 1995 and 2001

1995	Commute				Non-commute				Other	All
		(%)	Direct	Chain		(%)	Direct	Chain		
All (millions)	58,681	(21.5)	45,868	12,813	205,870	(75.5)	168,193	37,677	8,248	272,799
Mon-Thu AM peak	13,882	(47.9)	11,221	2,660	14,313	(49.4)	12,001	2,312	785	28,979
Mon-Thu off-peak day	10,665	(16.5)	7,644	3,021	51,006	(78.9)	39,671	11,335	2,975	64,646
Mon-Thu PM peak	11,519	(31.9)	8,425	3,094	23,338	(64.7)	19,434	3,905	1,234	36,091
Mon-Thu off-peak night	6,199	(23.2)	5,490	709	19,700	(73.8)	17,370	2,330	805	26,704
Friday AM peak	3,305	(45.7)	2,686	619	3,778	(52.3)	3,094	684	144	7,226
Friday off-peak day	2,684	(15.2)	1,881	803	14,192	(80.4)	10,960	3,232	770	17,646
Friday PM peak	2,553	(26.5)	1,897	656	6,778	(70.4)	5,569	1,209	296	9,626
Friday off-peak night	1,434	(17.4)	1,251	183	6,620	(80.4)	5,766	854	176	8,229
Saturday all day	3,875	(10.1)	3,198	677	33,976	(88.2)	27,208	6,768	672	38,523
Sunday all day	2,567	(7.3)	2,176	391	32,168	(91.6)	27,121	5,048	393	35,128
2001	Commute				Non-commute				Other	All
		(%)	Direct	Chain		(%)	Direct	Chain		
All (millions)	56,903	(20.7)	43,162	13,740	213,827	(77.7)	174,461	39,366	4,497	275,226
Mon-Thu AM peak	13,519	(45.1)	10,440	3,079	15,835	(52.9)	13,337	2,498	590	29,943
Mon-Thu off-peak day	10,793	(16.7)	7,613	3,180	53,041	(82.1)	41,250	11,792	762	64,596
Mon-Thu PM peak	11,198	(31.8)	8,059	3,139	23,470	(66.6)	19,672	3,798	594	35,262
Mon-Thu off-peak night	5,913	(22.8)	5,097	816	18,905	(72.8)	16,599	2,305	1,157	25,974
Friday AM peak	3,266	(43.0)	2,544	722	4,218	(55.5)	3,580	639	110	7,595
Friday off-peak day	2,749	(15.6)	1,927	822	14,744	(83.5)	11,304	3,440	171	17,664
Friday PM peak	2,476	(26.4)	1,761	715	6,725	(71.7)	5,504	1,221	175	9,375
Friday off-peak night	1,298	(16.3)	1,077	221	6,317	(79.3)	5,595	722	353	7,968
Saturday all day	3,443	(8.6)	2,813	630	36,016	(90.5)	28,563	7,453	356	39,815
Sunday all day	2,247	(6.1)	1,831	416	34,558	(93.3)	29,059	5,498	229	37,034

Source: Lee, Gordon et al. (2006).

DISCUSSION

Unpriced access to busy roads and highways has long served as a textbook example of a market failure. Actually, as new technologies make toll collection and road monitoring costs cheaper, the widespread lack of road pricing can be seen as a policy failure.

The existence of growing networks of HOV lanes on the freeways of major U.S. metro areas provides an interesting opportunity for policy makers to implement pricing without major disruption because most HOVs are presently underutilized. Where they exist, they occupy 25 percent of the road space (1 of four lanes) but can accommodate just seven percent of the vehicles (those estimated to carry two or more passengers). The availability of HOVs was supposed to increase carpooling but this has not happened. California law was recently changed to allow hybrid vehicles onto the state's underutilized HOVs, no matter what the vehicle occupancy.

The HOT-lane proposal (to convert HOV lanes to HOT lanes) is summarized in a recent paper by Poole and Orski (2006, pp. 453-454). Note that they describe it as a transit as well as a highway policy.

> By changing the access requirement from vehicle occupancy to willingness to pay a market price (for cars) but allowing super high-occupancy vehicles (buses and vanpools) to use the lanes at no charge, we can accomplish three important goals: 1. Generate sufficient new revenue to building out today's fragmented HOV lanes into a seamless network; 2. Provide a congestion-free alternative for motorists on every congested freeway in the same metro area; and 3. Provide a congestion-free guideway for bus Rapid Transit service that can make this form of transit significantly more competitive with driving.

The authors show that converting HOV-2 lanes (those that allow two-person car pools) to HOT lanes would approximately double vehicle-per-hour and person-per-hour throughput (Table 6). They also estimate the costs of implementing their system in eight of the major metro areas of the U.S. The estimates range from $2.7 billion (Miami) to $10.8 billion (Los Angeles) but dedicated revenue bonds would cover two-thirds of these costs. In light of the high proportion of costs that can be met in this way, private capital and private management become plausible. This is an added attraction of the proposal.

Interestingly, there are two HOT lanes currently in operation in Southern California. They have each been in operation for over ten years and are described by Sullivan (2006):

> The two Southern California projects are applications of "value pricing," described in a U.S. DOT report to Congress as "a market-based approach to traffic management which involves charging higher prices for travel on roadways during periods of peak demand. Also known as congestion pricing or road pricing, value pricing is designed to make better use of existing highway capacity by encouraging some travelers to shift to alternative times, routes, or modes of transportation."…The Interstate 15 project uses dynamic value pricing where the toll can change in real time to adapt to unusual changes in demand. However, a schedule of typical daily tolls is also published. The State Route 91 project sticks to a published toll schedule, based on established patterns of daily demand.
>
> These projects have enjoyed substantial public acceptance, in part because they have been marketed as a kinder and gentler form of congestion pricing, in which innovative pricing is used to create a new product – a congestion-free travel option in an otherwise congested commute corridor. Travelers are free to use or avoid the value priced facilities as they see fit, since the original congested travel options remain available. This approach stands in sharp contrast to mandatory pricing of all private vehicle trips at targeted locations and times, which some regard as ideal congestion pricing (pp.189-190).
>
> … The impact studies have shown that the value-priced toll facilities, where travelers can bypass congestion for a price, are associated with significant and systematic responses in travel behavior. This suggests that demand-dependent pricing can be a powerful tool for managing highway traffic and providing more choices to the traveling public in similar corridors elsewhere (p. 214).

The success of these facilities is not surprising because they exist and operate in the context described in our analysis of the U.S. data. Origins and destinations are dispersed and travel patterns are most amenable to the use of singly-operated motor vehicles.

Table 6. Comparative throughput of HOV lanes and HOT network

	Typical HOV-2	Typical HOV-3	Ideal HOV-3	HOT Network
SOVs (average 1.1 person/veh.)	0	0	0	1100
HOV-2s (average 2.1 person/veh.)	788	0	0	300
HOV-3s (average 3.2 person/veh.)	150	350	1200	200
Vanpool (average 7.0 person/veh.)	10	20	20	60
Express bus (average 35 persons/veh.)	2	3	40	40
Vehicles/hour	950	373	1260	1700
Persons/hour	2275	1365	5380	4300

Source: Table 19.2 in Poole and Orski (2006).

CONCLUSIONS

Our findings complement and elaborate the recommendations of Poole and Orski (2006). Converting HOV lanes to HOT lanes and redirecting current planning away from more HOV lane development (as well as from conventional transit planning) towards their suggested plan is the way to go in light of what we know of U.S. settlement and travel trends. Dispersed origins and destinations are unlikely to be well served by conventional transit or by carpooling. And the increasing tendency to combine work trips with non-work trips reflects this and also favors the HOT-lanes policy.

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[1] In 1998, Singapore replaced the manual area licensing scheme by an electronic road pricing scheme, which charges tolls per entry at varying prices at different times of the day (Phang and Toh 2004).

[2] http://www.vtpi.org/tdm/.

[3] They plan to extend the London Congestion Charging Zone to include Royal Borough of Kensington and Chelsea. The westward extension will be effective from February 2007.