Solving Stanford's Parking Shortage

New Solutions for an Old Problem

Stanford University faces a parking shortage of 3600 spaces by the year 2000. Cost/benefit analysis of three possible solutions -- building additional parking structures; adding parking in surface lots on the perimeter of the campus; and allowing employees the option to partially 'cash out' their parking subsidy -- finds Stanford can realize net annual savings of $3 to $6 million by offering employees this latter option.

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Phil Williams' incisive memos framed the issues for me; Julia Fremon encouraged me to begin; and Jeff Tumlin never failed to point out my mistakes. The remaining errors are all mine.

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Introduction

> Our ability to pay for the capital and operating costs of...providing parking is sorely strained, probably to the breaking point . . . Though time pressure is heavy, the problems have yet to yield obvious solutions. We have included funding, policy and operational issues in the scope of work to date, but we are not confident that the path we are on leads in a promising direction . . . .
>
> - University Planner Phil Williams
> 1992 Parking Study Progress Report #2

The accompanying report concluded that implementing the University's 1991 Parking Plan would produce a cumulative operating deficit in the parking fund of $22.8 million by the year 2000, while the total debt outstanding would leap from $19.6 to $36.6 million.[1] The '91 Plan could not fund itself. Given the University's budget cutbacks, no one else could either. A series of key questions and issues, Williams wrote, had to be addressed.[2] Among them:

- Reducing parking or making it more remote could harm employee recruitment and retention. Increasing user fees sufficiently to maintain current parking standards could have a similar effect. Are we willing to risk staff retention by reducing parking convenience or increasing user fees when many employers in the region provide ample free parking?

- There are strong reasons based in environmental quality, aesthetics and safety for removing cars from the central sections of campus. Should we make land use commitments now that would preclude future parking in the central campus, by, for example, siting buildings in existing parking lots? Or should we take advantage of the few remaining opportunities to provide close-in parking, even at a premium construction cost?

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[1] Williams 1.
[2] Williams 2-3.

• When choosing between parking structures and surface lots, how should the trade-off between construction cost and land value be assessed?

• Perimeter surface parking can significantly reduce capital costs and offer functional and aesthetic benefits to the central campus, but uses more land, reduces convenience and would probably require free shuttle service to be workable for commuters.

• Should we invest money in alternative transportation programs to reduce parking demand, with unknown prospects for success? What incentives would get users to pay the cost of a less desirable alternative?

A more recent University report begins, "In order to address the challenge of getting people out of the 'one car - one person' mode and into alternative forms of transportation, we need to understand the parking needs of individuals and departments, the viability of the transportation alternatives and the economic trade-offs involved. The trade-offs among the alternatives are key to the plan's viability and affordability. Over the years, several physical planning scenarios have been considered. In most cases, their unaffordability has halted their implementation."[3]

This study tackles those questions, and others. We begin by examining closely the true cost of parking, since until this cost is known, we cannot know whether options for reducing demand are in fact cost-effective. We seek to count not just immediate dollar construction costs, but the full costs. Borrowing construction funds adds interest costs. Maintenance, enforcement, insurance and repairs are not free. Perimeter lots add costs in land, shuttles, staff time and security. Using the standard tools of cost/benefit analysis, we attempt to count and compare these costs. Section 1 examines the cost of structures. Section 2 looks at the very different costs attached to surface lots. Section 3 examines the additional costs that traffic congestion, and new government rules to deal with it, have added to our parking problem.

Structures and surface lots both work to solve shortages by increasing parking supply - but as the University's reports indicate, the outlook for this

[3]Stanford University Planning Office (1992c) 4.2.

approach has grown bleak. Attention thus turns to reducing demand. From Southern California and elsewhere, companies report that by introducing commute allowances, they have reduced parking demand for one-third to one half the cost of providing more parking. But can such an approach work at Stanford? Section 4 takes up this question. Finally, we conclude by comparing these three options in light of the goals of the University's ten-year parking plan.

Table 1

Case Study: Parking Structure III, Costs per Space	
1) Capital cost per space gained = $\frac{\text{\$7,750,000 total construction cost}}{\text{775 spaces created - 350 destroyed}}$ = \$18,235 per space resulting annual debt service on this capital cost at 7.5% interest =	\$1448
2) Maintenance = $\frac{\text{1.5\% of construction cost}}{\text{total number of spaces}}$ = $\frac{\text{1.5\% x \$7.75 m}}{\text{775 spaces}}$ =	\$150
3) Utilities = cost unknown = \$0	\$0
4) Insurance: Earthquake = no insurance carried Property = $\frac{\text{0.2\% of construction cost}}{\text{total number of spaces}}$ = $\frac{\text{0.2\% x \$7.75 m}}{\text{775 spaces}}$ =	\$15
5) Enforcement & Administration = $\frac{\text{\$1,071,000 budget}}{\text{17,206 spaces on campus}}$ =	\$62
6) Land cost = \$0 (No additional land used by adding 2nd level to existing lot)	\$0
7) Aesthetics = \$0	\$0
TOTAL	\$1675
Cost to Stanford = (\$1675 - \$224 'A' permit fee) =	\$1451 per space per year (\$121 monthly) (\$5.56 daily)

1. The Cost of Parking Structures

Parking Structure III, Stanford's most recent, offers a good example of the typical costs per space in a new structure. Smaller structures (the proposed Tresidder structure, for example) have a higher cost per space, so Parking Structure III offers a lower-end estimate of costs. Table 1 (at left) summarizes these costs. The notes below explain the table's results:

1) Capital Cost: Parking Structure III cost only $10,000 a space to build. People often cite this figure as Stanford's cost for new parking. But since an existing 350 space surface lot had to be torn up to make room for Parking Structure III, the final cost of each space gained almost doubled, to $18,235.[4] Placing structures on empty land avoids this problem (though a land cost is substituted), but in the congested central areas where structures are wanted, there is no more unused land. Virtually all proposed structures are slated to go on existing surface lots -- making structures much more costly than is often realized.[5]

Annual Debt Service Cost: Stanford borrows to finance the capital costs of its parking, largely because borrowing is cheaper than paying cash. Funds to pay up-front for all new parking could only be gotten from the University endowment. Endowment funds are parked in long-term investments which normally earn an annual return of 11 percent or more. Thus, borrowing at 7.5 percent is cheaper than giving up the 11 percent return that funds earn when left in the endowment.[6]

The debt service cost shown, $1448 per year per parking space, is the payment Stanford would need to collect every year for the forty-year expected life of the garage to just repay the principal and interest on the construction loan. Appendix 1 presents the accounting formula and calculations behind this figure, and analyzes how costs change when the interest rate or the expected life of the garage changes.

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[4] Stanford University Planning Office (1992) 9.
[5] Appendix 5 considers the unlikely case of placing a parking structure on vacant land.
[6] Interviews with Julia Fremon, Director of Stanford Transportation Programs, and John Murphy, S.U. Financial Analyst.

2) Operations and Maintenance: The Facilities Department charges each building on campus, including parking structures, an annual fee of 1.5 percent of the construction cost to cover routine maintenance costs (elevator repair, painting, street sweeping and so on).[7]

3) Utilities Costs are unknown and would be difficult to ascertain since neither structures nor lots are likely to have separate water or electric meters, but they are likely minor.

4) Insurance: Stanford self-insures against many risks. A annual property insurance fee (against fire and some other risks) of 0.2 percent of construction cost must be paid for each building and parking structure into Stanford's self-insurance fund. One major risk is not covered by the fund: earthquakes. Quakes have severely damaged and sometimes collapsed parking structures. Geologists place the likelihood of a major quake in the next 30 years at over 50 percent. But as the University no longer carries any earthquake insurance and has no explicit 'earthquake insurance fee', we made no attempt to guess at risks or costs ourselves.[8] To maintain a conservative bias and avoid overestimating, we simply assume earthquakes will impose no costs.

5) Enforcement and Administration: Stanford spends $1,071,000 annually to write tickets and tow cars, but Santa Clara County receives all of the revenue.[9]

6) Land Cost: Note discussion under capital costs above.

7) Aesthetics: More parking by the Quad is wanted, but no matter what the cost savings, the Stanford community would reject a parking structure on the Oval or towering behind Memorial Church. So how much is it worth to avoid visual impacts? Quantifying such costs is notoriously difficult, varies sharply from location to location on Campus -- and whether a structure is an eyesore is largely in the eye of the beholder. Nonetheless, the campus reaction to

[7]Stanford University Planning Office (1992) 6.
[8]All insurance information cited here obtained from interview with Bob Beth, Director of Risk Management.
[9]Interview with Julia Fremon.

parking structures in even more acceptable locations suggests there is a real cost imposed. Students in Lagunita complain that Parking Structure II's five stories of 24-hour fluorescent lights have “destroyed the night”. A similar structure looming in the Tresidder lot will discomfit many.
However, to keep a conservative analysis, we again bias our estimate downward by assigning aesthetics a $0 value, even as we note that these costs exist, and are substantial enough to make many otherwise excellent parking sites on campus unthinkable.

This analysis calculates structure costs assuming that interest rates will remain at 7.5 percent, a 35-year low; that earthquakes impose no risk or cost to structures; and values aesthetic impacts at zero. Several smaller costs -- utilities, running temporary shuttles during construction -- were also left out. Given these optimistic assumptions and the costs ignored, the figure presented here, $1675 per space per year, should be taken as a lower-bound estimate.

Table 2

Perimeter Surface Parking, Costs per Space	
1) Land Cost: (value land at $1.25 million per acre = $28.70 per square foot) = $28.70/sq. ft. x 340 sq. ft. per parking space = $9,758 per space resulting annual opportunity cost of land (discounted at 7.5%) =	$755
2) Construction Cost = $3000 per space resulting annual debt service on this capital cost at 7.5% interest =	$238
3) Maintenance = 1.5% of construction cost = 1.5% of $3000 =	$45
4) Utilities = cost unknown = $0	$0
5) Insurance: (no fee assessed to surface lots) = $0	$0
6) Enforcement & Administration:	$62
7) Shuttle Operating Costs: = $32 per hour x 10 hrs/day x 252 workdays/year = shuttle served 1000 spaces in Stock Farm lot	$81
8) Waiting & Travel Time Costs for Staff: = 20 minutes per workday x 252 workdays = 84 hours per year Low estimate: (value staff time at campus minimum compensation of $9.94 per hour)... High estimate: (value staff time at average employee compensation rate of $30.95 per hour)................................	$835 to $2621
TOTAL	$2036 -3822
Cost to Stanford = (same as total since 'Z' permit parking is free to encourage use of remote lots)	$2036 - 3822 per space per year ($170 - $318 monthly) ($8.08 - $15.17 daily)

2. The Costs of Perimeter Surface Lots

We have seen that the costs of structures are high. Building surface lots on the outskirts of campus is the major proposed alternative. To examine this option, we again summarize the numbers in the table at left and use the text below to explain the reasoning behind them. Many consider perimeter parking a low-cost alternative. But examining the full costs, some surprising results emerge:

1) Land Cost: Stanford land cannot be bought or sold, so no market price exists to help us determine the value of acres turned into parking lots -- yet doing so is a key question in comparing perimeter lots against structures. However, a range of standard economic techniques -- comparing our land to the market value of nearby land, examining the income potential of Stanford's land when leased, and checking Stanford's cost to buy back leases already granted -- can establish a reasonable range of values for Stanford's land.

Let's take the last technique first. The Medical Center is now planning to acquire more land for parking by buying back leases on several parcels of Stanford land along Welch Road. David O'Brien, Director of the Medical Planning Office, and Chuck Spielman, Medical Center Financial Planner, put the value of these Welch Road parcels - and other land in the area - at $1-1.5 million per acre.[10]

The cost of buying back the use of our land offers one measure of its value. A second way to judge the value of the land we already have is by the cost of getting more. For example, we can use our own land for faculty housing, or purchase home lots in neighboring Palo Alto. Stanford land, being closer and more convenient, is more valuable for our purpose. Still, Palo Alto lot prices provide a lower-bound on the value of our own land for residential use. Similarly, when leased commercially, Stanford land commands a price as high, and often higher, than land in surrounding towns. Thus, for this use too, we know Stanford should value its own land at least as highly as the market price of acreage in Palo Alto or Menlo Park. Surveying the range of prices,

[10] Interviews with O'Brien & Spielman.

especially those along Stanford's borders, confirms O'Brien and Spielman's estimate of $1 to $1.5 million per acre.[11]

Finally, Stanford's own actions offer an internal assessment of land value. In recent years, the university has demolished hundreds of central parking spaces (to make way for buildings) and replaced them with three parking structures, reflecting the judgement that these central sites are now worth more as academic buildings than as parking. Subtracting the value of the asphalt torn up ($3000 per space) from the cost of the structures ($18,000 per space), we can see that Stanford paid $15,000 per space just to gain the use of this central land. This works out to slightly more than $2 million per acre.

Land outside the perimeter of Campus Drive, however, seems more plentiful. Is it much less valuable? Is $1 million an acre far too high a price to put on it? The first observation to make is that, as one planner put it, "there are development plans for every inch of this campus." Land along Sand Hill Road is slated for Campus West and other faculty housing. Many other acres (the golf course, or the playing fields between El Camino and Campus Drive) are unbuilt, but obviously valued for recreation. Other open space (the Arboretum, the eucalyptus groves, or the foothills behind Lake Lagunita) can certainly be considered, but the community's past reaction to the possible loss of these islands of quiet and beauty suggests that Stanford's open space is valued as well. In short, whenever land is used for a parking lot, there is an opportunity cost to be paid: it can no longer be faculty housing or student dorms; or leased as commercial property; or left a hillside of old oaks and golden poppies.

The cost of land in surrounding communities, of buying back the use of leased Stanford land, or of conserving land by building parking structures - all these measures suggest a value for Stanford land in excess of $1 million per acre. To take a mid-range estimate, we use a value of $1.25 million per acre, or $28.70 per square foot. Proposed lots require on average 340 square feet per space, giving a land cost of $9,758 per space.

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[11] *Palo Alto Weekly* commercial real estate notices, City of Palo Alto land sales records and interviews with Larry Owen, Director of Real Estate Investments for Stanford Management Company, and David Longbine, Director, Stanford Shopping Center, helped to establish this range.

To change this initial cost into an annual figure, businesses use the same discounting technique as is used to calculate the interest and principal payments on initial construction costs (see Appendix 1). The resulting figure - $775 per year - is the average opportunity cost of using land for parking. In some cases (the Welch Road parcels, for example), this represents the actual cost to the university of buying out current leaseholders. In other cases it represents the income forgone from not leasing the land as commercial property or faculty/staff housing. Or, finally, when playing fields, open space or academic sites are converted to parking, this figure represents the loss of that use.

2 - 6) Construction, Maintenance, Utilities, Insurance and Enforcement Costs: All are much the same as in the case of parking structures, except that no property insurance fee is assessed on surface lots.

7) Shuttle Costs: The actual costs of the temporary Stock Farm shuttle operated while Parking Structure III was under construction provide a good example of the costs involved in running shuttle service to perimeter lots. According to Mike Stultz, who oversaw the shuttle, it ran 10 hours per day (6-10 am and 5-9 pm) at a cost of $32 per hour. Combined waiting and riding time from the Stock Farm lot to the center of the Medical Center averaged 17 minutes per trip. The shuttle served roughly 1000 spaces in the lot. Doing the numbers, we see that operating this relatively infrequent shuttle cost $81 per space per year (assuming 252 workdays per year).[12] More frequent service could also be provided: shuttles twice as often will cost twice as much, three times as often threes times as much, and so on. This experience with the Stock Farm shuttle probably offers a lower-bound estimate of the cost of running shuttles to perimeter lots, since other proposed perimeter lots are more distant from worksites.

8) Waiting and Travel Time Costs: Phil Williams asked, "Alternatives that reduce parking and/or make it more remote from destinations may have a negative effect on employee recruitment and retention....Are we willing to

[12]All shuttle information from interviews with Stultz and Fremon.

risk staff retention by reducing parking convenience or increasing user fees when many in the region provide ample free parking?"[13]

Stanford must hire employees in a competitive market - in many cases, a fiercely competitive one. In such a market, employers who cut pay and benefits assuredly increase staff turnover and attract lower quality employees. Hiking parking fees is, to employees who still drive, simply a pay cut; making parking more remote forces them to pay with their time instead. There's no free lunch in shifting costs to employees: Stanford will have to pay for employees' losses of time and convenience, either by paying higher salaries or by suffering the price of staff turnover and a low quality workforce.

How large are these losses? Stanford's experience with the Stock Farm and Track House lots, and the distances involved in other proposed perimeter lots, suggest that remote lots will be on average at least a 10 minute walk or shuttle ride from offices. For example, Mike Stultz reports that while combined waiting and riding time for the Stock Farm shuttle averaged 17 minutes, walking time from the lot to Packard Hospital was only 13 minutes, and to Stanford Hospital only nine and a half minutes. At 10 minutes each way, those using these lots will lose, on average, 20 minutes a day, or 84 hours per year.

How should we value this lost time? By making remote lots free and charging higher fees for close-in parking, Stanford has attracted lower-paid employees and those less bothered by walking to remote lots. But the number of such people is limited. The more heavily Stanford substitutes distant lots for close-in parking, the more it will have to force employees unwillingly to them. Other campuses have done this by several means. Some explicity ration by offering good parking only to senior staff. Harvard banishes undergraduates to these lots - but since Stanford mostly needs spaces at the Medical Center, where few students park, this strategy will be of limited use here. Berkeley oversells permits, creating a first-come, first-served kind of rationing: late-comers are forced to outer lots after fruitlessly searching closer in. If Stanford resorts to such means, we must value the time lost highly, since employees who value their time highly, or for whom walking is a burden, will be forced to outer lots. This might include, for example,

[13]Williams 3.

employees with tight schedules or limited lunch hours, those who need a car during the day, or those with strong safety fears.

In this case, we suggest the cost to employees can best be measured by valuing their time at Stanford's average compensation rate (wage plus benefits) of $62,400 per year, or $30.95 per hour.[14] This gives the high-end figure of 2,621 per person. Less reliance on distant lots will allow Stanford to continue to avoid sending employees there who would be greatly inconvenienced. Then the campus minimum compensation of $9.65 per hour will be a better estimate of how employees value the time lost. This gives the lower figure in our cost range.

When we consider only the cost of laying asphalt, perimeter surface lots seem cheaper than structures. But when the full costs are examined -- when we no longer assume that Stanford land is valueless, or that costs can be passed on to employees without consequences -- perimeter lots are no longer a bargain. Depending on how heavily Stanford relies on them, we calculate that their true costs to the University range from $2000 per space upward to nearly $4000 per space per year. Finally, on top of these costs already detailed, there remain some additional costs to take into account. Section 4 considers these.

[14]Interview with Ann Klause, S.U. Compensation Specialist.

3. Additional Costs: The Price of Traffic

The previous three sections explored most of the costs involved in supplying new parking. This decade, Stanford is considering building 3600 parking spaces. 1300 would replace lots displaced by buildings, and therefore create no new traffic. But the other 2300 would expand the total campus parking supply to meet increased demand, and thus bring with them more traffic. More traffic imposes several incremental costs:

1) Noise, Traffic Jams, Accidents, Pollution, and Road Repair: All of these problems increase in tandem with traffic. Many of the resulting costs (for example, time and gasoline wasted, road damage, accident response by police and fire departments, accident injury costs to campus health care) are readily quantifiable. Others are elusive. The toll of stress and fatigue extracted from commuters is obvious enough to those fighting traffic. Costing it, or the resulting lower work productivity, is difficult. However, even leaving out such elusive costs, studies of traffic have found large benefits in reducing traffic congestion. Professor Jane Rothenberg Pack of the Wharton School calculates a social benefit of $10 to $11 per vehicle per day when a commuter switches to public transport, in decreased commuting time for others and avoided noise, pollution and accidents.[15] Similarly, a Montgomery County, Maryland study found quantifiable benefits of $5 to employers and $5 to the public per automobile trip avoided in their county.[16] Since Stanford would not capture all of the benefits of reduced car-commuting, total benefit to our community might be conservatively valued at one-tenth the value measured in these studies, or $1 per workday for each car avoided.

2) Road-building and Intersection Expansion: Our Santa Clara County General Use Permit requires that we meet the goal of “no increase in peak hour commuter trips”, or else pay to expand 13 nearby intersections as they become overloaded.[17] Dividing the estimated $4 million cost (See Appendix 2) by the 2300 additional spaces puts this incremental cost at $1740 per space, or

[15] Pack 51.
[16] Montgomery County 1990 Parking Tax Study, cited in Natural Resources Defence Council (1992) 22.
[17] Interview with Fremon.

$132 annually. Adding parking lots also often requires widening and improvement of surrounding roadways to handle rush-hour peaks as commuters exit the lots (the recent widening of Quarrry Road to handle Medical Center development was one such example), and normally imposes additional costs. Thus, the $132 per space cost figured here may undercount the actual road-building costs required.

3) The Trip Reduction Rule: This Congestion Management Agency rule requires Stanford raise its 'Average Vehicle Ratio' to 1.35 employees per car arriving on campus by 1998, with this ratio steadily increasing thereafter.[18] No penalties have yet been specified for failing to meet targets, but Los Angeles' equivalent rule has now been stiffened to include penalties in the thousands of dollars per day for large employers. When Bay Area rules will acquire such teeth is unclear, but as traffic worsens, the steady thrust has been toward stiffer standards and penalties. To meet this rule, Stanford will have to limit the rise in commuter trips - and thus parking demand - to about 7 percent, or 1100 parking spaces. It may be unwise to increase our overall campus parking supply by 2300 spaces in the face of two government targets, the first ("no increase in peak hour commuter trips") demanding that we hold parking demand constant, and the second that demand increase by only 1100, rather than 2300 spaces. If we meet these targets, the extra spaces will be unneeded. Clearly then, we should increase overall campus parking supply only if we expect to fail the General Use Permit requirement, and add more than 1100 spaces only if we expect to violate the Trip Reduction targets as well.

The mandates of government and the burden of traffic both add to the cost of supplying new parking. Table 3 below adds these incremental costs to the price of structures (the lowest total cost option), to find the minimum cost to Stanford of expanding the parking supply.

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[18]Specifically, the rule is Bay Area Air Quality Management District, Regulation 13, Rule 1, Trip Reduction Requirements for Large Employers. Interview with Colleen McCarthy, Commuter Network Director, Santa Clara County Congestion Management Agency.

Table 3

Minimum Cost to Expand Campus Parking Supply (Costs Per Space Per Year)	
Parking Structure Cost	$1675
Traffic Costs (time and gasoline wasted, congestion, accidents, noise and pollution	$252
Road-building & Intersection Expansion	$132
TOTAL	$2059
Cost to Stanford = ($2059 - $224 'A' permit fee) =	$1835

4. Commute allowances: A New Direction

We have examined the costs of parking in some detail. Our analysis agrees with the conclusion that many at the University have already reached: the costs of supplying new parking have grown prohibitive. Structures carry a price tag of over $1600 per space per year. Forcing staff to perimeter lots offers no better solution. While cheaper at first glance, when the full costs - in land, salaries, staff time and shuttles - are counted, even conservative estimates reveal a price higher than that of structures. The old solution - solving parking shortages by increasing supply - carries a cost Stanford can no longer afford. Before this hurdle the 1991 Parking Plan, and every other attempt to meet needs by simply building more parking, have stumbled.

Attention thus turns to reducing demand. Examining the evidence, we find the record of both Stanford and other institutions in getting commuters out of their cars is decidely mixed. Is, for example, adding transit viable? Stanford's Marguerite shuttle to the train stations carries commuters at an average cost of $76 per commuter per month, or half the $153 per month each solo driver costs the university.[19] Assuming that at least half of those commuters would drive if the Marguerite ceased running, the shuttle is a cost-effective alternative. But the potential to expand it seems poor: a experimental shuttle through the faculty housing areas in 1990 attracted few riders and was quickly discontinued.[20] If expanding transit has doubtful prospects, what then? Stanford already has an extensive menu of the alternative benefits commonly offered to encourage ridesharing: free and preferential carpool parking spots, ridematching services, and so forth. Traditional incentives, it appears, are already largely in place.

Looking to the experience of Southern California firms reveals mixed results as well. There, all firms with more than 100 employees at a single worksite have been required, under Regulation XV of the South Coast Air Quality Management District, to implement 'Employer-Based Trip Reduction Plans." Studies carried out for the Air Management District by the accounting

[19] Stanford University Office of Transportation Programs "Marguerite Survey, Ridership & Costs", memorandum, May 1992.
[20] Interview with Fremon.

firm of Ernst & Young found that employers spent an average of $250 (!!) per month for each automobile commuter removed from peak-hour traffic. Since some of these trips were simply shifted to off-peak hours (defined as 6AM to 10AM), the cost to reduce parking demand by one car was likely even higher. Still more strikingly, the Ernst & Young study found that employers' costs per commute trip reduced varied more than thirty-fold, and that the correlation between an employer's cost and results achieved was exceedingly weak (a correlation coefficient of .171). Shoup gives one probable explanation for this large variation in costs: that reducing car commuting at some worksites is cheap, at others expensive, while Regulation XV requires equivalent reductions at all sites.[21] A second explanation suggests itself. Not all demand reduction measures are equally cost-effective; nor are companies, largely new to this game, yet expert in choosing effective ones. Those slow to learn are likely to have chosen ineffective and thus costly means.

So what makes people stop driving -- and does so cost-effectively? To see, it is helpful to look at disaggregate models of personal travel behavior, which allow one to examine and control for multiple factors affecting commuters' choices. Richard Willson's recent multinomial logit analysis of commuters in downtown Los Angeles uses data from the Los Angeles CBD Employee-Employer Baseline Travel Survey.[22] The survey, performed on a matched sample of 5060 employees and their employers in downtown Los Angeles, included questions about both employees, their employers, and the employers' transportation programs and incentives.

Table 4 shows the estimated coefficients for the model.[23] All but estimated travel time are significant at a 95% confidence level. One factor, over which most employers have complete control, stands out. Raising parking price, as shown in Figure 1, strongly reduces the percentage of workers who choose to drive alone.

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[21]Ernst & Young survey cited in Shoup (1992) 36.
[22]Willson (1991) 133-145.
[23]Willson, cited in Shoup & Willson 188.

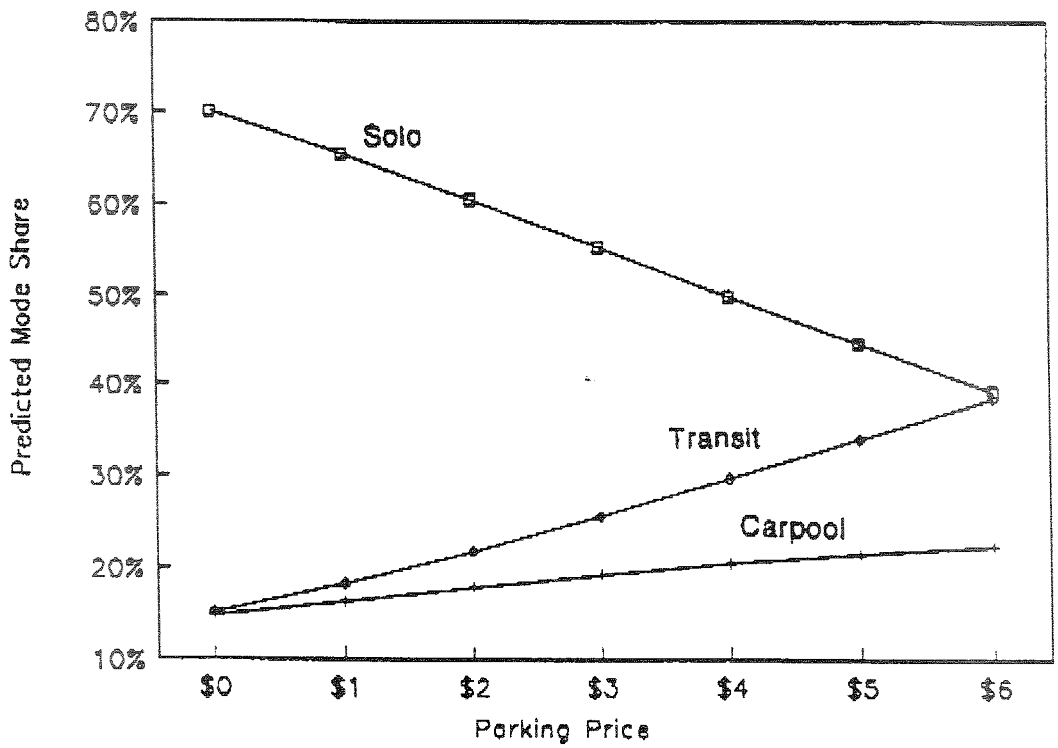
Table 4

TABLE III—ESTIMATED MULTINOMIAL LOGIT MODELS OF COMMUTER MODE CHOICE (Office Workers in Downtown Los Angeles[a])

Independent Variable (Applicable mode in parenthesis)	*Estimated Coefficient*	*t statistic*
Daily parking cost, in cents (1–2)	−0.0029	(−6.7)
Daily running cost, in cents (1–3)	−0.0062	(−5.5)
Round-trip auto travel time, in minutes (1–2)	−0.0042	(−0.87)
Round-trip transit travel time, in minutes (3)	−0.029	(−5.9)
Annual pre-tax household income, in dollars (1)	0.000020	(5.4)
Employee occupation dummy (1)	0.58	(3.0)
Employer rideshare program dummy (2)	0.73	(3.2)
Flextime program dummy (2)	−0.87	(−4.0)
Auto constant dummy (1)	−1.7	(−3.8)
Carpool constant dummy (2)	−3.2	(−5.7)
Likelihood ratio index	.27	
Log Likelihood at zero	−783.3	
Log Likelihood at convergence	−572.2	

a. Mode 1, auto (solo driver); Mode 2, carpool/vanpool; Mode 3, transit.

Figure 1



Yet how can employers reduce parking subsidies -- a popular fringe benefit enjoyed by most employees -- without harming employee recruitment and retention? A small but growing number of employers have realized that by allowing employees the option of taking cash instead of a parking space, they can drastically increase the effective price of parking without damaging employee morale. In doing so, they have found that they can sharply reduce demand for one-third to one-half the cost of building more parking.

In 1990, for example, the County of Los Angeles replaced free parking with commute allowances for its employees. Each employee now receives a $75 monthly commute allowance in their paycheck, which they can spend as they wish. Employee parking, formerly free, now costs $75 per month. The result: demand for parking in the County's lots has dropped by 40 percent.[24]

Such results seem surprising, especially since County employees who continue to drive still receive free parking: they use their commute allowance to pay the new parking charge, and the County then gets back the money it has just given out. However, financial incentives for employees have shifted radically. Now, if they carpool or bicycle or ride the train they get $75 per month: continuing to drive alone means giving this money up. The effective price of parking (its opportunity cost) has gone from $0 to $75 - and this change brings strong results.

In case studies involving thousands of commuters (see Table 5 right), raising the effective price of parking (in most cases from $0 to $30 a month) reduced parking demand by an average of 27 percent. Drops ranged from a low of 15 percent to a high of 38 percent. For the County of Los Angeles (not included in these case studies), a larger commute allowance ($75 a month) created an even larger 40 percent drop. What would similar results mean at Stanford? By the year 2000, demand for parking is projected to reach 19,500 spaces.[25] Decreasing that projected demand by just 15 percent would free up more than 2900 spaces. A 40 percent reduction would free 7800 spaces. And an

[24]Association for Commuter Transportation 47.
[25]Patrick Siegman, Stanford Transportation Programs, “Parking Supply Five-Year Forecast”, memorandum, April 14, 1994.

Table 5

Increasing Parking Price Reduces Parking Demand

Case Study and Location (type)	Increase in price	Autos Driven per 100 employees: Employer pays for parking	Driver pays for parking	Decrease in parking demand
Commuter Computer Mid-Wilshire Blvd., Los Angeles (before/after)	$0 to $58	48	30	-38%
20th Century Insurance Co. Suburban San Fernando Valley, Los Angeles (before/after)	$0 to $30	92	64	-30%
Businesses in Century City District, West Los Angeles (with/without)	$0 vs. $30	94	80	-15%
County and Federal Govt. Employees, L.A. Civic Center (with/without)	$0 vs. $30	78	50	-36%
Federal Govt. Employees Downtown Ottowa, Canada (before/after)	$0 to $23	39	32	-18%
Average of Case Studies		70	51	-27%

Note: Before/after studies compare commute behavior at a company before and after a parking price increase. With/without studies compared matched samples of employees at companies with and without free parking benefits.

Source: Donald Shoup and Richard W. Willson, Employer-Paid Parking: The Problem and Proposed Solutions (Transportation Quarterly, April 1992).

average result, 27 percent demand reduction, would mean over 5200 fewer spaces needed, more than eliminating Stanford's need to build new parking.

What would it cost? Paying employees $30 a month not to drive is less than one-quarter the sum Stanford must pay to provide new parking. However, an allowance this size may attract too few takers, leaving Stanford still needing to build hundreds of (expensive) new spaces. The trade-off is this: the smaller the allowance offered, the more a firm saves each time an employee accepts it instead of parking. The larger the allowance, the more employees will accept. To find the right balance, employers must ask how much demand reduction they seek, and how responsive employees will be. Predicting this is not simple, but fortunately, there is little risk in setting the allowance incorrectly. If the allowance offered at first is too small, so that few accept, employers can easily increase the offer. As long as the allowance given remains smaller than the cost of providing new parking, the employer comes out ahead.

How large an allowance should Stanford offer? To avoid building more spaces, Stanford needs to reduce demand by 18 percent. Achieving the more ambitious goal, favored by many trustees, of removing all large surface parking lots from the center of campus, would require a reduction of 5900 spaces, or 30 percent, to meet demand without building more parking. Both of these goals argue for at least a medium-sized commute allowance, in the range of $30 a month. The resulting savings would be substantial: A $30 commute allowance plan, for example, would cost only a quarter the alternative of building new parking, counting building costs alone. Add in avoided incremental costs of expanding intersections and coping with other traffic problems, and we find that while building an additional parking space costs Stanford a total of $153 monthly, reducing demand costs $30 - a savings of over 80 percent.

Of course, nothing is quite that simple. Two complications will reduce these savings. First, 20,000 current permit holders actually occupy only 17,000 spaces at Stanford: some work swing shift, some drive only part-time, and so on.[26] Thus, to reduce demand by one parking space, one must actually pay 1.18 employees to stop driving. This reduces savings. Instead of paying $30 per space freed up, the cost is $35.

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[26]Stanford University Planning Office(1992) 16.

Second, Stanford already has roughly 2800 bicycle, train, bus and carpool commuters: by the year 2000, that number will rise to 3375, assuming the number grows at the same rate as the commuter population.[27] Offering them a commute allowance will cost the University $30 a month apiece, but won't produce any savings on parking costs, since they already avoid bringing a car to campus. Helping them out will be a more equitable policy. It won't, however, be of help in reducing costs.

Taking these complications into account, what savings remain? To gain a basic estimate of the magnitude of the savings involved, let us take a snapshot of the year 2000, when the currently planned program of building projects will be complete and projected demand will reach 19,500 spaces. Savings for the year can be calculated by the formula

$$\text{Savings} = \text{Parking Costs Avoided} - \text{Cost of Commute Allowances}$$

where, letting SP = demand reduction desired (in spaces); CA = commute allowance in $/month; and $AC_{existing}$ = number of existing alternative commuters,

$$\text{Parking Costs Avoided} = \$1835 \text{ minimum cost per space} \times SP$$

and

$$\text{Cost of Commute Allowances} = 12 \text{ months} \times CA \times (AC_{existing} + 1.18 \times SP)$$

That is, 12 months worth of commute allowances must be paid both to the people already not driving, as well as to 1.18 commuters per parking space freed up.

Consider a pessimistic scenario. In the case studies documented, companies generally offered at $30 a month commute allowance: the worst result they achieved was a 15 percent reduction in demand. Suppose, pessimistically, that Stanford achieves only this same 15 percent reduction. As shown below,

[27]Patrick Siegman, Stanford Transportation Programs, “Alternative Commuters -- Current & Achievable Rates,” memorandum, March 1994.

Stanford will then avoid building 2900 parking spaces for a savings of $5.3 million annually; pay out $2.4 million per year in commute allowances; and earn a net savings of $2.9 million per year:

Savings = Parking Costs Avoided - Cost of Commute Allowances

Parking Costs Avoided = $1835 minimum cost per space x 2900 spaces
= $5.3 million

Cost of Commute Allowances
= 12 x $30 monthly x (3375 existing + 1.18 x 2900 spaces)
= $2.8 million

Savings = $5.3 million - $2.8 million = $2.9 million

Suppose, more optimistically, that a $30 commute allowance at Stanford produces the average result seen in the observed case studies: a fall of 27 percent in parking demand. Projected demand will then fall by 5200 spaces, for (following the same formulas as above) a net savings of $6.2 million per year compared to the cost of building an equivalent number of spaces.

Efficiency and Equity Considerations

Note that the savings calculated here result purely from the elimination of economic waste. When valuable commodities are drastically underpriced (as is Stanford parking) or given away for free (as is Stanford road capacity), the savings generated by moving even partway toward a market price can be huge. That so many commuters have been shown to prefer $30 a month in cash to a parking privilege that often costs their employer $120 a month or more to provide makes clear the magnitude of the waste normally involved. In Stanford's case, the gains to be reaped by getting parking prices right are even larger, because Stanford is a community as well as an employer. As a town with a daytime population of over 30,000, Stanford -- whether in the General Plant Improvement (GPI) budget for roadway expansion, or lost productivity and insurance premiums for employees and students injured in traffic accidents -- eventually picks up the tab for many of the traffic costs caused by increased automobile use. Raising parking prices not only reduces economic waste in the parking system, but, because it simultaneously reduces automobile use on campus, conserves many of these unpriced Stanford resources as well.

While producing economic efficiency, allowing employees the option of cashing out their parking subsidy produces equity gains as well. Employees who choose not to accept the option are no worse off. Among those who do, the subsidy is proportionately larger in relation to income for the lowest-paid Stanford employees. Finally, the option extends transportation benefits to employees who, whether because they carpooled with someone from another company, or rode the train, or cycled, or simply walked, were previously excluded from any benefit.

Examining Price Responsiveness

But some might ask, can Stanford really expect to reduce demand as others have? Two objections might be raised.

First, some suggest that Stanford cannot hope to, because poor transit service here leaves no alternative to driving alone. Objection overruled. Several of the companies cited have public transportation far worse than Stanford's. For example, 20th Century Insurance Co. sits in the Los Angeles suburbs of San Fernando Valley - where everyone drives, bus lines are meager and light rail still a dream.[28] There, a $30 change in parking price brought a 30 percent decrease in parking demand: carpooling turned out to be the underused option. Stanford, with Caltrain service, the Marguerite shuttle, better bus lines and far better cycling conditions, offer much better transit alternatives. On this count, Stanford should expect much better results than 20th Century achieved.

A second objection might be that Stanford employees surveyed have said that cost is <u>not</u> an important factor in their commute choice.[29] If so, changing financial incentives will not be effective. However, as CH2M Hill Corp. in

[28]Willson & Shoup 147.
[29]Moore Iacofano Goltsman, Inc., “Stanford University Parking Plan Analysis”, March 1993.

Bellevue, Washington found, introducing commute allowances can sharply change survey results. There, surveys said 80 percent would drive alone to their new offices. Seven months later, after a $40 a month commute allowance was introduced, only 54 percent did (see Appendix 3).[30] Why was the survey wrong? Employees had declared their preferences when subsidized parking was the only option given them, and the cost of parking hidden. Commute allowances revealed their employer's high cost of providing parking, and allowed employees the option of cash instead. Given new options, employees made new choices.

Similarly, here at Stanford the real cost of parking is hidden. Understandably, when asked about cost, employees consider whether the $0 to $18 a month they now pay for parking is important, not the University's $120 a month cost. When that cost becomes visible, and employees have the option of cash instead, responses here, as at CH2M, will be quite different.

Response of Campus Commuters to Increases in Parking Price:
Empirical Study

From 1982 to 1991, relatively small increases in parking prices at Stanford ('A' permits rising from $9 to $17 monthly and 'C' permits from $2 to $4.50 monthly in real terms) occurred. To determine whether these small price hikes, carried out over the course of a decade, affected campus commuters' behavior, university permit sales records and commuter population figures were used to estimate equations of the form

$$(\text{'A' PERMITS PER CAPITA})_t = \alpha_0 + \alpha_1(\text{'A' PRICE})_t$$

$$(\text{'C' PERMITS PER CAPITA})_t = \beta_0 + \beta_1(\text{'C' PRICE})_t$$

$$(\text{TOTAL PERMITS PER CAPITA})_t = \theta_0 + \theta_1(\text{AVERAGE PRICE})_t$$

where ('A' PERMITS PER CAPITA)$_t$ = natural log of 'A' permits sold per Stanford commuter in year t; ('C' PERMITS PER CAPITA)$_t$ = natural log of 'C' permits sold per Stanford commuter in year t; (TOTAL PERMITS PER CAPITA)$_t$ = natural log

[30] Association for Commuter Transportation 19.

of total 'A' and 'C' permits sold per Stanford commuter in year t; $(\text{'A' PRICE})_t$ and $(\text{'C' PRICE})_t$ are the natural logs of the prices, in real terms, of 'A' and 'C' permits, respectively; and $(\text{AVERAGE PRICE})_t$ is the natural log of the sales-weighted average of 'A' and 'C' permit prices.

Parameter estimates for the three equations are presented in Table 6[31] The coefficient of 'A' PRICE in the first equation is significantly negative at the .01 level, indicating, as would be expected, that demand falls as price rises. As figure 2 illustrates, this effect was strong: per capita demand for 'A' permits fell by 36% over the decade, in response to only a $9 per month real increase in parking rates. The coefficient for 'C' PRICE in equation 2, however, is significantly <u>positive</u> at the .05 level, while the estimated coefficient for AVERAGE PRICE in equation 3 is not significantly different from zero.

Stanford parking policy offers a possible explanation for these results. Policy set 'A' permit fees at four times the price of 'C' permits. Thus, rate increases, while equal in percentage terms, sharply widened the absolute gap in price between 'A' and 'C' permits over the decade ('A' permits increased in price by $9 per month in real terms, 'C's only by $2.50 monthly). Meanwhile, building programs, and a policy of meeting demand for both 'A' and 'C' parking spaces with acceptable (defined as 10% vacancy rates) made the two permit types increasingly indistinguishable commodities. (In the new parking structures, 'A' and 'C' spaces are separated by only a single level, while new buildings nearer the edge of campus are often closer to 'C' lots than 'A's.) Facing increasingly different prices for increasingly similar parking lots, Stanford commuters likely reacted by substituting 'C' permits for 'A's.

[31]The TSP program and data set used in the estimations are presented in Appendix 4.

Wide year-to-year variations in permit sales (caused in part, suggests Fremon, by large fluctuations in enforcement) and the small overall increase in parking price over the decade, make any trend in overall sales indistinguishable. Census data, however, offer additional clues. From 1980 to 1990, the drive-alone rate for Bay Area commuters rose from 63.1% to 68.2%. Santa Clara County commuters were no exception: 77.8% drove to work alone in 1990, compared to 72.5% a decade earlier. Yet Stanford commuters bucked this trend: the drive alone rate for campus commuters held steady at 55%.[32] Since most population growth at Stanford over the decade occurred at the Medical Center, where commuters are far more likely to drive to work, the result is striking.[33]

These results suggest that Stanford commuters are, like other commuters, sensitive to changes in parking price -- even the relatively small changes in price, carried out over the course of a decade, seen here.

We cannot predict exactly how far demand will decline, but other evidence suggests that Stanford will meet or exceed the results obtained by other companies. Stanford employees live closer to work than employees in the other case studies cited: an average round-trip commute of 22 miles, compared to 36 miles for commuters in the Los Angeles case studies.[34] As noted above, transit service here is better than in most of the case studies cited. Stanford and neighboring Palo Alto, sometimes called the 'bicycle capital of the nation', also offer far better conditions for cyclists. Finally, commuting students - especially graduate students on small stipends and undergraduates on financial aid (over half the student body) - are likely more price-sensitive than the average commuter, and thus more likely be attracted by the offer of a commute allowance.

Additionally, a 1989-90 survey of parking permit applicants by the Office of Transportation programs found:[35]

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[32] Metropolitan Transportation Commission. 1993. “The Journey to Work in the Bay Area, 1990 Census Transportation Planning Package,” April 1993, 47-48 and Table C.2.3.
[33] Stanford University Medical Center Planning Office, 5-6.
[34] Stanford University Office of Transportation Programs (1990) 15 and Shoup & Willson 170.
[35] Stanford University Office of Transportation Programs (1990).

- 38 percent [of auto commuters] already use an alternative form of transportation at least one day a week.

- Only 22 percent of those who drive alone every day stated that no incentives would get them to use an alternative.

-Bicycling is the preferred alternative of 21.5 percent, with carpooling a distant second at 8.5 percent.

These results too suggest that the potential for commute allowances is high, with cycling likely to be the most preferred option.

5. Conclusions

Stanford's ten year Parking Plan sets eight goals:[36]

1) Reduce parking demands.
2) Reduce traffic trip generations.
3) Respond to recent legislative mandates.
4) Create a comprehensive financial response.
5) Increase land use opportunities for uses other than parking (e.g. academic sites or open space).
6) Improve transportation networks.
7) Maintain a safe and secure campus.
8) Support research, teaching, patient care and business programs.

Fundamentally, Stanford can meet these goals in only two ways: increase parking supply or reduce demand. How do the two compare?

Any plan which attempts to solve the shortage simply by increasing supply fails to meet the first two goals - reducing parking demand and traffic - and therefore must fail the third goal as well, since reducing traffic is precisely what recent legislation mandates. Moreover, 'build more parking' plans fail either the test of affordability, or of conserving land use opportunities, or both. 'Optimal' plans, emphasizing structures, are too costly, and would still consume an additional six acres of scarce central campus land. Plans relying on perimeter surface lots are worse: they require far more land and ultimately prove more costly, as shifting costs to employees results either in higher salary demands or more staff turn-over. Finally, such remote lots respond poorly to the last two goals of maintaining safety and supporting University programs.

Commute allowances, by contrast, support each of Stanford's goals. Regarding the first two: where introduced, commute allowances have reduced traffic and parking demand by an average of 27 percent. Such gains will allow Stanford to not just meet, but far exceed, the targets specified by recent

[36] Stanford University Planning Office (1992c) 4.3.

legislation. An average response - 27 percent drop in parking demand - will push Stanford's current Average Vehicle Ratio from 1.34 to 1.83 employees per car, surpassing Trip Reduction Rule and General Use Permit targets to the year 2000 and beyond.

On the fourth goal, affordability, the arithmetic is clear: paying an employee $30 a month not to drive costs less than meeting the $140 monthly debt service payment on a structure. Count the other benefits - millions in spending on intersection expansion avoided, fewer accidents, less traffic, more peace and quiet - and the savings grow. Even given the substantial cost of extending commute allowances to commuters who already do not drive, this cost/benefit analysis finds that by offering commute allowances, Stanford can realize overall net savings of $3 to $6 million annually.

Consider the fifth goal, increasing land use opportunities: a commute allowance plan which reduced demand by only 15 percent would free up 2900 spaces, or 23 acres. A 40 percent reduction would save 61 acres. Several Stanford Trustees have expressed the desire of removing cars from central areas of campus to open up building sites and expand the quiet of the pedestrian zone. Given the strains on Stanford's budget, commute allowances are perhaps the only affordable way to fulfill that wish.

Sixth: Commute allowances work to improve transportation networks by creating new demand for public transportation. In the case studies documented, demand for public transit increased by an average of 87 percent. Given higher demand, transit service can add new routes and operate more frequently - and this improvement in service in turn attracts new riders.

Seventh: On safety, reducing demand can help in two ways. First, staff are not forced to a long and vulnerable walk to distant new lots. The second, more substantial, though often overlooked benefit is that reducing traffic reduces accidents as well.

Eighth, and last: To support teaching, research, patient care and business programs, commute allowances offer an affordable solution to the university's parking shortage, where expanding supply would impose far larger costs.

Perhaps most important for the success of any new parking plan, commute allowances offer staff new options, rather than punitive parking fees or relegation to distant lots.

Current policy offers employees a take-it-or-leave-it choice between a parking subsidy and nothing. Commute allowances instead help employees however they choose to arrive at work. By adopting them, the university can replace a subsidy which works against all of its goals with one that advances them; reap substantial economic gains through the elimination of economic waste; and repair and restore both the environment and quality of life on the Farm. And, as UCLA's Donald Shoup writes, all these benefits derive simply from subsidizing <u>people</u>, rather than cars.

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Appendix 1
Calculating Debt Service Costs

<u>Annual payment needed to pay back interest and principal over the 40 year life of a parking structure:</u>

We know that the construction cost of Parking Structure III was $18,235 per space. If Stanford pays cash, how can this cost, incurred now, be compared to the benefit of receiving parking permit fees every year over the useful life of the structure -- that is, over about the next 40 years? Or, if Stanford takes out a construction loan, how large an annual payment, for each space, will be needed to pay off the loan -- to just recover the cost of building the space?

As Stanford economist Joseph Stiglitz writes,

> The basic procedure employed by economists (and businesspeople) is based on the premise that a dollar today is worth more than a dollar tomorrow. If the firm receives $1 today, it can take it down to the bank, deposit it, and have (if the rate of interest is 10 percent) $1.10 at the end of the year. Thus $1 today is worth $1.10 next year. The firm is just as well off receiving $1 today as $1.10 next year. If the firm invests the $1.10 it will have at the end of the following year $1.21. Accordingly, the firm is indifferent between receiving $1 today and $1.21 in two years' time.
>
> [Note: Stanford, rather than take money down to the bank, invests money in the endowment, where it earns 11% or better interest. Alternatively, we can borrow money long-term at 7.5% interest. Then, the same basic idea applies: to get $100 today, we must pay back $107.50 next year, or $115.56 in two years' time.]
>
> To evaluate projects with receipts and expenditures in future years, it multiplies those receipts and payments by a discount factor , by a number (less than one) that makes those future receipts and payments equivalent to current receipts and payments. The discount factor is smaller the further into the future the benefit is received. The discount factor for payments in one year is just 1/1+r, where r is the rate of interest (in our example r =.10, so the discount factor is 1/1.1 = .9); for payments in two years' time it is just $1/(1+r)(1+r) = 1/(1+r)^2$ (in our example it is 1/1.21). The value today of $100 to be received two years in the future is thus $100/1.21 = $82.60. We then add up the value of what is to be received (or paid out) in each year of the project. The sum is called the present discounted value of the project, often abbreviated as PDV. If R_t is the net receipts from the project in period t,, and r the rate of interest, then if the project lasts for N years, its PDV is given by

$$PDV = R_0 + \frac{R_1}{1+r} + \frac{R_2}{(1+r)^2} + \frac{R_t}{(1+r)^t} \ldots + \frac{R_N}{(1+r)^N}$$

In our case, we can use the equation above to figure out the present discounted value of a stream of payments collected over the lifetime of the parking structure. R_0 is the payment made this year; R_1 the payment made next year, and so on, up to the Nth year. N is the useful life of the parking structure: commercial operators generally place this at 40 years. r is the interest rate Stanford has to pay on the construction loan (currently 7.5%).

To find the annual payment needed to just pay back the initial construction cost, we set the present discounted value of the stream of payments equal to the construction cost of the space:

$$\text{Construction Cost} = \text{PDV} = R_0 + \frac{R_1}{1+r} + \frac{R_2}{(1+r)^2} + \frac{R_t}{(1+r)^t} \ldots + \frac{R_N}{(1+r)^N}$$

If the annual payment, R_t, is the same every year, then the mathematical series on the right-hand side of the equation can be reduced to the single expression

$$\text{Construction Cost} = \text{PDV} = \frac{R_t\,[1 - (1+r)^{-N}]}{r}$$

Now we rearrange the equation to solve for the annual payment needed, R_t:

$$\text{Annual Payment} = R_t = \frac{\text{Construction Cost x } r}{1 - (1+r)^{-N}}$$

For Parking Structure III, the values we need to plug into the equation above are:

Construction Cost = \$18,235 per space
r = interest rate = 7.5%
N = useful life = 40 years

Plugging these in, we find that the annual payment needed to just recover the construction cost is

$$\text{Annual Payment} = R_t = \frac{\$18235 \text{ per space x } .075}{1 - (1+.075)^{-40}} = \$1448 \text{ per year}$$

This is the annual debt service cost for Parking Structure III at 7.5% interest, which is used in Table 1: Parking Structure III, Costs Per Space.

It can also be revealing to change the key assumptions used above and see how this affects the final result:

<u>1) If the useful life of the structure is much longer than forty years, how will this affect costs?</u> Suppose we assume the structure will last forever, instead of only 40 years. Then N = ∞ (= infinity), and the annual payment needed to pay for the garage will be

$$\text{Annual Payment} = R_t = \frac{\$18235 \text{ per space x } .075}{1 - (1+.075)^{-\infty}} = \$1368 \text{ per year}$$

The annual payment needed doesn't change much, even though the structure will now provide useful service and collect annual payments forever, instead of only forty years. This is because payments to be made more than 40 years from now are worth little in today's dollars: For example, the value today of \$1,368 to be received 40 years from now is only \$75.81. (To many, this discounting of future payments seems odd. If it does to you, consider placing an extra $75.81 from your next paycheck in a savings account. In forty years, you will have $1,368 or more. If that idea sounds unattractive, then you too have decided that $75 now is at least as good as $1,368 forty years from now.)

<u>2) What happens if interest rates change?</u> The present long-term interest rate of 7.5% is a 35-year low. Historically, Stanford has had to pay more nearly 9% on loans. Moreover, some economists expect interest rates to rise by the end of the year. What effect would this have? At 9% interest, the annual payment needed would be

$$\text{Annual Payment} = R_t = \frac{\$18235 \text{ per space x } .09}{1 - (1+.09)^{-40}} = \$1695 \text{ per year}$$

Thus, a one-and-a-half percent rise in the interest rate adds $247 per year to the cost of each parking space. If interest rates climbed back to 11%, costs would soar to $2,037 per year. Roughly, every 1% rise in interest rates translates into an additional $170 per year in payments for each parking space. (Conversely, if interest rates dove below historic lows -- a less likely prospect --, an additional 1% decline would lower the cost of each space by $170 annually.)

Appendix 4

Table 3

Parking Structure III If Placed on Vacant Land, Costs per Space	
1) Land Cost: (value land at $1.25 million per acre = $28.70 per square foot) (Building Footprint = 350 parking spaces x 340 sq. ft. per space = 119,000 sq. ft.) = $28.70/sq. ft. x 119,000 sq. ft. / 775 parking spaces = $4,407 per space resulting annual opportunity cost of land (discounted at 7.5%) =	$350
2) Construction Cost = $10,000 per space resulting annual debt service on this capital cost at 7.5% interest =	$794
3) Maintenance = 1.5% of construction cost = 1.5% of $10,000 =	$150
4) Utilities = cost unknown = $0	$0
5) Insurance: Earthquake = no insurance carried Property = 0.2% of construction cost / total number of spaces = 0.2% x $7.75 m / 775 spaces =	$15
6) Enforcement & Administration = $1,071,000 budget / 17,206 spaces on campus =	$62
7) Shuttle Operating Costs: Low range: (For close in lot, no shuttle needed).. High range: = $32 per hour x 10 hrs/day x 252 workdays/year / shuttle served 1000 spaces in Stock Farm lot = ...	$0 to $81

8) Waiting & Travel Time Costs for Staff:	
Low range: (For close in lot, no waiting or travel time costs)........................	$0 to
High range: 20 minutes per workday x 252 workdays = 84 hours per year	
Low estimate: (value staff time at campus minimum compensation of $9.94 per hour)................................	$835
High estimate: (value staff time at average employee compensation rate of $30.95 per hour)......................	to $2621
TOTAL	$1371 - 4073
Cost to Stanford = (Total - $224 'A' permit fee) =	$1147 - 3849 per space per year ($96 - 321 monthly) ($4.55 - 15.27 daily)

Parking Structures on Vacant Lots

As we noted above, in the congested central areas where structures are wanted, there is no more unused land. Virtually all proposed structures are slated to go on existing surface lots -- and that fact nearly doubles the final cost of each space. Parking Structure III cost only $10,000 a space to build, for example, but since an existing 350 space surface lot had to be torn up to make room for Parking Structure III, the final cost of each space gained almost doubled, to $18,235.

But suppose vacant land were found for a new structure. The last Manzanita trailers, for example, and perhaps the old Encina gym, may be demolished soon to make way for new construction. Or, further out from the campus center, the open fields of Campus West await development. Placed on vacant land, what would a new structure cost? Table 3 (above) summarizes the case by considering what Parking Structure III would have cost had it been placed on a vacant lot. The notes below explain the results:

1) Land Cost: Again, we judge the value of land at $1.25 million per acre, or $28.70 per square foot. Since a 350 space lot had to be torn up to put in Parking Structure III, we can measure the building footprint (the land taken up by PS III) as the area needed for 350 spaces: approximately 119,000 square feet.[1] Multiplied by $28.70 per square foot, and divided by the 775 spaces of Parking Structure III, this works out to a land cost of $4407 per space, or $350 per year.

2) Construction Cost: Since no existing spaces are destroyed, construction cost is simply the basic construction cost for a new structure of $10,000 per space.

3 - 6) Maintenance, Utilities, Insurance, Enforcement: These figures remain unchanged.

7 - 8) Shuttle Operating Costs; Waiting & Travel Time Costs for Staff: If a structure is conveniently sited right beside existing offices, as Parking Structure III actually is, shuttles are not needed and no waiting or travel time costs are counted: the parking is as close and convenient as parking can be. If close-in ‘vacant’ land could be found (perhaps the Manzanita Trailers site, or the lawn of the Oval) these costs would be zero, giving us the lowest cost estimate: $1371 yearly per space. If, less sensibly, structures were built on the outskirts of campus, then the same travel and waiting costs found for perimeter lots would be added to the tremendous expense of structures, giving us the high-end cost of $4073 annually.

In practice, ‘vacant’ land in the center of campus is rare. The open spaces which do exist -- the Oval, playing fields beside dorms, and the pedestrian promenades between buildings -- are all highly valued as open space. On the rare occasions when demolishing an old building frees up land, it is instantly claimed by departments wanting to site a new one. Our assumption for land cost above, valuing all land at $1.25 million per acre, likely undervalues acreage at the heart of campus.

Our assumption that aesthetics costs should be placed at $0 also becomes improbable when we consider siting a parking garage on open space at the heart of campus: few if any would agree that dropping a parking structure on White Plaza or one of the grassy swards between dormitories would cause no loss.

[1]Stanford University Planning Office (1991) 27.

Likely because of these two factors -- aesthetics and the value of scarce central building sites -- none of Stanford's 16 proposed parking structure sites are on 'vacant' central land.[2] If a proposed structure is close-in, it will sit on an existing parking lot.

[2] Stanford University Planning Office (1991) figure 8.