The Price Isn't Right: Mobility Alternatives and their Plight

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SUBMITTED TO THE DEPARTMENT OF URBAN STUDIES AND PLANNING IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF

MASTER IN CITY PLANNING
AT THE
MASSACHUSETTS INSTITUTE OF TECHNOLOGY
JUNE 2015

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The Price Isn’t Right: Mobility Alternatives and their Plight

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Submitted to the Department of Urban Studies and Planning
on May 26th, 2015 in Partial Fulfillment of the
Requirements for the Degree of Master in City Planning

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ABSTRACT

When it comes to car size, the conventional wisdom of both auto manufacturers and drivers alike would dictate that smaller cars are designed for and work best in the tight confines of the city. Small cars—and specifically for this study, sub-compact ‘city cars’ such as the Smart Fortwo—do indeed offer distinct advantages in terms of fuel efficiency, parking flexibility, increased visibility, as well as better maneuverability. However, empirical observations in the Boston Metropolitan Region finds little—if any—correlation with greater share of such vehicles in downtown settings as opposed to more suburban surroundings. Given the suggested advantages of these small cars, why don’t they proliferate downtown?

This study presents several possibilities, beginning with the likelihood that consumers apply a heavy discount to small vehicles as dictated by larger cultural values that may easily outweigh purely economic benefits. The study measures these economic benefits, employing an accounting-based methodology to calculate true long-term costs of driving, highlighting the compared costs of four car models: those of the Toyota Camry, Smart Fortwo, Smart Fortwo Electric, and the Nissan Leaf. Such a comparison illustrates the difficulty small cars face in expensive downtown settings such as Boston’s; counterintuitively, the greater the number of costs that must be paid for by drivers—parking rates, tolls, congestion fees to name a few—the lower the comparative advantage often becomes for city cars and their like.

On the other hand, if prices could be set to reflect real market conditions, especially in downtown areas where city cars are designed to excel, comparative economic advantages for these small cars grow quickly. This is particularly true for parking—should parking rates be charged in relation to how much space is actually used, city cars in particular could hold significant long-term economic advantage over larger options, a potential game-changer for urban mobility.
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Introduction

Despite routine spikes in oil prices in recent years and current at-the-pump prices that remain above the long term average, Americans continue to buy large vehicles like SUVs and ‘crossovers’ in record numbers. In 2015, out of 5.4 million new vehicles sold year to date, 2.9 million—54%—were just such larger framed vehicles the auto industry terms ‘light trucks’\(^1\). Our preference for bigger vehicles seems to be continuing unabated. Nevertheless, Americans are at the same time becoming more urban, increasingly living in denser and larger cities and communities. How is it that America can both be becoming more urban, seemingly more environmentally friendly and yet continue to prefer the same old large cars?

The research presented here suggests that key market variables are artificially distorted to inadvertently favor large vehicles, even in dense urban setting where they should instead be discouraged. On the other hand, current policy prevents small vehicles from capturing their true and full economic benefit; the true, real world price for vehicles currently on the street simply isn’t right. This simple reality is illustrated through cross-comparative accounting methods for industry-standard 5 year cost of ownership for four vehicles: the Toyota Camry, Nissan Leaf, Smart Fortwo, and Smart Fortwo Electric. These vehicles were chosen as representatives of their class of car, with the Camry exemplifying the average American sedan, the Leaf a standard electric drive vehicle, the Fortwo the prototypical city car, and the Fortwo Electric as a fully electric city car.

The accounting methods employed in this study follow similar ownership cost models produced by major automotive consumer groups. While these accounting methods are useful in comparing the typical ownership and operating costs of the average driver, they ignore larger

societal costs – the so-called negative externalities of driving. This is especially problematic for urban areas in which high population density, as in Boston, must inherently yield greater externality costs. Most importantly, they ignore the deeply distortionary policy and costs of parking. While much has been written on the problems that ensue with free and underpriced parking, this study’s accounting methodology illustrates that current parking policy artificially reduces the natural economic advantage of small vehicles in Boston’s downtown core.

Although it is indeed exceptionally difficult for policy makers to shift consumer car buying behavior overall, this paper recommends several straightforward, market-based mechanisms to at least give smaller vehicles a stronger comparative economic advantage in urban environments. Most significant of these would be the introduction of a ‘space used’ price for parking method, whereby drivers should only have to pay for the amount of parking space actually used by their car. In a dense, expensive driving environment such as Boston’s, this shift alone is enough to provide a powerful economic advantage to smaller vehicles – in particular, to sub-compact ‘city cars’ like the Smart Fortwo that have long been championed as that natural fit for urban drivers.

**Why Small Cars?**

The advantage of the small car against their more sizable alternatives have been highlighted by designers for nearly as long as the automobile has been in existence. Overall, these can be broken down into 5 main advantage points:

- Lower upfront cost
- Higher fuel efficiency/ lower running cost
- Lower environmental footprint
- Higher maneuverability
- More compact parking flexibility
The cost advantage even today may be the most apparent advantage these cars hold, one rooted in the early years of car production. In the early 20th century, up-and-coming manufacturers such as Ford Motors focused on the lower production costs for smaller vehicles, transforming what was once a luxury item into a product for the masses. Perhaps no car better captures this motive better than the famed Ford Model T, which at 134” long by 66” wide, is still smaller than today’s most popular U.S. subcompact car, the Honda Fit:

“I will build a car for the great multitude. It will be large enough for the family, but small enough for the individual to run and care for. It will be constructed of the best materials, by the best men to be hired, after the simplest designs that modern engineering can devise. But it will be so low in price that no man making a good salary will be unable to own one.”

In Germany, a similar ‘car for the masses’ mantra was the impetus for the People’s Car project in the 1930’s, with the goal of producing a small, family car affordable to the majority of the country’s growing population. War of course interrupted the project, but resulted in the formation of the Volkswagen automotive group and their iconic VW Beetle. A similar parallel is found today in India where beginning in 2008, Tata Motors began selling the Nano city-car which, at around $2,000, is the least expensive car sold globally. Designed with affordability in mind, the car is marketed to win over value-conscious buyers.

---


customers from India's burgeoning middles class from otherwise cheaper 2-wheeled vehicles. At 122" by 59" wide, it is also among the smallest cars on the road.⁴

Europe witnessed a surge in fuel prices through the 1960's and 1970's as a result of turmoil in the Middle East, and with it came a newfound appreciation for fuel-sipping city cars. German made 3-wheeled Messerschmitt KR175's became popular across the continent, despite a diminutive frame set on three wheels and powered by little more than a motorcycle engine. These objectively odd appearing “bubble cars” encouraged the British Motor Corporation to design a purposefully more stylish, though still affordable and efficient city car. Introduced in 1959, their Mini has become arguably the most successful city car brand, today manufactured and sold by BMW; it's sporty, youthful design is one that does much to showcase how ‘cool’ small can be.

The Mini⁵

Perhaps the most advanced iteration of the city car concept is one currently being produced by the Changing Places Research Group at MIT's Media Lab. The MIT CityCar,

---

now being manufactured in Spain as the Hiriko, is an engineering marvel that manages to excel in all marks true city cars are to be measured. As described by Hiriko lead designer William Lark, Jr. in his doctoral dissertation, the vehicle offers an ultra-compact footprint, high maneuverability, high fuel efficiency and negligible environmental impact, and ideally when produced, low cost:

The CityCar exploits technologies such as a folding chassis to reduce its footprint by 40% and Robot Wheels that each are allotted between 72 to 120-degrees of rotation to together enable a seven-foot turning circle. Just over 1,000 pounds, its lightweight zero-emitting electric platform, comprised of significantly fewer parts, curbs negative externalities that today’s automobiles create in city environments. Additionally, the vehicle platform developed from the assembly of several core units empowers a consortium of suppliers to self-coordinate through a unique modular business model. Lastly, the CityCar specific uMEV confronts problems within urban transit by providing a nimble folding mobility solution tailored specifically to crowded cities. Benefits, such as a 5:1 parking density and its reduced maintenance demands, are especially reinforced in the context of shared personal transportation services like Mobility-on-Demand.⁶

Unlike earlier cars, the Hiriko/CityCar is intended to integrate the flexibility of a Mobility-on-Demand system, along the lines of popular bike sharing programs; the cars would be retrieved from designated stations where they wait in an ultra-compact folded-up state, to be driven to a similar station in a convenient location to again be folded for future use. A feature offered by no other vehicle on the road, it may very well set a new precedent for urban mobility, especially when paired with the near-tangible reality of automated vehicle technology.

The Hiriko

In the perspective of this study, few of Lark's design benefits are greater than the Hiriko's advantage over the typical sedan when parking:

At curbside, the Hiriko holds a 3.3:1 parking advantage to the average sedan; as the illustration above suggests, 10 folded-up Hirikos can fit in the same space as just 3 sedans in typically marked parking spaces. Lark explains that the Hiriko is designed to "take an exceptionally sub-compact footprint to ease parking and preserve precious real estate". This likewise extends to off-surface parking where the Hiriko holds a 3.2 to 1 ratio advantage:

---
Lark’s design highlights what may be the singularly greatest advantage of city cars: their small size in saving valuable real estate, with downtown Boston’s being among the most expensive such real estate in the world. This connection between vehicle and land use is an important one—and if carried out incorrectly, as UCLA’s parking economist Donald Shoup contends nearly all U.S. parking policy is, the additive cost to society is enormous. Shoup contends that minimum parking requirements are particularly onerous—that the mandated provision of such “free parking” in 2002 dollars actually amounted to a total cost of $374 billion a year\textsuperscript{11}—over $100 billion more than federal Medicare spending and roughly on par with federal defense spending.

Last, designers and marketers of small vehicles rarely appreciate the potential comparative safety of smaller vehicles on city streets. Unfortunately, research remains very limited on the connection between car size and overall accident risk. Vehicles with high centers of gravity, typical in SUV design, have been found to pose a substantially greater risk of serious injury and death due

to roll-over incidents.\textsuperscript{12} Light truck category vehicles are also found to often be incompatible with the safety frames of small to medium sized vehicles – in fatal accidents between these vehicle groups, 81\% of fatalities are found to be occupants of the smaller vehicle.\textsuperscript{13} Additionally troublesome for downtown environments, light truck class vehicles are found to significantly increase the risk of serious injury or death to pedestrians struck as compared to regular framed cars in similar accidents.\textsuperscript{14} While studies have not been extended to compare small and city-car sized vehicles to these larger class vehicles, it doesn’t take a major logical shift to suppose that city car sized vehicles shouldn’t hold a similar advantage given their lower weight, added visibility, shorter stopping distance, and agility, especially in regards to pedestrian and bike safety in urban centers.

For policy makers at least, small cars should be prioritized in urban centers for just these reasons: reduced air pollution in dense environments, lower urban carbon footprint, reduced risk of accident, and lastly, the ability to significantly reduce the land use impact of parking.

The Problem with Small Cars

While small cars offer the advantages detailed above, few of the most significant of these advantages are actually passed on to drivers themselves, as will be discussed in detail further. Additionally, many of the benefits—for instance, fuel efficiency and low sticker price costs—are benefits to drivers regardless of location; they simply may not be a significant advantage in a strictly urban environment, and as will be discussed further, do not contribute much to the comparative economic advantage small vehicles hold.

\textsuperscript{13} Lefler, Devon and Gabler, Hampton. The Emerging Threat of Light Truck Impacts with Pedestrians. Rowan University, 2003.
\textsuperscript{14} Lefler, Devon and Gabler, Hampton. The fatality and injury risk of light truck impacts with pedestrians in the United States. Rowan University, 2003.
These problems are empirically observable. In a study of Boston area car size by proximity to urban center *(found in Regression Analysis 1 in the Appendices)*, there does not seem to be a statistically significant correlation between the percentage of small cars within a census tract and its distance to the center of Boston. Similarly, no such correlation was found to be significant when comparing the percent of small cars with population density. In other words, despite the Boston area being a seemingly prime environment for smaller-sized and city cars due to its reputation for expensiveness as well as urban density, these vehicles are no more popular downtown than they are in the suburbs. Surprisingly, in absolute numbers, city car and compact sized vehicles only make up around 2% of Boston area cars—and those combined with small cars together only account for around 17% of area personal vehicles:

<table>
<thead>
<tr>
<th>Miles from Center</th>
<th>Very Small Cars</th>
<th>Small Cars</th>
<th>Small and Medium Cars</th>
<th>Large Vehicles</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 to 2</td>
<td>3%</td>
<td>15%</td>
<td>55%</td>
<td>45%</td>
</tr>
<tr>
<td>2 to 5</td>
<td>1%</td>
<td>18%</td>
<td>53%</td>
<td>47%</td>
</tr>
<tr>
<td>5 to 20</td>
<td>2%</td>
<td>13%</td>
<td>55%</td>
<td>45%</td>
</tr>
<tr>
<td>Mean</td>
<td>2%</td>
<td>15%</td>
<td>54%</td>
<td>46%</td>
</tr>
</tbody>
</table>

For reasons that will be discussed further, Boston drivers clearly prefer larger vehicles regardless of location – suggesting that the benefit of driving small vehicles is somehow being suppressed.

Similarly problematic are the results of hedonic modeling as accomplished for this study, where the price of a major U.S. car brand vehicle is found to be:

\[
\text{Price} = 311 \times (\text{sq. feet}) + 746 \times (\text{height, inches}) + 15,804 \times (1 \text{ if luxury, 0 if not}) - 49,744
\]

*(Found in Regression Analysis 2 in the Appendices)*

In other words, car consumers are willing to pay $311 for every additional square foot of car footprint; $746 for every added inch of height; and $15,804 for luxury status, with the $49,744 being the ‘constant’ term. As is well understood, American willingness to pay for larger vehicles
is significant – the marginal $311 per square foot of car space is well above what most pay for their home’s floor space. More troublingly when considered the increased accident risk of larger vehicles, we exhibit a willingness to pay hundreds of dollars for additional car height. Despite real risks and significantly higher social costs, we like our big cars and are all too willing to shell out big bucks for big trucks – with automakers all too eager to oblige this appetite. As will be discussed next, this illustrates not only a difficult economic market for small cars and city cars, but perhaps more importantly, a collective behavioral bias against them.

The Value of Driving

In many ways, American culture is car culture – cars in many ways define who we are for better or worse, shaping our cities, where we find our homes, our jobs, where we shop, eat, and find entertainment. For the vast majority of Americans, car driving is an integral part of everyday life—one for which we spend lavishly; after home buying, the acquisition of a car is typically the second largest purchase we make. Likewise, after the cost of housing, transportation for most Americans ranks as the second greatest cost, above that of food and recreation, often even rivaling that of housing itself.\(^{15}\) We love our cars—and value them above nearly all else.

There are various ways to express the value of complex relationships and goods beyond flat dollar accounting. In brief, utility can be expressed simply as:

\[
U = \beta \ast \chi + \varepsilon
\]

\(^{15}\) National Housing Conference and the Center for Neighborhood Technology. “Losing Ground: The Struggle of Moderate-Income Households to Afford the Rising Costs of Housing and Transportation” 2012.
Where utility \((U)\) is the product of a set preference rate \((\beta)\), the valuation of a unit of consumption, action and a real world cost or benefit \((\chi)\) such as dollars, time, or size, plus some amount of random error that is unexplainable \((\varepsilon)\).

When an individual makes a decision over his or her means of transportation, the utilities of two or more options are weighed against each other such that the probability of choosing one vehicle \((x)\) over another vehicle \((y)\), together \(P(x|y)\), is:

\[
P(x|y) = P(U_x \geq U_y)
\]

In other words, the probability an individual will choose one vehicle over another is dependent on the probability that the utility of vehicle \(x\) \((U_x)\) is greater than or equal to the utility of vehicle \(y\) \((U_y)\). This method of formalizing the decision making process of vehicle purchasing makes it clear that it is not any one particular factor that leads an individual to purchase a city car-like vehicle or not, but rather, a basket of values that collectively form a valuation of \(U\).

For policy makers, influence on this decision making process can therefore focus on the three parameters discussed: personal characteristics and implicit preference \((\beta)\), and characteristics of a vehicle and its measurable cost and benefit \((\chi)\). The majority of this study focuses on this last term \((\chi)\); in influencing the auto market, price control is perhaps the strongest and most straightforward approach for policy makers to take, although concurrent efforts should be made to address the more difficult to measure behavioral preference \((\beta)\), in particular the preference clearly outlined above for American drivers in purchasing larger vehicles. Such an intervention could take the form of a more nebulous public educational campaign, whereas the intervention in the measurable cost and benefit \((\chi)\), which will be outlined through this study’s analysis of the
comparative costs of driving, can simply take the form of economic incentives and disincentives outlined in this study's recommendations.

Calculating the Costs of Driving

For as much a part of us as cars are, we as drivers nevertheless have a difficult time understanding the true cost of driving. Various prices and values are advertised incessantly - we compare things like MSRP; MPG; reliability; resale value. But we intuitively know these numbers at best only tell half the story - what about everyday maintenance? Licensing fees? Tolls? Fuel costs? And then the more abstract costs - pollution? Greenhouse gases? Noise? Congestion? These are hard to understand and appreciate for the individual driver - and we routinely undervalue these costs on the whole - often significantly so. In a study of Canadian drivers, the Canadian Automobile Association found that 60% of drivers underestimated their annual costs by C$4000 or more; 2/3 believed their costs of driving to be below the cost of groceries, whereas the true cost of driving was found to be 176% of annual grocery costs - approaching twice the cost.\textsuperscript{16} Clearly we have trouble calculating these large, dynamically changing numbers - given how significant a percent of our personal budget driving composes, we must do better. Undoubtedly, this shared misperception of significantly lower costs of driving results in the widespread misallocation of resources across the transportation sector, with this widespread confusion over such a costly activity in itself a call for serious policy intervention.

Standard Estimates of Annual Costs

How then should we estimate costs? Unfortunately, this is a deeply complex question where estimates vary dramatically. Adding to the difficulty is the lack of standard methodology in forming these estimates, particularly when comparing out-of-pocket costs, herby termed ‘explicit costs’, against costs paid by society at large or costs that are largely hidden from drivers, herby termed “implicit costs”. Leaders in the estimation of explicit costs include well known auto-policy organizations such as Kelley Blue Book, Consumer Reports, The American Automobile Association (AAA), and Edmunds.com among others, each of whom offer various ‘cost of ownership’ estimates, providing, for example, average annual costs of driving:

<table>
<thead>
<tr>
<th></th>
<th>Average Annual Cost, All Cars</th>
<th>Average Annual Cost, Sedan</th>
<th>Average Annual Cost, 2015 Toyota Camry LE 4 Cylinder</th>
</tr>
</thead>
<tbody>
<tr>
<td>AAA(^\text{17})</td>
<td>---</td>
<td>$9,122</td>
<td>---</td>
</tr>
<tr>
<td>Consumer Reports(^\text{18})</td>
<td>$9,100</td>
<td>---</td>
<td>$7,023</td>
</tr>
<tr>
<td>Edmunds(^\text{19})</td>
<td>---</td>
<td>---</td>
<td>$7,243</td>
</tr>
<tr>
<td>Kelley Blue Book(^\text{20})</td>
<td>$9,100</td>
<td></td>
<td>$7,390</td>
</tr>
</tbody>
</table>

These accounting-style comparisons do share several standard characteristics which prove helpful for further cross comparison – they assume a standard 15,000 miles of annual driving (as opposed to the estimated us average annual average of 13,476)\(^\text{21}\), and use U.S. average fuel costs and insurance rates.


This study builds off these base estimates, in particular using data from Edmunds.com, which provides adjusted location-specific costs as well as cost breakdowns by year. In lieu of using overall cost averages across the U.S., cost comparisons between the 2014 Toyota Camry LE 4-cylinder, 2014 Smart Fortwo, 2014 Nissan Leaf, and 2014 Smart Fortwo Electric all made within the Boston metro area context. For this study, the Camry will serve as the ‘base model’ vehicle—a car intended to approximate what a Boston area ‘average’ car could cost under typical driving conditions.

The Camry

The Camry—stout and a bit squat, with the rounded edges, elongated engine and trunk compartments and ample seating space of the prototypical mid-sized sedan—is in many ways emblematic of the modern family car. For drivers, the Toyota Camry is the goldilocks choice—not too large, not too small; not too sporty, but certainly not sluggish—overall, the car just right, an average car of average size well-suited to the typical routine of the average American family. With available seating for 5, spacious cargo room, and an impeccable safety record, the Camry is no doubt on every buyer’s mind when searching for the next car—which is no wonder that the vehicle has been the top selling mid-size sedan for the last 12 years. In 2014 alone, 428,000 Camrys were sold in the United States; over the last 10 years, more than 4 million. At the 2015 MSRP of $22,970, Americans have spent more than $90 billion on the vehicle over this period of time.

The Camry will serve as a proxy for the ‘average’ car for the ‘average’ Bostonian commuter for this exercise. Of course, this is not quite accurate—as mentioned previously, the vehicle makeup of Boston area roads echoes the national trend towards larger vehicles; in the first
months of 2015, the ‘light truck’ category which includes pickups, minivans, SUVs and crossovers represented 52% of personal vehicles sold.\textsuperscript{23} When reading, keep in mind that the mid-size sedan like the Camry may no longer the best exemplar of the modern American car, whereas instead it may be something larger—such as the top-selling mid-size Honda CRV SUV. The argument that large vehicles like SUVs and other ‘light trucks’ should be discouraged from entering dense urban environments is easy to make and relatively well understood. The argument presented here goes one step further—raising the bar even for comparatively smaller sized vehicles like the Camry—that not only are large vehicles like SUVs, pickup trucks and minivans costly in dense urban environments, but so too are today’s more modest midsized vehicles. Importantly, the comparative advantage the Camry holds over these larger vehicles is simply not good enough when compared to the much better alternative of the Smart Fortwo city cars showcased in this study.

**Standards in Accounting for Annual Driving Costs**

As mentioned, this study will investigate the comparative costs of the 2014 Toyota Camry LE 4-cylinder, 2014 Smart Fortwo, 2014 Nissan Leaf, and 2014 Smart Fortwo Electric. In comparing these vehicles, total driving costs are estimated over a standard 5-year ownership period adding both the typically assumed private explicit costs of driving along with the rarely discussed implicit social costs of driving, all assumed unless otherwise stated to be at the standard 15,000 miles driven per year.

As mentioned, costs have been divided into two overarching classifications for this study: Explicit and implicit. Explicit costs are those costs born directly by the driver. These driving costs are somewhat difficult to predict; costs are highly variable and may differ dramatically as a result.

of place of purchase, cost of gas, personal driver characteristics, driver credit rating, tolls, parking rates, and countless other variables. However, these are nevertheless costs that can in hindsight be calculated and clearly accounted for, as is done by organizations such as Edmunds, Kelley Blue Book, AAA, and Consumer Reports. Implicit costs on the other hand are those costs borne by society at large, for example, carbon emissions. These costs are largely invisible to the driver and for the most part are not taken into account by the aforementioned auto cost measuring organizations, nor by drivers themselves for that matter. Worse, it is often difficult or impossible to realistically determine these sorts of costs. While comparatively easier to estimate, even calculating explicit costs has its own problems due to the variability of personal driving habits and needs. Nevertheless, these costs are estimated and subdivided into two groups – carrying costs, which are fixed, and operating costs, which are variable.

**Carrying Costs**

Carrying costs are a measure of the simple cost of owning and holding a vehicle; even without driving, an owner must pay the initial purchase taxes, yearly licensing fees, and if purchased through financing, interest, as well as the full cost of depreciation.

<table>
<thead>
<tr>
<th>Average Carrying Costs (Fixed)$^24$</th>
<th>% of Total Explicit Costs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Depreciation</td>
<td>44%</td>
</tr>
<tr>
<td>Taxes &amp; Fees</td>
<td>6%</td>
</tr>
<tr>
<td>Financing</td>
<td>6%</td>
</tr>
</tbody>
</table>

---

Depreciation amounts to the difference between the purchasing price and the current resale value of the car; to most, it is well understood that a car after 5 years is worth considerably less than when first purchased, as is the 'drive off the lot' price drop phenomenon. However, what may not be fully appreciated by drivers is that this depreciation cost is indeed a yearly cost, one borne in total at the purchase of the next vehicle, and is in fact the single greatest explicit cost of car driving—fully 44% according to Kelley Blue Book.\(^\text{25}\) Depreciation itself is the result of comparative obsolescence, especially true for cars with significant differences between model years, a weaker market for used vehicles, as well as a significant portion resulting from wear and tear of usage on the vehicle, which technically makes it a blend of both fixed and variable costs.

Likewise, for the typical Camry driver, depreciation is the single largest individual expense—$12,184 over the first 5 years. Logically, the more expensive the car, the greater the depreciation expense. At a $21,677 Edmunds estimated sales price,\(^\text{26}\) a 2014 Camry after full depreciation would therefore lose $21,677 in value. Full 5 year carrying costs for the Camry are composed of this depreciation cost along with costs associated with taxes and fees as well as financing\(^\text{27}\):

<table>
<thead>
<tr>
<th>Year</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Depreciation</td>
<td>$5,410</td>
<td>$2,016</td>
<td>$1,775</td>
<td>$1,572</td>
<td>$1,411</td>
</tr>
<tr>
<td></td>
<td>Taxes &amp; Fees</td>
<td>$1,433</td>
<td>$523</td>
<td>$360</td>
<td>$172</td>
<td>$89</td>
</tr>
<tr>
<td></td>
<td>Financing</td>
<td>$626</td>
<td>$496</td>
<td>$362</td>
<td>$223</td>
<td>$79</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>$7,469</td>
<td>$3,035</td>
<td>$2,497</td>
<td>$1,967</td>
<td>$1,579</td>
</tr>
</tbody>
</table>


The cost profile for carrying costs is downward sloping - over time, carrying costs per year decline; the first year in particular costs nearly four times as much as Year 5. Depreciation is highest this first year, more than twice as much as in Year 2, as the car enters the used car market; taxes, and fees are highest at sale; and financing in the first years pay the highest interest premiums.

**Operating Costs**

Operating costs are derived from the variable day-to-day use of the vehicle. By and large, the more one drives, the higher these costs become and vice versa. Fuel costs predominate, accounting for fully 26% of explicit costs, although this cost share itself is also variable in terms of the price of gasoline in the U.S., which has ranged from $2.00-$4.00 per gallon over the last 5 years.

<table>
<thead>
<tr>
<th>Average Operating Costs (Variable)</th>
<th>% of Total Explicit Costs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fuel</td>
<td>26%</td>
</tr>
<tr>
<td>Insurance</td>
<td>9%</td>
</tr>
<tr>
<td>Maintenance</td>
<td>5%</td>
</tr>
<tr>
<td>Repairs</td>
<td>4%</td>
</tr>
</tbody>
</table>

---

Maintenance represents necessary, scheduled upkeep to the vehicle as a result of normal driving such as oil changes, tire replacement, and brake pad replacement, all of which are a factor of total miles driven. Repairs are unscheduled maintenance to the vehicle as a result of normal driving, such as most issues with major internal components like the engine or transmission; these repairs are not necessarily predictable, but will increase in occurrence with miles driven. Together, maintenance and repairs account for nearly 10\% of an average driver’s explicit expenses. Insurance in theory is a similarly variable cost – the likelihood of accident or injury is directly related to the number of miles driven in a given vehicle. However, in practice, car insurance policies are offered at more or less flat rates for drivers using vehicles for purposes other than recreation. This is problematic in that occasional drivers effectively subsidize heavy drivers – essentially, above-average driving is subsidized.

As opposed to carrying costs, operating costs increase with time as maintenance and repair costs rise with car age. Assuming no change in gas price or driving habits, fuel costs will remain the same; however, in practice, these can vary dramatically on a yearly basis. Insurance rates in Massachusetts are above average as compared to the rest of the nation, as are gas prices; at current rates of $2.56 per gallon in Massachusetts, and $1,460 in insurance per year on average in Massachusetts, the cost of fuel and insurance are roughly equal; for a driver in the Boston area, both approach $9,000 over 5 years.
5 Year Explicit Costs
Adding operating costs to carrying costs produces what this study terms “explicit costs” – the 5 year total cost paid out of pocket by drivers in the Boston area. It is at this point that most well-known cost estimators produce their topline, final accounting figures such as those offered earlier. According to this rubric, overall explicit costs for the typical Camry driver total $37,483 for the first 5 years - $16,547 (44%) as carrying costs, with $20,936 (56%) as operating costs.

After the second year, explicit costs stabilize to some degree before rising slightly after year 4:
Although the Camry is highly regarded for its affordability, reliability and comparatively low operating costs, at the Boston regional median household income of $52,792, the $7,500 per year average explicit cost of ownership represents fully 14% of pre-tax earned income. Despite this high cost and the relatively straightforward means with which to calculate them, it is unclear to what degree drivers typically take even this readily available information into account when purchasing a vehicle.

**Implicit Costs**

As high as these explicit costs are, these are just the start - as mentioned, a significant portion of driving costs are not imposed on drivers themselves. Implicit costs are those costs paid not by the user, but by society as a whole as ‘externalities’. These costs are difficult—if not
impossible—to properly account for. As a guide, The Victoria Transport Policy Institute (VTPI) in its comprehensive analysis of travel costs concludes that in an urban setting, the average driver incurs $1.11 of direct costs per mile as well as $0.64 in external costs in 2015 dollars — in other words, nearly 40% of all driving costs are thereby estimated to be implicit costs not incurred by drivers themselves.²⁹

According to VTPI, these costs include but are not limited to:

- Operating Subsidies
- External Crash Costs
- External Health Costs
- External Costs of Parking
- Congestion
- Road Facilities
- Land Value
- Traffic Services
- Transport Diversity
- Air Pollution
- Greenhouse Gas Emissions
- Noise
- Resource Externalities
- Barrier Effects
- Land Use Impacts
- Water Pollution

²⁹ Victoria Transport Policy Institute. “Transportation Cost and Benefit Analysis II – Cost Summary and Analysis” 2009
While these costs are difficult to estimate, VTPI analysis illustrates a rough ranking of overall costs both internal and external with the costs of vehicle ownership, car crashes, vehicle operation, travel time, and parking accounting for the top five costs. While individually accounting for a smaller percent of the total cost of driving, the larger number of externalized costs clearly add up to a significant portion of overall costs:

As mentioned, for every dollar spend directly by drivers, $0.59 is paid by others; this combined with the total magnitude of the combined thousands of dollars spent annually by America’s 200 million drivers, all cumulatively driving some 3 trillion miles31, yields staggering potential overall costs:

The magnitude of unpaid externalized costs in particular—even if estimates exaggerate the costs to some degree—is almost certainly in the hundreds of billions of dollars per year. These massive unpaid costs necessitate regulation of the automotive and transportation sectors of the economy and serve as the reasoning for continued, expanded policy intervention to reduce these costs. Therefore, to achieve any significant reduction in these unpaid societal costs, it is instrumental for urban policy makers to encourage consumer choice to switch from high externality vehicles in the light truck category to smaller vehicles, and in particular, to city-cars. While this study limits the calculation of implicit costs here on out to costs that could potentially be at least partially paid for through policy, such as unpaid highway expenses, the total cost of accidents, congestion, carbon emissions, air pollution, and the cost of parking, this is not to say these are the only costs worthy of being addressed.

**Implicit Costs of the Toyota Camry**
As was done previously for explicit costs, the Camry will serve to illustrate realistic implicit costs, continuing with the same accounting methodology. As carrying costs were added to operating costs to form total explicit costs, total implicit costs for this study will be the sum of: unpaid highway expenses; total cost of accidents; congestion; carbon emissions; air pollution; and the cost of parking – as mentioned, costs that have the potential to be regulated through regulatory policy.

<table>
<thead>
<tr>
<th>Total Miles Driven Annually</th>
<th>3 Trillion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Per Mile ($)</td>
<td>Total Annual U.S. Costs (in $ Trillion)</td>
</tr>
<tr>
<td>Explicit Costs</td>
<td>1.11</td>
</tr>
<tr>
<td>Implicit Costs</td>
<td>0.64</td>
</tr>
</tbody>
</table>
These total implicit costs will then go on to be added to total explicit costs to form a final total 5 year cost estimate, a rubric which will then be additionally applied to the Smart Fortwo, Nissan Leaf, and Smart Fortwo Electric for cross-comparison.

### Unpaid Highway Expenses
Mackenzie, Dower, and Chen finds that some 40% of all road and highway maintenance costs are not paid directly by drivers, but instead through other means such as property taxes, or through general budgets32 – applying this logic to Massachusetts, the combined $0.424 per gallon in state and federal gas taxes amounts to some $0.71 per gallon in total highway costs – of which an estimated $0.283 per gallon is paid through other sources. A driver driving a vehicle with the national average gas mileage of 23 miles per gallon and at 15,000 miles per year will therefore incur around $184 in unpaid road expenses per year. While not a particularly sizable amount, the simple fact that roads themselves are not even fully paid for by drivers is illustrative of the level of subsidy implicitly provided to drivers and to driving in general.

### Cost of Accidents
Accidents impose some of the greatest overall costs of driving due to the inherently costly nature of medical bills, lost productivity, property damage, loss of quality of life, and of course,
death. In 2010, The National Highway Traffic Safety Administration (NHTSA) recorded 32,999 vehicle related deaths, 3.9 million injuries, and 24 million vehicles damaged for a cumulative estimated cost of $277 billion, or $1,300 per driver per year. However, if quality of life valuations are added, the NHTSA calculates that cost would rise to $871 billion, or a staggering $4,100 per driver per year – a cost significantly larger than any other single cost factor. A similarly high $4,500 per year in accident costs is found through VTPI averaged statistics, suggesting a per-mile cost of $0.35.

While insurance covers much of this cost (as stated, averaging around $1,400 per year in Massachusetts), there remain many externalized costs, especially when considering losses in quality of life. Additionally, many internalized costs are paid outside insurance, such as small damages, while the cited insurance cost mentioned does not include standard policy costs such as co-pays, deductible, and damages beyond insurance limits. The reality that many of these costs are not fully appreciated or accounted for despite their very high cost undoubtedly serves as one of the greatest distortions of the transportation market.

While accident costs are applied flatly to all vehicles as part of this study, it is instead likely that these costs are not shared equally by vehicle type, as alluded to earlier. In particular, large vehicles such as SUVs likely have a significantly higher per driver cost off accident – not only are they at a greater risk for dangerous roll-over accidents that harm passengers in the vehicle itself, but they may impose higher risk of death in accidents involving smaller vehicles and in pedestrian strikes, are more than twice as likely in comparison to a standard sized car to result in a fatality.

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This point in particular is most relevant for urban environments: where pedestrian traffic is highest, large vehicles likely maximize the expected cost of accidents. On the other hand, it seems logical that smaller vehicles like city cars that offer externalized safety benefits such as greater visibility, increased maneuverability, shorter stopping distance, and smaller size and mass should minimize the expected cost of accidents and do much to reduce pedestrian and bike injuries and fatalities. While not enough research has been conducted to allow for a cost estimate based on car size, it seems quite possible that the advantage city cars and other small vehicles offer in externalized safety could easily be the single greatest economic and societal benefit these vehicles provide—as such, this warrants significant further examination.

**Congestion**

Congestion is perhaps the most salient of these implicit costs readily identifiable to drivers. In its 2011 report, the Texas A&M Transportation Institute calculates that Boston area drivers annually lose 53 hours due to congestion, along with 26 extra gallons of gas burned for a total cost of $1,147 per driver per year in 2011 dollars, the 5th worst congestion ranking in the nation. However, given that TTI’s estimate that peak travel time only takes 28% longer than non-peak time, it should be noted that these numbers seem to be if anything an understatement of the true cost of congestion. Indeed, most accounting for time lost in congestion, including TTI’s, assumes a seemingly low valuation of personal commuting time; for instance, the World Bank suggests a value of 0.3 times hourly household income. Assuming Boston’s median household income of $53,000, and assuming 2,080 annual hours of work, an hour saved in daily commute time would only be worth about $7.61. Nevertheless, given real world examples of willingness to pay for

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expedited commuting time through several HOT programs, most traveling behavior indeed seems to value commute time below $10 per hour saved.\textsuperscript{38, 39} For this comparative study, vehicles are assumed to have equal costs of congestion, although again, it would make since that smaller cars may offer marginal benefits over their larger counterparts.

**The Cost of Carbon Emissions**

Carbon emissions are among the most popularly recognized and discussed externalized cost. Driving undoubtedly contributes to a large portion of Boston area carbon emissions, echoing national trends– the EPA estimates that around 1/3 of all U.S. carbon emissions are produced by the transportation sector.\textsuperscript{40} Unfortunately, the true social cost of carbon emissions is the focus of intense debate and uncertainty, with the cost per unit emitted ranging widely depending on the model used, the year of release, and the discount rate attributed to future damages. For this study, the EPA average cost for emissions released in 2015 at the EPA standard 3% discount rate is used, which in 2015 dollars equates to $40.70 per metric ton.\textsuperscript{41} Importantly, it should be noted that the department includes a range of possible costs up to the 95% confidence level cost of $121.05 per metric ton; others suggest an upper bound in excess of $1,000 per ton at a similar confidence level.\textsuperscript{42} In this instance, the Camry’s EPA estimated 309 grams\textsuperscript{43} of CO\textsubscript{2} emitted per mile rating yields 4.64 metric tons of carbon emissions per year. This amounts to $189 in annual externalized

\begin{thebibliography}{99}
\bibitem{42} Frank Ackerman; Elizabeth Stanton. “Climate Risks and Carbon Prices: Revising the Social Cost of Carbon” 2012
\end{thebibliography}
cost in the standard EPA estimate and $561 in the high estimate – a surprisingly low number considering the political furor over the issue and an example of how such a major global issue can be at least partially addressed by simply paying for some of the implicit cost.

**Air Pollution**

On the other hand, air pollution seems to have fallen out of mainstream political consciousness, despite its considerably greater direct health consequences. For a medium sized car like the Camry, the VTPI estimates air pollution costs to health and the environment of around 4.1 cents per mile\(^4\), or $615 per year—$50 more than the EPA high estimate for carbon emissions. These costs include damage from pollutants such as ozone, particulates, carbon monoxide, nitrogen oxides, sulfur dioxide and lead among others, together linked to a plethora of health issues of various severity, worst of which include: respiratory issues, pulmonary and heart disease, stroke, hypertension, development issues along with a general increased rate of morbidity in areas facing the highest concentration of pollution. Combined with the cost of carbon, these tail-pipe emissions impose significant societal costs that could be alleviated through the use of more efficient, smaller vehicles.

**The Camry’s 5 Year Costs - Explicit and Selected Implicit**

For the Camry, the above costs add up fast, amounting to $26,066 over 5 years of externalities that go unpaid by drivers. Adding these costs to the Camry’s earlier 5 year total explicit cost of $37,483 yields a total 5 year explicit and implicit cost of $63,549:

\(^4\) Victoria Transport Policy Institute. “Transportation Cost and Benefit Analysis II – Air Pollution Costs” 2009
This accounting suggests that fully 41% of the real cost of driving a Camry by Boston area drivers are implicit, indirectly paid costs—in line with the previously mentioned global estimate of 37% by the VTPI. These are surprisingly high costs for a car with an overall reputation for efficiency, especially in comparison to larger SUV alternatives. And yet, this still does not yet account for what this study suggests to be the single largest implicit cost—that of parking.

**Parking in Boston**

The vast majority of parking in America—perhaps up to 99% of it—comes free of charge to drivers. Even in Boston proper, one of the most expensive parking markets in the nation, it is likely that the majority of available parking is free. Despite its reputation for congestion, some 300,000 cars are registered by Boston residents alone, contributing to high internal demand for parking. Complicating matters, the city has handed out some 93,987 parking permits to residents in neighborhoods viewed to have parking shortages. Additionally, the city has perhaps 134,000

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45 Victoria Transport Policy Institute. "Transportation Cost and Benefit Analysis II - Cost Summary and Analysis" 2009
off-street spaces, although surveys haven’t been conducted since the late 1990’s to ensure how many spaces remain in circulation.\textsuperscript{47} As part of the 1978 Clean Air Act, freezes on new parking construction has stalled the creation of new off-street parking in much of the Boston metro region. For example, the amount of off-street commercial parking in the central business district is capped at 35,556\textsuperscript{48}; a similar 1993 state imposed freeze capped non-residential parking in South Boston\textsuperscript{49} to mitigate the central artery reconstruction project; another state law freezes new parking in East Boston for airport travelers and a similar freeze on Logan airport caps parking at 21,088 spaces.\textsuperscript{50} Cambridge’s parking was similarly frozen in 1973 due to the Clean Air Act, with off-street parking targeted not to rise to more than 10% of 1973 levels. However, until recently, the freeze was weakly implemented and only now limits commercial parking to some 13,542 spaces.\textsuperscript{51}

The freezes have nevertheless effectively managed to control the typical spread of the superfluous parking infrastructure in downtown neighborhoods so visible across other American cities in the quixotic pursuit of providing free, or at least cheap, parking. Of course, the tight restriction in parking supply has led to Boston being the second most expensive city to park in America, after New York, at a monthly cost of $405.\textsuperscript{52} Similarly, an analysis of available market rate parking in downtown Boston for this study (detailed in Parking Analysis I: Boston in the Appendices) produces an average monthly price of $400 in downtown, ranging from a low of $250

to a high of $561 per month. A similar analysis of parking in Cambridge (detailed in Parking Analysis 2: Cambridge in the Appendices) found an average price of $228 per month.

For the average commuter to downtown Boston, the $400 monthly rate would yield an annual driving cost of $4,803 and $24,019 over 5 years; for a commuter to Cambridge, the market rate of $228 would yield a $2,737 annual cost and $13,685 over 5 years.

These are huge costs. For a Boston area commuter driving a Camry, no other single cost comes close to the market cost of parking, which nearly doubles the second largest cost, that of depreciation. For the same driver commuting to Cambridge, parking remains the largest cost, roughly on par with depreciation. Remarkably, this suggests that any given parking space in downtown Boston is likely to be considerably more valuable than the car sitting above it.

Of course, few commuters pay market rate for parking, even in Boston. According to the Boston Central Transportation Planning Staff’s survey of off-street parking, fully half of all such parking is reserved for specific use – 27% as employee parking, 16% as customer and hotel
parking, and 7% for residents, suggesting the majority of built off-street parking is intentionally locked out of the market. A cursory glance at local employers illustrates this point:

<table>
<thead>
<tr>
<th></th>
<th>Discounted Rate Offered (Monthly)</th>
<th>Local Market Rate (Monthly)</th>
<th>Discount Rate (Percent Off Market Rate)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Berklee School of Music (Boston)</td>
<td>$250.00</td>
<td>$353.00</td>
<td>29.3%</td>
</tr>
<tr>
<td>Biogen (Cambridge)</td>
<td>Free</td>
<td>$195.00</td>
<td>N/A</td>
</tr>
<tr>
<td>Boston University (Boston)</td>
<td>$105.95</td>
<td>$300.00</td>
<td>64.7%</td>
</tr>
<tr>
<td>Draper Labs (Cambridge)</td>
<td>$30.00</td>
<td>$195.00</td>
<td>84.6%</td>
</tr>
<tr>
<td>Mass General Hospital (Nashua Street Garage, Boston)</td>
<td>$83.50</td>
<td>$400.00</td>
<td>79.1%</td>
</tr>
</tbody>
</table>

Much has been written on the pitfalls of offering free and discounted parking. Most often cited is the potential to encourage car usage, particularly the mode share of those commuting alone. This follows fundamental economic principle in that pursuing a policy of artificially lowering prices will naturally result in a higher quantity demanded of that good or service, in this case, parking space. In the case of the Boston metro where supply is capped, economic principle would dictate that providing below-market prices should result in a shortage whose magnitude is directly correlated to the size of the discount offered. For instance, in the case of Massachusetts

57 http://www.massgeneral.org/about/newsarticle.aspx?id=3655
General Hospital, which operates over 5,000 spaces, the waitlist for employee provided parking is long enough to ensure a waiting period of many months. It seems logical that travel mode share of MGH hospital staff is not so much dictated by collective preference and behavior as suggested in the earlier described utility functions, but rather simply by the fact that the hospital has a hard limit of how many vehicles can park on site, with each and every one being used to capacity.

Beyond the subsidized parking for commuters, jurisdictions in Boston’s urban center – Boston, Cambridge, Somerville and Brookline – each have extensive internal parking regimes to protect on-street parking for residents. Boston proper, for example, provides 93,987 resident parking permits at no charge to residents, and with no limit to how many permits are allowed per resident. In high-demand sections of the city such as Back Bay or the North End, these permits have the effect of giving a $400 per month, $4,800 per year tax-free parking subsidy to drivers, assuming street parking is valued at the same rate as off-street parking. A similar story is found in Brookline, Cambridge and Somerville:

<table>
<thead>
<tr>
<th>Household</th>
<th># Of Permits Allowed Per Yearly Charge</th>
<th>Market Rate Effective Annual Subsidy Per Car</th>
</tr>
</thead>
<tbody>
<tr>
<td>Boston</td>
<td>Unlimited Free</td>
<td>$400</td>
</tr>
<tr>
<td>Brookline</td>
<td>Unlimited $25</td>
<td>$174</td>
</tr>
<tr>
<td>Cambridge</td>
<td>Unlimited with $25 additional fee $25</td>
<td>$228</td>
</tr>
<tr>
<td>Somerville</td>
<td>Unlimited with $30 additional fee $30</td>
<td>$135</td>
</tr>
</tbody>
</table>

These regulations, while well-meaning to prevent city streets from being overrun by commuters, has the unintended consequence of providing a strong economic incentive for residents to own and operate a car. Additionally, city governments are clearly forfeiting the opportunity to a very valuable income stream. Assuming a market rate of $400 per parking space, Boston’s on-street parking could yield as much as $451 million a year, or potentially 16% of the City’s 2015 $2.86 billion budget – an amount larger than what the city receives in annual state aid. 66

The blind pursuit of parking affordability results in significant negative externality costs within urban environments as otherwise productive land is turned over to parking. In many cities, the prevalence of parking severely has severely degraded the value of downtown urban landscape; beyond the more noticeable visual costs of what may be ‘eyesores’, Donald Shoup suggests that this purposeful distortion of downtown land use imposes massive collective economic costs—between $168 billion and $497 billion in 2015 dollars—annually. 67 While the Boston area has limited the damage of these pressures through its various parking freeze measures, one only needs to look at Cambridge Street adjacent to the MGH hospital complex to visualize the legacy of pre-freeze parking policy still holds on the physical landscape of downtown Boston in the present day.

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Parking along Cambridge Street, Boston

That parking policy can yield such resilient and persistent transformations of the urban landscape, even long after new parking construction has been severely curtailed, should be reason enough to better appreciate the value of logical, sensible parking policy. On the other hand, the high value of parking in particular - $24,000 over five years in Boston and $14,000 over five years in Cambridge - signals a powerful path of policy intervention in vehicle choice behavior. Because of this, parking policy in particular plays a vital role in encouraging the use of smaller vehicles and alternative forms of mobility, as will be discussed further.

The Camry’s 5 Year Total Costs with Parking

Adding the cost of parking to the implicit costs detailed earlier dramatically grows the Camry’s 5 year total costs:

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For drivers in both Boston and Cambridge, the true 5-year total cost of driving is more than twice what is typically accounted for by most available online tools—without the detailed analysis as provided above, the best-in-field cost estimates available to the average consumer severely discount the true cost of driving, even while consumers are still likely to pay closest attention to the worse-yet estimate provided by top-line manufacturer issued MSRP. In other words, it is unlikely that the price figures used by car shoppers approximate the real cost of owning and operating vehicles.

**Accounting for Smaller, More Efficient Cars**
As shown, drivers of cars like the Camry benefit from large, unpaid costs that can be passed off as externalities—essentially, as our road transportation system currently operates, larger vehicles
are subsidized at higher levels. This no doubt encourages the purchase of such vehicles in
difference to smaller, more efficient options. The questions presented below are then: how much
of a comparative advantage, if any, can small, efficient cars recover from larger vehicles if more
implicit costs were instead paid for? Additionally, what economic advantage, if any, do these
vehicles actually have in dense, downtown environments? These questions will be addressed in
part by comparing the cost breakdowns of three additional vehicles – the Smart Fortwo, Nissan
Leaf, and Fortwo Electric to those of the Camry, employing the same methodology as before in
accounting for total cost.

The Smart Fortwo – A City Car Advantage?
The Smart Fortwo is currently the smallest and among the least expensive cars offered for
sale by a major automotive group in the U.S. The inspiration of Swatch founder Nicolas Hayek in
the mid 1990’s, the car was originally intended to be a manifestation of the Swatch ethos of style,
affordability, and efficiency in automobile form.\(^69\) The resultant vehicle, an ultra-compact city car
that is both efficient and affordable, no doubt reflects these original ideals well. Currently
distributed and sold in the USA through Mercedes-Benz USA, the SmartUSA brand offers the
Fortwo model in the US in three trims as well as a fully electric drive vehicle.

\(^{69}\) Lewin, Tony. Smart Thinking: The Little Car That Made It Big. Osceola, Wis.: Motorbooks International :, 2004.
The company makes it clear that the Fortwo is to be the vehicle of choice for urban drivers. Annette Winkler, CEO and director of Smart Automobile, describes the car as one which “pushes urban mobility” by virtue of its “extremely compact” design. 71 Dr. Dieter Zetsche, Chairman of the Board of Management Daimler AG and Head of Mercedes-Benz Cars calls it “a clever solution” that is a “unique car that combines driving pleasure with lifestyle and exemplary fuel efficiency” with “outstanding safety features, the distinctive smart design, as well as top quality, reliability, and economy.” 72 The firm’s sales literature and advertisement media almost universally depict the vehicle amidst dense, Manhattan-like downtown environs. Even horsepower aficionado Car and Driver seems impressed by the car’s 22.8 foot turning circle, “two feet better than a London cab”. 73 Undoubtedly, this maneuverability gives the Fortwo an advantage in agility in the typical urban setting.

72 “10 Years Of The Smart ForTwo: Compact Model Celebrates Its Birthday | eMercedesBenz - The Unofficial Mercedes-Benz Weblog.” Accessed May 24, 2015.
Smart is quick to highlight the Fortwo’s other distinct advantage: At 106 inches, the Fortwo is nearly half as long as the Toyota Camry’s 191 inch frame; with an overall footprint of 45.2 sq. ft., it takes up less than half the space of a Camry, which occupies 94.2 sq. ft.

In one ad, which dubs the Fortwo the “ultimate city car”, an otherwise unimpressively diminutive Fortwo snags a parking space passed on by a large SUV. Smart explains that "this unbig car squeezes into

As good off road as an offroader in the city.
parking spaces other bigger, less efficient cars can’t” 75, that the Fortwo serves to “make daily life easier, especially to facilitate parking.”

Car and Driver is less impressed. While acknowledging the Fortwo’s urban credentials and benefits, they question its use and viability beyond:

“The cute and stubby Fortwo is made for the city—and that’s exactly where it should stay, since driving it on the highway can verge on terrifying. The rear-mounted 89-hp turbo three-cylinder teams with a six-speed automatic and is adequate for urban errands. The tall, upright body lends an airy feel to the cabin and is roomy for driver and passenger, although trunk space is limited. Don’t expect sporty handling, but its diminutive dimensions will allow you to park where other cars fear to tread...It’s a likable city companion, but it still feels like the answer to a question that very few U.S. buyers will be asking anytime soon.” 76

Car and Driver’s critique has some merit – if city cars such as the Fortwo really do offer superior advantages in the urban environment, why aren’t they more popular? As mentioned, only around 2% of personal vehicles on Boston area roads (and a slightly higher 3% in downtown areas) are what could be considered ‘subcompact’, in a similar category as the Fortwo. The car undoubtedly offers an advantage in accessing street parking, navigating tight turns, providing superior visibility, and excellent fuel efficiency. In other words, the Fortwo is clearly a viable ‘answer’ to the urban mobility challenges of agility and difficulty of parking. But is that enough?

A simple analysis of long-term costs suggests that the pure economic benefits of driving a small car like the Fortwo may not outweigh the high value drivers place on driving larger, higher-cost vehicles – behaviorally, the combined utility of the Fortwo for the vast majority of drivers is less than the combined utility of a larger car:

\( U_{\text{Fortwo}} \leq U_{\text{Camry}} \)

**Cost Comparison: Toyota Camry and Smart Fortwo**

To help illustrate this point, costs for the Smart Fortwo are compared against those of the Camry. As before, explicit cost data is derived from data collected by Edmunds.com on the 2014 model year Fortwo, sold as new.

The overall cost profile for the Fortwo in part mirrors that of the Toyota Camry, as seen below:
For the Fortwo, insurance and fuel overtake depreciation as the leading 5 year cost as a result of its low starting sales price. While the Fortwo offers a distinct absolute advantage over the Camry over total 5 year costs, its sticker price advantage is nevertheless significantly eroded after 5 years of operating expenses that are not much lower than the Camry's.
### Table

<table>
<thead>
<tr>
<th></th>
<th>Average Price Paid</th>
<th>Sticker Price Discount on Camry</th>
<th>5 Year Carrying Costs</th>
<th>5 Year Operating Costs</th>
<th>Total 5 Year Costs</th>
<th>5 Year Discount on Camry</th>
</tr>
</thead>
<tbody>
<tr>
<td>Camry</td>
<td>$ 21,677.00</td>
<td>---</td>
<td>$ 16,547.00</td>
<td>$ 20,936.00</td>
<td>$ 37,483.00</td>
<td>---</td>
</tr>
<tr>
<td>Fortwo</td>
<td>$ 13,427.00</td>
<td>38%</td>
<td>$ 9,564.00</td>
<td>$ 20,825.00</td>
<td>$ 30,389.00</td>
<td>23%</td>
</tr>
</tbody>
</table>

Surprisingly, while the Fortwo is marketed as a much more economical choice as a result of its fuel efficiency, its 5 year operating costs are barely different from those of the Camry’s. This stems in part to the Fortwo’s recommended use of premium gasoline, which limits the car’s fuel cost advantage.\(^77\) Insurance for the Fortwo, its single largest cost, is also only marginally less than the Camry’s, despite the fact Fortwo drivers in more urban environments are likely to drive fewer total miles. However, as mentioned, despite the fact that the risk associated with driving is directly correlated with distance driven, in practice insurance companies provide rates only assuming the ‘average’ amount of driving. Additionally, as it partially covers externality costs of crashes, much of the coverage is for other cars and drivers on the road – only a portion of the rate covers the risk for the vehicle itself, limiting the potential value of driving a more affordable car when it comes to insurance. On the other hand, insurance for drivers driving an above-average number of miles and those with more expensive vehicles in effect have their insurance rates subsidized.

The fact that the operating costs for the Fortwo are barely lower than a significantly larger vehicle undercuts one of the more significant advantages of the car, and as a result, the 38% sticker price advantage declines to only a 23% discount when accounting for all explicit 5 year costs. The initial $7000 discount for the Fortwo primarily serves to lower the carrying cost through lower depreciation, whereas all other costs when added actually dilute the long-term advantage against

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the Camry; given the actual makeup of cars on Boston streets and the high marginal value attributed to car size seen in the earlier remission analysis, it seems likely that most drivers find a larger car easily worth an extra $7,000. Further, that if:

\[ U = \beta \chi + \epsilon \]

The behavioral utility for both vehicles can be described as:

\[ U_{\text{Fortwo}} = \beta_{\text{small car}} \times \$13.4k + \epsilon \]
\[ U_{\text{Camry}} = \beta_{\text{regular car}} \times \$21.7k + \epsilon \]

And since:

\[ U_{\text{Camry}} \geq U_{\text{Fortwo}} \]
\[ \beta_{\text{regular car}} > \beta_{\text{small car}} \]

In other words, because observed real-world drivers use far more large cars than small cars despite their noticeable economic advantage in the \( \chi \) variable, the implicit behavioral relation with economic costs must differ when evaluating large and small cars – that the \( \beta \) preference for large cars must be significantly stronger than the \( \beta \) preference for small cars. This similarly agrees with the second regression analysis which finds that the expected market value of small cars to be deeply discounted from larger cars. Problematically, what emerges is a pattern in which as more long term costs are added to city cars like the Smart, the lower their comparative advantage over larger vehicles becomes—making it less likely that consumers will choose such an option. Are city cars simply the “answer to a question that very few U.S. buyers will be asking” after all?
Comparing with the Nissan Leaf

The Fortwo’s economic advantage disappears entirely when facing the Nissan Leaf, the first all-electric vehicle marketed and sold for mass appeal in the U.S. The Leaf, despite being a sedan, beats the Fortwo at its own game on nearly every level when it comes to standard explicit carrying and operating costs:

<table>
<thead>
<tr>
<th></th>
<th>Average Price Paid</th>
<th>Sticker Price Discount on Camry</th>
<th>5 Year Carrying Costs</th>
<th>5 Year Operating Costs</th>
<th>Total 5 Year Explicit Costs</th>
<th>% 5 Year Discount on Camry</th>
</tr>
</thead>
<tbody>
<tr>
<td>Camry</td>
<td>$21,677.00</td>
<td>---</td>
<td>$16,547.00</td>
<td>$20,936.00</td>
<td>$37,483.00</td>
<td>---</td>
</tr>
<tr>
<td>Fortwo</td>
<td>$13,427.00</td>
<td>-38%</td>
<td>$9,564.00</td>
<td>$20,825.00</td>
<td>$30,389.00</td>
<td>23%</td>
</tr>
<tr>
<td>Leaf</td>
<td>$25,830.00</td>
<td>+19%</td>
<td>$7,935.00</td>
<td>$13,481.00</td>
<td>$21,416.00</td>
<td>43%</td>
</tr>
</tbody>
</table>

While the Leaf has an average sale price 19% higher than the Camry, drivers benefit tremendously in states like Massachusetts where tax rebates and credits defer the cost of electric vehicles. For instance, a buyer there is eligible both for a full $7,500 federal tax credit as well as Massachusetts’ $2,500 Mor-EV program, together a $10,000 reduction in up-front carrying costs.

![5 Year Explicit Costs, Nissan Leaf](image-url)
These benefits are so generous that using the same accounting measures of cost, the first year of ownership actually yields a profit – in theory (although hopefully not in practice), a driver could sell a Leaf after the first year after receiving all rebates and taxes and walk away with extra cash – a car that’s better than free for the first year! That alone should give the leaf a substantial leg-up on the competition.

Of course, this doesn’t even yet mention the primary benefit of electric vehicles to customers, which is in fact their substantially lower operating costs in comparison to their conventionally powered competition.

<table>
<thead>
<tr>
<th></th>
<th>Camry</th>
<th>Fortwo</th>
<th>Leaf</th>
</tr>
</thead>
<tbody>
<tr>
<td>5 Year Fuel Costs</td>
<td>$8,877.00</td>
<td>$7,593.00</td>
<td>$6,482.00</td>
</tr>
<tr>
<td>Discount on Camry</td>
<td>N/A</td>
<td>14%</td>
<td>27%</td>
</tr>
</tbody>
</table>

Running on electricity is nearly universally cheaper than gasoline, yielding a 27% discount on costs for the leaf over the Camry; and yet, these costs estimated by Edmunds may be overstated – for instance, EPA estimates instead suggest annual costs of $600 per year, for a total of $3,000 over 5 years.\(^7\)\(^8\) In theory, electric drive motors should require significantly less maintenance than their conventional counterparts, although this is also not observable in Edmunds’ cost estimation.

The Leaf advantage over both the Camry and Fortwo only grows when certain implicit costs—total externalized crash costs, congestion, air pollution, the cost of carbon, and the cost of highway externalities—are added:

---

Both the Leaf and the Fortwo outperform the Camry on these costs. Air pollution is significantly reduced for the Leaf as it releases no pollution from the combustion process—being electric, it releases no harmful chemicals such as ozone, sulfates, carbon monoxide and particulates that result from normal combustion, apart from pollutants emitted upstream through the electricity generating process. The Fortwo, though, cuts these emission costs by nearly 1/3 as a result of its significant gas mileage advantage over the Camry – 36 mpg combined over 28 mpg combined for the Camry. Likewise, a similar advantage emerges with the cost of carbon emissions; the Fortwo’s carbon costs are 22% lower than the Camry’s, whereas the Leaf’s costs are 67% lower (stemming only from carbon emissions from upstream electricity generation). Other implicit costs—the externalized cost of car crashes, congestion, and unpaid highway expenses—are assumed to be equal, although as mentioned, this is unlikely to be the case; more research needs to be conducted to evaluate the relation of specific subclasses of car and their relation with these costs to determine the magnitude of advantage one car may have on another.

79 http://www.fueleconomy.gov/feg/Find.do?action=sbs&id=34460&id=34289
Interestingly, when all costs—implicit and explicit—are accounted for, the discount for the Leaf is reduced from 43% to 30%; the Fortwo’s discount is reduced even more, from 23% to 13%. In fact, this is a general trend, which makes logical mathematical sense – for every new cost introduced that offers less of an advantage to a vehicle than its prior advantage, the cumulative discount becomes diluted, lowering the comparative advantage in comparison to the base (in this case the Camry). In other words, adding a new accounting variable such as the externality cost of accidents, which even in reality may favor vehicles such as the Fortwo and Leaf, can actually reduce the overall apparent advantage such vehicles hold.

This has significant policy implications as regulators attempt to charge for externalities; if constructed without proper consideration for the varied cost structure of different vehicles, policy
makers may inadvertently diminish the comparative advantage of the very vehicles that should be encouraged—namely, small and fuel efficient cars. For example, policies intended to defray the public costs of auto-accidents—by far the greatest unpaid externality—if applied flatly on all vehicles would actually reduce the advantage of smaller, safer vehicles.

The problem for the city car on the other hand becomes more complicated. As seen in the prior comparison alongside the leaf, apart from an originally lower sticker price, at no point does the Fortwo offer a greater cost advantage over the Camry than does the Leaf; in a purely economic match up, consumers should therefore favor the larger Leaf to the Fortwo city car, despite that car’s presumed urban bona fides.

Is there a Future for the City Car?

As seen, there are two fundamental challenges facing small vehicles in America’s urban center. First, Americans exhibit distinct preference ratings for both small and normally sized cars, with the preference factor ($\beta$) for small cars being significantly lower than that for regular and large cars; this stronger preference for larger vehicles can outweigh even large economic benefits to small cars. Compounding this problem, the economic advantage detailed above ($\chi$) of a city car like the Fortwo is surprisingly small in comparison to a larger vehicle like the Camry, especially when low-running cost electric cars like the Nissan Leaf are included. For city cars to be successful, both of these fundamentals need to change. Luckily, there are three clear paths forward: first, the integration of electric powertrains with city cars to reduce operating costs; a greater policy prioritization of high efficiency vehicles by local governments; and most importantly, reforming the pricing system for urban parking.

To be sure, while electric vehicles like the Leaf can provide greater economic benefit outside the densest core when compared to standard gasoline powered Fortwo’s, there’s nothing
to prevent city cars from integrating this same electric drive technology; in fact, Smart has already done just that, with electric drive Fortwos on the road in the U.S.

Combining the advantages of both the Fortwo standard—low depreciation and running costs—with the advantages of the Leaf—a $10,000 government provided subsidy as well as ultra-low running costs, the Fortwo electric in fact provides a 44% discount on the Camry on 5 year explicit costs. This alone is a significant step forward in increasing the economic advantage of the city car.

Policy makers of course should more directly encourage these smaller, more efficient electric vehicles due to their significantly lower implicit costs to society, particularly when it comes to air pollution and carbon emissions. Additionally, as mentioned before, it would also
make sense that the social cost of accidents as well as congestion levels could also face significant reduction (although this is unable to be taken into account):

<table>
<thead>
<tr>
<th>Year</th>
<th>Total Implicit Costs</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>$26,666.71</td>
</tr>
<tr>
<td>4</td>
<td>$26,000.00</td>
</tr>
<tr>
<td>3</td>
<td>$25,500.00</td>
</tr>
<tr>
<td>2</td>
<td>$25,129.19</td>
</tr>
<tr>
<td>1</td>
<td>$25,000.00</td>
</tr>
<tr>
<td>0</td>
<td>$24,500.00</td>
</tr>
<tr>
<td>-1</td>
<td>$24,000.00</td>
</tr>
<tr>
<td>-2</td>
<td>$23,500.00</td>
</tr>
<tr>
<td>-3</td>
<td>$23,000.00</td>
</tr>
<tr>
<td>-4</td>
<td>$22,500.00</td>
</tr>
<tr>
<td>-5</td>
<td>$22,000.00</td>
</tr>
<tr>
<td>-6</td>
<td>$21,500.00</td>
</tr>
<tr>
<td>-7</td>
<td>$21,000.00</td>
</tr>
</tbody>
</table>

For both electric-drive vehicles, these implicit costs are at least $3,000 less than those of the Camry—in other words, for every medium sized car that can be replaced from the street by an electric drive vehicle, total societal costs can be lowered by $3,000—a sum that can quickly add up in large urban areas, particularly those like Boston facing concerns over climate change and issues of air quality.

**Space Used Pricing**

Perhaps the most promising path forward exists simply through better parking policy. If parking could somehow be priced according to the amount of space a vehicle uses while parked—what this study calls a ‘space used’ pricing system—small footprint city-cars like the Fortwo would have a distinct economic advantage in dense, urban environments—just as designers and marketers of the Fortwo and Hiriko are quick to point out. A change in one policy—parking—can yield an environment in which these vehicles are significantly more advantageous.
As in earlier examples, the Fortwo’s advantage diminishes considerably if parking is paid at market rates on a per-space basis, as is the current standard for both on and off street parking.

As before, the Fortwo Electric’s discounted rate from the Camry declines from 44% to 27%, which would surely diminish the likelihood drivers paying market rate prices would purchase or use a city car as opposed to purchasing a larger vehicle; as before, the consumer choice model would still likely weigh heavily in the direction of the Camry:

$$\beta_{\text{Camry}} \times \chi_{\text{Camry}} > \beta_{\text{Fortwo}} \times \chi_{\text{Fortwo}}$$

As an alternative, space-used pricing would dictate that drivers only need pay for the amount of space actually used by their vehicle. In other words, a car half the size of a Camry would
only cost half as much to park; a car 50% larger than the Camry would likewise have to pay for the extra amount of space used. This is how we pay for real estate in the space market; why not extend this as well to the parking space market?

A much improved environment for small vehicles and city cars is created when parking is instead paid based on this space-used pricing method. In this case, both versions of the Fortwo enjoy heavy comparative discounts with the Camry, with the Fortwo Electric nearly cutting total costs by half:

In fact, as long as parking is paid according to a space-used pricing schedule, the Fortwo Electric’s advantage over the competition extends into environments even with ample free parking, such as...
found in suburban Boston. In such a scenario, not only would the Fortwo electric provide high value as a city car, but also as a longer-distance commuter car, with the cost advantage ranging from a high of a 47% reduction from the Camry’s total 5 year costs in a high-cost-of-parking environment to a low of a 44% discount on the Camry’s costs in a free-parking environment.

<table>
<thead>
<tr>
<th>Fortwo Discount over Camry</th>
<th>Leaf Discount over Camry</th>
<th>Fortwo Electric Discount On Camry</th>
<th>Equivalent Neighborhood</th>
</tr>
</thead>
<tbody>
<tr>
<td>$400</td>
<td>32%</td>
<td>30%</td>
<td>47%</td>
</tr>
<tr>
<td>$350</td>
<td>31%</td>
<td>31%</td>
<td>47%</td>
</tr>
<tr>
<td>$300</td>
<td>30%</td>
<td>32%</td>
<td>46%</td>
</tr>
<tr>
<td>$250</td>
<td>28%</td>
<td>33%</td>
<td>46%</td>
</tr>
<tr>
<td>$200</td>
<td>27%</td>
<td>35%</td>
<td>46%</td>
</tr>
<tr>
<td>$150</td>
<td>25%</td>
<td>37%</td>
<td>45%</td>
</tr>
<tr>
<td>$100</td>
<td>23%</td>
<td>38%</td>
<td>45%</td>
</tr>
<tr>
<td>$50</td>
<td>21%</td>
<td>40%</td>
<td>44%</td>
</tr>
<tr>
<td>$0</td>
<td>19%</td>
<td>43%</td>
<td>44%</td>
</tr>
</tbody>
</table>

It should be noted as well that as the cost of parking increases, the comparative economic advantage one vehicle has over the other will naturally converge on the comparative size of the two cars, the size being a key determinant of overall costs.

Using this method of space-used pricing, the purely economic advantage of city cars is radically increased; no other policy intervention investigated produces nearly as significant an advantage for smaller vehicles and city cars. While this single handedly may not shift the market’s cumulative behavioral choice preference to favor smaller vehicles, it would no doubt increase the number sold as a result of higher economic benefit of driving smaller:

\[ \chi_{\text{fortwo}} > \chi_{\text{camry}} \]
In such an environment, even if the $\beta$ behavioral coefficients for mainstream sized cars is significantly larger than those for smaller vehicles, the very large outright economic advantages ($\chi$) of cars like the Fortwo may rebalance consumer choice, especially for submarket consumers:

$$\beta_{\text{fortwo}} \cdot \chi_{\text{fortwo}} > \beta_{\text{camry}} \cdot \chi_{\text{camry}}$$

Better yet, when such parking reforms are matched with efforts to alter car choice behavior in consumers at large, the overall market demand preference could shift dramatically into one favoring smaller vehicles. With a few regulatory changes simply in parking, downtown Boston can easily become the domain of the city car, just as designers have long seen it to be.

**Recommendations**

As this study illustrates, small cars, specifically city cars like the Smart Fortwo, hold significant advantages over more traditionally sized vehicles in urban areas and even beyond. For the most part, these recommendations highlight a common theme: allow pricing mechanisms and natural market forces to allow drivers of these vehicles to recapture what is a natural comparative advantage for these vehicles.

1. Implement a ‘Price as Used’ mechanism for Boston’s paid parking. In other words, drivers should only have to pay for the amount of parking space used, as described above. A driver of the Fortwo, at 48% of the Camry’s size, should only have to pay 48% of what a driver of the Camry has to pay. Similarly, a driver of a large SUV such as the Chevy Suburban, 132% of the size of the Camry, should have to pay 132% of what a Camry driver would pay. This only seems fair to begin with – in general, we pay for what we use. To implement such a strategy in the near-term, city rules could simply be written to mandate that garage operators provide these discounts to drivers of small cars. Again, as subcompact cars only average 2-3% of all cars on the street, any immediate
loss to garage owners would be minimal. But such a change would provide a significant incentive
to drivers to drive smaller cars, as this study highlights – for a driver of a Fortwo sized car, market
rate parking in downtown Boston would drop from $400 a month to $192 per month. With time
and increasing small car use, garage owners would on their side be incentivized to provide smaller-sized parking for these vehicles to maximize total space used.

In the longer term, off-the shelf 3D imagery tools could be used to scan space used in real-
time, ideally linked to other technologies that assist in finding and optimizing space along with
tools to automate the billing process. Parking in a garage can be as simple as a swiping a button
on a cell-phone that can direct the driver to a pre-selected space, seamlessly billing for total space
and time used. Again, with a price gradient existing for cars of differing size, garages would be
incentivized to invest in such space-optimizing technology to maximize revenue.

2. Free residential parking should be discouraged and eventually phased out. As mentioned,
free parking is in essence a subsidy for residential drivers – a subsidy worth up to $4,800 per year
in some parts of Boston. From the other perspective, city governments are willingly dismissing
significant revenue streams that could be put to better use, for instance, in the metro region’s transit
infrastructure. This subsidy as mentioned only further encourages driving in precisely the areas in
which car ownership should be discouraged; on top of that, the lack of restriction essentially opens
the door to the classic ‘tragedy of the commons’ scenario in which excessive parking is not only
encouraged, but drivers find the greatest personal benefit by parking larger vehicles – maximizing
the free parking they can consume. As mentioned, this results in a lack of a car size gradient for
downtown environments – large cars essentially are no less common in Boston’s densest, most
centrally located neighborhoods as they are in the far less constrained suburbs. In a healthy parking
ecosystem, a clear gradient of an increasing proportion of smaller cars as one moves closer to
downtown should with time emerge on Boston streets.

In the near term, yearly parking fees can be applied to permit holders to help control excess
demand. As car dimensions are readily known, fees should be scaled according to car size as in
the aforementioned space-used scenario. For instance, sub-compact city cars such as the Fortwo
may have a fee of $250 per year; mid-sized sedans such as the Camry would cost $500 per year;
extra-large SUV's like the Suburban could pay $700. Implementing a scaling fee structure would
help solve multiple problems at once: reduce the demand for on street parking by raising the cost,
reduce car use amongst residents, encourage the use of smaller, safer, more efficient cars, and last,
implicitly increase the available stock of parking as smaller cars require less space – all the while
providing a valuable income stream back to the city.

3. Local governments should provide limited on-street electric charging stations. One of the
great hurdles to electric vehicles in many residential areas of downtown Boston is the difficulty of
recharging. Residents with only on-street parking may be unable to charge an electric car; simply
investing in a charging station at a place of residence by no means guarantee the spot in front of
the charging station is available for that resident’s own use. Cities can instead use this shortage as
added leverage to encourage electric car use; perhaps for a small yearly fee, residents may be able
to lease a reserved electric-charge capable on-street space. Not only would drivers of electric
vehicles be able to charge on-street, but they would also have the luxury of a designated parking
space – a major reward that could motivate greater use of electric vehicles in comparison to the
hide-and-seek challenge of parking for conventional cars.

4. As cities and their residents face disproportionately large negative externalities to driving,
city governments should focus efforts to recoup some of those loses in the form of driving fees.
This is especially true for suburban commuters who, while producing an elevated costs per driver as compared to urban counterparts, pay no other form of compensation in terms of taxes or fees.

In a perfect world, such a pricing mechanism could be seamlessly integrated with proven congestion zone charging, such as seen in London. As noted though, policy makers should take care that these externality costs are not simply spread evenly – such a pricing scheme could inadvertently reduce the comparative advantage of the very sort of small-impact vehicles that should be encouraged. Instead, just as with parking, these costs should scale in line with the overall comparative advantage of the vehicle; for example, electric vehicles should face a significantly lower externality fees than their combustion pollution emitting counterparts, and smaller city-car vehicles a similarly lower fee due to their reduced accident risk to pedestrians and other drivers. Due to the difficulty of accounting for what these varied costs may be, it is perhaps not so much important to have fees directly align with calculated costs as it is simply to insure that policy is in place to both encourage the use of smaller, less costly vehicles while discouraging the use of costly large vehicles.

5. The way we approach on-street parking has little changed since the introduction of the parking meter in the 1930’s. The addition of mobile-phone integrated ticket machines for example doesn’t fundamentally alter the basic structure of a driver pre-paying at a set rate for a set parking space of average dimensions of 8’ by 24’. The fact that on-street parking is so heavily regulated and subsidized provides little incentive for governments to provide any meaningful innovation (especially in light of the lucrative nature of parking violation fees). Instead, governments should explore the feasibility of leasing out these spaces, just as the city can for any other land it owns, to private parking operators. Applying the same parking regulations as mentioned in Rec. 1, these operators would be similarly incentivized to maximize the efficiency of parking space used, while
being given greater flexibility in pricing mechanisms, such as demand-responsive pricing, to combat parking shortages. With better integration with mobile phone technology, it would be perfectly feasible in the near future for drivers to pre-reserve a space via a tool such as SpotHero.com, be directed to that spot via GPS, have an independent operator automatically detect usage of that space and seamlessly send a bill – all without the fear of being unable to find a spot, lacking the cash needed, or the fear of a $40 ticket for missing a time limit. All the while, small vehicle use would continue to be incentivized by the lower comparative cost of parking.

Going a step further, on-street parking could just as easily be leased out for other purposes. As mentioned, at even $400 a month, the market rate per square foot of downtown parking space is far lower than the rentable rate for other uses. Why then shouldn’t the city be free to rent out some of this space at real market rates? Certainly, $400 a month for a 200 sq. ft. street-front space would be a great deal for a newsstand, coffee shop, or food truck. Portland, Or. for instance is experimenting with restaurants extending seating into parking spaces:

![Image](http://imgick.oregonlive.com/home/olive-media/width960/img/oregonian/photo/2014/04/mississippi-pizza-street-seatsjpg-b6edd1a818454130.jpg)

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Or, as has been made popular in the Boston region, neighborhoods and neighborhood associations could rent space for ‘parklets’, which could be especially attractive in otherwise green-sparse neighborhoods.

In other words, instead of continuing with a current policy that provides massive parking subsidies only to result in rampant parking shortages and encouraged car—particularly larger car—usage, we should instead more directly realize the cost of this behavior. While cars clearly provide a valuable mobility option, we need to be more cognizant that they do so only at considerable cost. Perhaps better yet, residents should be made more aware of the wide world of possibilities that can be unlocked from parking infrastructure, a world that can only be a great improvement over a 200 sq. ft. section of asphalt containing a single private car baking in the sun.

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Conclusion

While the current state of small car usage in urban America remains at very low levels, there are reasons to be hopeful that drivers in the future will increasingly turn to city car alternatives for their commuting needs. This study’s accounting of the comparative costs of the Toyota Camry against the Smart Fortwo, Nissan Leaf, and Smart Fortwo illustrates a general environment in which smaller, more efficient vehicles do indeed hold a marginal comparative long-term cost advantage against standard sized cars. However, it also illustrates a somewhat counter-intuitive problem: as drivers are faced with greater flat fees, common in downtown environments particularly when it comes to parking, the comparative advantage of smaller, more efficient vehicles can actually decline. In other words, under current market and regulatory conditions, the very cars that should be more economical and desirable in downtown environments—city cars like the Fortwo—lose some of their cost advantage.

More than anything else, it becomes clear that parking policy is the core issue that can make or break the city car—at the current, cost per space pricing scheme, why not simply fill that space with as large a car as one can fit? On residential permit-only streets, why not simply drive a big-framed SUV as if one lived in the suburbs—who’s to say no? It is only when drivers are faced with paying for the true space occupied by their vehicles that the true comparative value of city cars are unlocked—savings in the thousands of dollars a year in reduced parking costs for drivers of such vehicles.

Of course, this exercise isn’t one to promote small cars for the sake of small cars, new, shiny, miniaturized, folded, automated technology for the sake of highlighting the latest whiz-bangs in the automotive field. Instead, this is a study that showcases the real-world accountable advantages held by city cars. Indeed, urban policy makers must make it a priority to encourage
smaller vehicles in downtown settings—for health, for safety, for the environment, and for more efficient land use. Let’s not lock our streets to the treads of needlessly large cars; we shouldn’t need to invest so much money, both public and private, to ensure that ample affordable parking exists for vehicles that impose such high implicit social costs. Let’s instead work to transform our downtown streets to the vibrant space that remains hidden—places not simply for the passage and storage of our big cars, but shared spaces for retail, small business, entertainment, and recreation, all of which can seamlessly co-exist with the movement of the human-scaled city car.

The Hiriko in Spain

Appendices

Regression Analysis 1 – No Place for the City Car
Where are the small cars? It's common knowledge that small cars—specifically, sub-compacts and city cars like the Smart Fortwo are made for urban driving, that they are more ‘popular’ in urban settings such as downtown Boston. But is this true?

From the perspective of urban economics, this should be the case – small cars should predominate in dense, expensive downtown areas. Monocentric city models illustrate that not only is there a clear density gradient as one changes distance to an urban center, but also a notable price gradient: expenses rise with proximity to the center. Real estate compensates for this rise in land value both by increasing density per unit of land as well as by reducing the size of products sold – homes and offices in downtown settings are smaller than their counterparts in the suburbs.

Cars, besides being a means of transportation, are also part of this space market due to their need to park. Parking spaces, like all other space, exhibit a similar price gradient with distance to city center. As a result, it would make sense that drivers should react to this gradient by favoring smaller cars in expensive downtown environments.

Small cars should therefore be more likely to be present in Boston’s urban core, specifically in the 2 mile radius area surrounding City Hall which encompassing the densest population and commercial districts in all of New England, than the surrounding areas. If the parking space market is integrated with the real estate space market, there should be a clear, strong positive correlation between proximity to downtown Boston and the percentage of smaller vehicles parked within a neighborhood.
Furthermore, the city’s well documented scarcity of parking is the reasoning behind the Boston area’s notoriously strict parking regulations and enforcement. Because of the difficulty of finding parking space as well as these strict parking regulations, it would also seem logical that drivers would prefer smaller vehicles when parking in downtown areas to make use of what little space may be available and reduce time spent trying to find parking.

Additionally, the city governments of Boston, Cambridge, and Somerville should favor smaller vehicles for a host of reduced negative externalities: reduced use of on-street parking, reduced air pollutants and carbon emissions and as well as a significant reduction in the health and safety problems of larger vehicles. These cities should pursue policies intended to encourage the use of smaller cars while discouraging the presence of larger vehicles.

**Research Hypothesis:** There should be a clear, large correlation between the percentage of small vehicles in a neighborhood with distance to the urban center and neighborhood population density.

**Null Hypothesis:** There is no relation between a census tract’s distance from the urban center and share of small cars parked within.

**Methodology:** 20 census tracts within the Boston metropolitan area were selected to reflect three differing characteristics:

- Distance as identified from the near-centroid of the tract to Boston City Hall as identified with Google Maps using the shortest-mileage option
- Population density as measured by the 2010 US Census
- Median income as measured by the 2010 US Census
- Household median income

Data was collected from the 2010 Census. Census tracts were selected to provide variation between each of these characteristics; 7 are tracts within 2 miles of downtown; 5 from between 2-5 miles;
8 from tracts located beyond 5 miles. Similarly, tracts were chosen to reflect a diversity of income and population density:

<table>
<thead>
<tr>
<th>Census Tract</th>
<th>Distance to Center (Miles)</th>
<th>Median Income (in $k)</th>
<th>Population Density (People per Sq. Mile)</th>
</tr>
</thead>
<tbody>
<tr>
<td>303</td>
<td>0.2</td>
<td>$107</td>
<td>18,251</td>
</tr>
<tr>
<td>701.01</td>
<td>0.6</td>
<td>$42</td>
<td>15,000</td>
</tr>
<tr>
<td>201.01</td>
<td>0.7</td>
<td>$93</td>
<td>48,668</td>
</tr>
<tr>
<td>203.03</td>
<td>0.8</td>
<td>$87</td>
<td>19,619</td>
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<td>108.01</td>
<td>1.7</td>
<td>$112</td>
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<td>1.8</td>
<td>$61</td>
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<td>$85</td>
<td>50,961</td>
</tr>
<tr>
<td>101.04</td>
<td>2.4</td>
<td>$35</td>
<td>44,540</td>
</tr>
<tr>
<td>804.01</td>
<td>3.4</td>
<td>$15</td>
<td>15,935</td>
</tr>
<tr>
<td>3501.04</td>
<td>3.7</td>
<td>$47</td>
<td>20,620</td>
</tr>
<tr>
<td>813</td>
<td>4.8</td>
<td>$17</td>
<td>21,243</td>
</tr>
<tr>
<td>4006</td>
<td>5.1</td>
<td>$122</td>
<td>10,946</td>
</tr>
<tr>
<td>903</td>
<td>5.1</td>
<td>$16</td>
<td>21,665</td>
</tr>
<tr>
<td>916</td>
<td>5.5</td>
<td>$30</td>
<td>25,991</td>
</tr>
<tr>
<td>3391</td>
<td>6.3</td>
<td>$67</td>
<td>2,357</td>
</tr>
<tr>
<td>3384</td>
<td>9.6</td>
<td>161</td>
<td>2,439</td>
</tr>
<tr>
<td>3738</td>
<td>10.4</td>
<td>101</td>
<td>6,000</td>
</tr>
<tr>
<td>4161.01</td>
<td>11</td>
<td>98</td>
<td>1,540</td>
</tr>
<tr>
<td>4043.02</td>
<td>17</td>
<td>104</td>
<td>3,542</td>
</tr>
</tbody>
</table>

At least two streets were observed in each census tract. Vehicles were counted and categorized based on size using the following criteria:

- **Very Small** – Sub-Compact or city car – E.g. The Smart ForTwo; Mini Cooper
- **Small** – Compact car: E.g. Toyota Corolla; Honda Civic
- **Medium** – Sedans, sports cars, luxury sedans: E.g. Toyota Camry; Ford Taurus
- **Large** – Cross-overs, SUV’s, minivans, small pickups: E.g. Mazda CX-5; Honda CRV; Toyota Sienna; Toyota Tacoma
- **Extra Large** – Full size vans, full size pickups, large SUVs: GMC Savannah; Ford F-150; Chevrolet Suburban
Business-related vehicles and vehicles unable to be categorized were excluded. Counting within a tract stopped at the closest intersection after a sample of at least 50 vehicles were recorded. The results for all tracts are summarized below:

<table>
<thead>
<tr>
<th></th>
<th>Very Small</th>
<th>Small (15%)</th>
<th>Medium (39%)</th>
<th>Large (41%)</th>
<th>Extra Large (4%)</th>
<th>Combined: Very Small, Small, Medium</th>
<th>Combined: Large, Extra Large</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total</td>
<td>24 (2%)</td>
<td>172</td>
<td>503</td>
<td>531</td>
<td>57</td>
<td>699 (54%)</td>
<td>588 (46%)</td>
</tr>
<tr>
<td>Total Observed</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

With summary statistics:

<table>
<thead>
<tr>
<th>Variable</th>
<th>Mean</th>
<th>Standard Deviation</th>
<th>Minimum</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Percent Small Cars</td>
<td>13.1</td>
<td>6.22</td>
<td>3</td>
<td>25</td>
</tr>
<tr>
<td>Percent Medium Cars</td>
<td>38.95</td>
<td>5.86</td>
<td>30</td>
<td>51</td>
</tr>
<tr>
<td>Percent Small and Medium Cars</td>
<td>54.05</td>
<td>4.62</td>
<td>47</td>
<td>62</td>
</tr>
<tr>
<td>Percent Large Cars</td>
<td>41.3</td>
<td>3.34</td>
<td>35</td>
<td>48</td>
</tr>
<tr>
<td>Percent Extra Large Cars</td>
<td>4.5</td>
<td>2.67</td>
<td>0</td>
<td>11</td>
</tr>
<tr>
<td>Percent Large and Extra Large Vehicles</td>
<td>45.95</td>
<td>4.63</td>
<td>38</td>
<td>53</td>
</tr>
<tr>
<td>Distance to Center of City (City Hall)</td>
<td>4.695</td>
<td>4.36</td>
<td>0.2</td>
<td>17</td>
</tr>
<tr>
<td>Density (Hundreds of People per Sq. Mile)</td>
<td>208.6</td>
<td>167</td>
<td>15</td>
<td>564</td>
</tr>
<tr>
<td>Median Income ($ Thousands)</td>
<td>70.8</td>
<td>42.3</td>
<td>$15</td>
<td>161</td>
</tr>
</tbody>
</table>

Model:

This study employs an ordinary least squares regression, with a theoretical model that:

$$ Smallmedprct = \alpha + \beta_1(distcent) + \beta_2(density) + \beta_3(Medincome) + \epsilon $$
Where:

- Smallmedprct is the percentage of cars categorized as very small, small and medium sized within a census tract – essentially, everything not considered ‘large’ or ‘very large’
- Distcent is the distance from the centroid of the census tract to City Hall, using the shortest path distance on google maps
- Density is hundreds of people (instead of thousands, to stay in scale) per Sq. mile per tract as determined by the 2010 Census
- Medincome is the median income of a tract using data from the 2010 Census

Linearity was tested by plotting the three independent variables Distcent, Density, and Medincome against the dependent variable, smallmedprct:

**Percent of very small, small and medium per tract by distance from City Hall:**

As expected, simple fitting illustrates a trend of decreasing percent of very small, small and medium cars per tract as observations move from the city center. Additionally, the data appears to be linear. However, the data has very high variance; in fact, if data had been only recorded for tracts within 10 miles of the city center, the relationship would have reversed: the percent of very small, small and medium cars per tract would increase with distance.
Percent of very small, small and medium per tract by population density:

Again, as expected, the percent very small, small and medium cars per tract seems to increase with density, and the relationship appears to be linear.

Percent of very small, small and medium per tract by Median Income:
The relationship with the percent of very small, small, and medium cars per census tract appears to be quite strongly negative and linear. This makes logical sense – small cars tend to be cheaper to buy and therefore more popular among lower-income residents whereas larger vehicles are more of a luxury item, more popular with higher-wealth residents.

The independent variables distcent, density and Medincome were regressed against Smallmedprct producing a model equation of:

\[
\text{Smallmedprct} = 57.08 - 0.075 \times \text{distcent} + 0.0025 \times \text{density} - 0.045 \times \text{Medincome}
\]

The coefficient found for distance to center (distcent) is found to be negative, as might be expected, but is small; essentially, the model suggests that for every mile of distance away from city hall, the percent of very small, small, and medium sized cars only declines by \(0.075\%\); a suburb 20 miles away should only expect the share of these cars to decline by \(1.5\%\). Additionally, with a t score of -0.24, the term is not statistically significant.

The coefficient found for density (density) is found to be positive, also as to be expected, but is also a very small number at \(0.0025 \times \text{density}\); in other words, for every added density of 100 persons per square mile, the percent of very small, small, and medium sized cars only increases by \(0.0025\%\); for every additional 10,000 residents per square mile, the percent of very small, small, and medium sized cars only increases by \(0.25\%\). Additionally, the t score for density is low at 0.33; this is not statistically significant.

On the other hand, the coefficient for medium income, with a t score of -1.75, is significant at the 0.1 level (albeit just barely, and not at the 0.05 level). The coefficient, -0.0451, suggests that income seems to correlate negatively with the percentage of very small, small, and medium size cars in a census tract; that for every thousand dollar increase in a tract’s median
income, the share of very small, small, and medium sized cars declines by 0.0451 percentage points.

Troublingly, the t scores for 2 of the three independent variables are not significant. Similarly, the adjusted R$^2$ for the model is only .072; the model can only explain 7.2% of the variance in the dependent variable of car size share. With this model, the null hypothesis cannot be rejected.

An Improved model was also tested:

$$V_{ssmprc}=a + \beta_1(distcent) + \beta_2(density) + \beta_3(Medincome) + \epsilon$$

Where Vssmprc is the % share of very small and small cars in a census tract.

$$Smallmedprct= 57.08 + .226*(distcent) + 0.01*(density) - 0.094*(Medincome)$$

This model produces an adjusted R$^2$ of .35, which can explain 35% of the variance in the dependent variable of car size share. Although this is higher than the initial model, it is still quite low, unable to explain the majority of the relationship.

Furthermore, In this case, the coefficient found for distance to center (distcent) is found to be positive; essentially, the model suggests that for every mile of distance away from city hall, the percent of very small and small cars actually increases by 0.22%; at 20 miles, the share of small cars is suggested to increase by 4.4%. Additionally, with a t score of 0.67, the term is not statistically significant.

The coefficient found for density (density) is again found to be positive, but is remains a very small number at 0.01*(density); in other words, for every added density of 100 persons per square mile, the percent of very small, small, and medium sized cars only increases by .01%; for
every additional 10,000 residents per square mile, the percent of very small, small, and medium sized cars only increases by 1%. Additionally, the t score for density relatively low at 1.23; this is not statistically significant.

Again, the coefficient for medium income, with a t score of -3.34, is statistically significant at even the 0.01. The coefficient, -0.094, suggests that income seems to correlate negatively with the percentage of very small and small cars within a census tract; that for every thousand dollar increase in a tract’s median income, the share of very small, small, and medium sized cars declines by 0.094 percentage points.

However, as before, the t scores for both distance from the center as well as for density are not significant. Similarly, still low adjusted R² cannot support the research hypothesis. In both cases, the null hypothesis— that there is no relation between a census tract’s distance from the urban center and share of small cars parked within—cannot be rejected.

Conclusion:

It is somewhat surprising to see a lack of evidence for a significantly larger percentage of smaller vehicles in downtown Boston. Conventional wisdom suggests this to be the case, as does the marketing for small and subcompact cars. Additionally, given the social benefits of smaller vehicles, local policy should shift the incentive and behavioral structure for drivers into one that promotes small car use.

Of course, the sample size used is small—only 20 census tracts were observed. It’s entirely possible that with a greater sample size, a stronger correlation may emerge. However, this study suggests a highly stable makeup of car size share across the Boston Metropolitan Area:

<table>
<thead>
<tr>
<th>Miles from Center</th>
<th>Very Small Cars</th>
<th>Small Cars</th>
<th>Small and Medium Cars</th>
<th>Large Vehicles</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 to 2</td>
<td>3%</td>
<td>15%</td>
<td>55%</td>
<td>45%</td>
</tr>
</tbody>
</table>
The split between small and medium cars above appears very stable at all distances from the center, differing little from the overall mean of 54% for small and medium vehicles and 46% for larger vehicles. For comparison, in 2015 to date cars of all types accounted for 46% of all personal vehicle sales; the light truck category, which overlaps with vehicles in the Large and Extra Large categories, accounted for 54%; while small cars accounted for 19% of purchases.\(^3\)

Far from the notion that small cars are more popular in dense urban environments, it seems as though they are no more popular there than they are in suburban areas of the Boston region. Conversely, there is no evidence that SUVs and other light trucks are discouraged from use in urban downtown areas—to the detriment of city dwellers. At the same time, the one clear correlation that does exist is that regardless of location or density of the surrounding environment, wealthier neighborhoods are home to larger vehicles than their less affluent counterparts.

**Regression Analysis II – The Market for Big**

Price and dimensional specification was recorded for 44 vehicles sold in the U.S. by Acura, Toyota, Ford, Chevy, Fiat, Honda, Smart Scion and Mazda. Price was regressed on the total square foot size of vehicles as well as their heights and status of being a luxury vehicle or not. These 3 variables alone produce a regression with an adjusted R squared value of 0.845 – 84.5% of the variance of price can be explained by changes in these variables.

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\(^3\) 2015 Auto Sales. The Wall Street Journal. 01 May. 2015
http://online.wsj.com/mdc/public/page/2_3022-autosales.html
The coefficients used all yielded t scores with very high significance levels. The following equation was then formed using these coefficients to calculate the value of new model year vehicles based on dimensional information and luxury status:

\[
\text{Price} = 311.33 \times \text{sq. foot of vehicle} + 746.07 \times \text{height of vehicle (inches)} + 15803.78 \times (1 \text{ if luxury; 0 if non luxury}) - 49744.45
\]

This equation suggests that the value of height to be of particular importance to car buyers—an implied added value of some $746 for every additional inch added to a car, which may explain the enthusiasm car companies express towards marketing SUV style vehicles – or why the notably small-centric Mini brand sells the Cooper Countryman, a significantly raised-up Mini-branded SUV.

Troublingly, given the large negative constant term, the model suggests a severe drop in the value of small vehicles as size is reduced. For vehicles the size of the Smart Fortwo at 60.7 inches tall and 45.2 sq. feet, the model predicts a value of $9,775, nearly $4000 less than average
selling price; for theoretical vehicles below this size, predicted price quickly turns negative – the model suggests drivers would actually have to be paid to drive very small cars.

This can be explained by several factors. Due to the paucity of subcompact cars in the American market and therefore as part of the collected dataset, it is possible the model is simply overfitted, that the constant term is exaggerated through the regression process to better fit the data provided. More importantly, the general car buying population may very well heavily discount small vehicles, as the prior street survey analysis suggests with the very low percent of very small cars on Boston streets. On the other hand, it is reasonable to believe that sub-compact cars and city cars belong in a separate market segment from larger vehicles – it seems likely that the personal characteristics and behavior of buyers of these vehicles are quite different from the larger car market.

Parking Analysis 1: Boston
Methodology: Monthly cost of Parking, Boston CBD

Monthly prices listed on bestparking.com within two miles of City Hall within the Boston City limits were found for 77 off-street parking establishments. Eight additional garage prices were found using Spothero.com. The prices were then averaged to a price of $395.62. This was averaged with the price estimated by Colliers International group of $405 to produce a composite average price of $400.31 per month for downtown Boston.

Parking Analysis 2: Cambridge
Methodology: Monthly cost of Parking, Cambridge

Monthly prices listed on BestParking.com were found for 14 garages offering monthly parking across Cambridge; an additional 10 garages were observed with ParkingSpotter.com, one using
SpotHero.com, and one garage owned and operated by the city of Cambridge for a total of 26 garages. Prices were averaged, producing a monthly price estimate of $228.
Bibliography


Frank Ackerman; Elizabeth Stanton. “Climate Risks and Carbon Prices: Revising the Social Cost of Carbon” 2012


Victoria Transport Policy Institute. “Transportation Cost and Benefit Analysis II – Cost Summary and Analysis” 2009


Victoria Transport Policy Institute. “Transportation Cost and Benefit Analysis II – Air Pollution Costs” 2009

Victoria Transport Policy Institute. “Transportation Cost and Benefit Analysis II – Cost Summary and Analysis” 2009
