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Small, local and cheap?
Walkable and car-oriented retail in competition

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Abstract

I develop a model of competition between walkable shops, and other shops whose customers drive (car-oriented shops). Walkable shops operate in monopolistic competition within a local area, or neighborhood. A small cost advantage for car-oriented shops can turn into a larger price advantage. High prices in walkable shops effect a regressive transfer from poorer to richer consumers, since the poorer are less likely to have cars. Internalizing environmental and social costs of urban automobile use could reduce prices and increase capacity utilization in walkable shops in more densely populated local areas. Many common combinations of planning and pricing tools fail to internalize important costs, and may actually subsidize driving to shop, but a combination of planning and the pricing (through taxation) of retail parking could effectively internalize the relevant costs.

Keywords: walkability, monopolistic competition, retail, parking tax

JEL codes: L13 R11 R32 R48

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1. Introduction

This paper presents a model in which consumers choose between buying from relatively small local retail shops to which they can walk, and from superstores to which they must use motorized transport. It shows that a small cost advantage for car-oriented shops can lead to a large price advantage; walkable shops, if they survive at all, are then left in the role of convenience stores, with high prices, limited local competition, and high excess capacity. This is, however, a two-way street: if residential density is sufficient, *and* if the environmental and social costs of motor vehicle use were internalized, the cost advantage could shift back to walkable shops.

'Walkable' shops are retail and consumer service establishments mixed into, or within walking distance of, their customers' residences. Such shops are regarded by many as a desirable feature in human settlements, whether village or megopolis (Evans 1999), and are at the centre of 'New Urbanist' and 'smart growth' discourses. Walkable settlements are seen to produce widespread health benefits from exercise, stronger and safer communities, and better environments for children and the elderly. Yet they have been in steady decline in many developed countries, and in some (the USA, Canada, Australia, New Zealand) they have all but disappeared. Moreover, where walkable shops exist, they tend to be high in price relative to car-oriented shops. In countries where car-oriented shopping is dominant, New Urbanist initiatives have struggled to establish walkable retail that is not high-priced – a convenience or a luxury – if, indeed, it exists at all (Falconer et al. 2010).

Not all observers, of course, view this as a problem: the decline and disappearance of communities with walkable services is seen by some as a largely desirable consequence of growing income and reduced travel costs (Brueckner 2000). I argue that while growing incomes and reduced travel costs contribute to the phenomenon, Brueckner's analysis is wrong, on three levels. First, there are direct external costs of urban car use; these go well beyond the costs of traffic congestion and greenhouse gasses (Litman 2009). Second, as I show below, failure to internalize these costs does not merely subsidize car-oriented shops, but actually raises costs and prices, and reduces variety, in walkable shops; increased prices and reduced variety in walkable shops induces further car use, with the attendant external costs. Third, since the use of car-oriented shops raises prices and reduces variety in walkable shops, it imposes an uncompensated welfare cost on non-drivers, who depend on walkable shops. This distributional consequence is independent of the reason for the lower net costs for drivers of using car-oriented shops; that is to say, it occurs whether the car oriented shops are cheaper because of a failure to internalize costs of driving, or because of differences in logistical efficiency or land prices. The model thus sheds light on the problems of 'food deserts' (Whelan et al. 2002), and of the poor paying more (Chung and Myers 1999).

An implication of the model presented in this paper is that while planning may help achieve certain conditions which are necessary for walkability, planning will not be sufficient in a world where many people have cars: pricing of the externalities associated with motor vehicle use is also necessary. Moreover, the most commonly applied pricing schemes – taxes on CO_2 or motor fuel; tolls on bridges or inter-urban highways; road pricing, generally cordon charges, geared for the reduction of congestion in town centers or major arteries; and fees for parking in commercial neighborhoods – are all inadequate to the task, alone or in combination. Indeed, in the absence of more appropriately targeted pricing, some of these measures actually undermine the viability of walkable shops.

The model is presented in Section 2; implications are discussed in Section 3; conclusions are presented in Section 4.

2. A model of walkable shops in competition with car-oriented shops

Building on Guy (2007), I develop a model with two kinds of shops (walkable, and car-oriented) and two kinds of consumer (driver and non-driver). Walkable shops here are walkable from the consumer's home: while some of the same issues arise with, say, walkable CBDs, shopping in and near residential areas is the focus of this paper. Walkable shops within a local area, or neighborhood, are in monopolistic competition; we can think of this as spatial competition between walkable shops located at different points in the local area. Car-oriented shops are assumed to be in perfect competition. All consumers are either drivers or non-drivers; for drivers, the cost of travel to car-oriented shops is lower than it is for non-drivers.

Before considering the technical details of this model, let us examine some of the assumptions. The stark division between walkable and car-oriented shops is, of course, a stylization: most car-oriented retail is walkable for some consumers, and most walkable shops have some customers who arrive by car. Still it is useful, for analytical purposes, to make a sharp distinction between two logistical systems, one of which typically uses larger retail facilities and lower-priced land but depends on the extensive private use of automobiles, the other of which typically uses smaller facilities and more expensive land but does not require the use of private automobiles (a third logistical system, home delivery, is of growing importance but beyond the scope of this paper).

The scale and location of car-oriented services, together with reduced residential density and other changes in the built environment, have led to a situation when in many countries most people do not live within walking distance of competitively priced basic retail services for even the most mundane products. Hence, 93% of shopping trips in the US, 59% of those in Germany were made by car in 2001/2 (Buehler 2011) while in Britain in 2010 the figure was 65% (Transport 2010). While the proportion of shopping trips taken by car in the countries just mentioned has not changed much in the past decade, in any country we can find periods of years where that proportion was increasing, as walkable shops were displaced by car-oriented ones: in New Zealand, the share of shopping trips in which the shopper drives a car rose from 48% in 1990 to 60% in 2004 (Harding and Powell 2010); in the Osaka-Kobe-Kyoto area, the proportion of shopping trips done by car rose from about 4% in 1970 to about 36% in 2000, and “energy consumption for shopping trips has increased with a much larger rate than that for trips for all purposes. Underlying this is the change in shopping behavior, from foot-based visits to neighborhood shopping streets or grocery stores to auto-based visits to faraway large-scale retail stores” (Kitamura et al. 2008).

There are of course many cases to the contrary – cases in which retail services thrive in walkable environments, sometimes in fairly large facilities (though not, it must be said, with individual hypermarkets on the scale of their largest car-oriented counterparts). Such can be found in parts of many European and Asian cities, and of Manhattan, at least, in North America. The existence of such cases is not in conflict with the model presented here; indeed, without them, this paper would be much less interesting, because the model presented here is most relevant if the widespread decline of walkable retail has occurred despite fairly small differences in minimum average cost, and not due to its decisive technological obsolescence as a means of delivering goods. The continued existence – and, in some instances, revival – of retail which is walkable, and which even consumers who have access to cars might choose to use for their routine needs, supports the argument here that even where there are large price differences between car-oriented and walkable retail, the underlying cost differences may be much smaller.

The assumptions that walkable shops are in monopolistic competition and that car-oriented shops are in perfect competition, are also stylizations, but close enough to the world we observe to serve here. The perfect competition for the car-oriented market is simply a modeling convenience – a way of making the price level in car-oriented shops parametric, as with the outside option in Salop circle models (Salop 1979). Monopolistic competition in the local, walkable, market is a realistic assumption due both to the spatial nature of the problem (a limited walking range for shoppers, which both restricts the local market size and gives a shop in any particular location a downward sloping demand curve), and scale (locating within walking distance of residences makes these shops relatively small, which favors free entry). I ignore issues of multi-market strategic interaction, and assume that within a local market the competitors are the shops – that is, it is not an issue here if those shops are independent, or owned by large chains that also compete in local markets (it is worth noting that, when supermarket chains do operate both large car-oriented shops and smaller walkable shops, pricing tends to be distinctly higher in the latter).

The cost-minimizing way for drivers to reach car-oriented shops is by car; non-drivers use some other means – it is not important here whether that is a bus, bicycle, taxi, or a very long walk, but simply that the marginal cost of getting to a car-oriented shop is higher for a non-driver than for a driver. In both cases, we interpret the travel cost as a net cost - the difference between the cost of reaching the car-oriented shops, and that of travelling (walking) to local shops, including the relative costs of one-stop shopping in a hypermarket and multi-stop shopping in a series of small shops. Marginal cost is short run – by assumption, drivers are those who already have cars.

The distance from the local area to the car-oriented shop is treated as exogenous. Travel costs vary across drivers and also across non-drivers. This variation of costs within each group represents differing personal circumstances: for drivers, for instance, this would include whether one already drives for work or for a school run; the walking distance to the local shops, and whether one is already walking for other purposes (e.g., from transit when arriving home from work); whether, at home, one has personally reserved parking, an expectation of easy on-street parking, or an expectation of a search for on-street parking; the fuel efficiency of one's car; personal preferences as to driving and walking; and so forth.

Now, the model. In a particular local area, let the equilibrium price in walkable shops be P^W. The price in car-oriented shops is P^C. There are N consumers in the local area, of whom some proportion, α, are non-drivers, and $(1-\alpha)$ are drivers. For convenience, we assume that there is a well defined local area, within which all shops are walkable for all residents, number of those shops being M.

Differences in travel costs are modeled as follows. Consumer j pays a travel cost, c_j, to reach a car-oriented shop. For drivers, c_j is distributed uniformly across the interval $[d, d + e]$, where d is the minimum travel cost and $d + e$ is the maximum. The density of the distribution is given by $1/e$ at all points in the interval. For non-drivers, c_j is distributed uniformly across the interval $[f, f + g]$, where f is the minimum travel cost and $f + g$ is the maximum. The density of the distribution is given by $1/g$ at all points in the interval. I assume that $f > d + e$: that is, the marginal travel cost for the non-driver with the lowest travel cost is strictly greater than that for the driver with the highest marginal travel cost. The assumption that travel for shopping is generally more costly for non-drivers reflects the time and inconvenience required for doing a supermarket without a car. The strict difference between the extremes of the two cost distributions simplifies the presentation here; it is not fundamental to the model, but in any case, considering that this is a model of one local area, it is a reasonable assumption. Nothing in the model requires a particular sign for c_j: for some consumers it may be less costly to drive to a car-oriented shop than to reach a walkable shop.

For simplicity, I assume that each consumer makes an all-or-nothing choice between walkable shops and car-oriented shops. Thus, driver j will use the walkable shop if $P^W < P^C + c_j$, and otherwise will drive. If $P^W - P^C > d + e$, then $P^W > P^C + c_\mathrm{j}$ for all drivers, and they all use car-oriented shops; conversely, if $P^W - P^C < d$, all drivers use walkable shops. The same follows for non-drivers, substituting f and g for d and e as appropriate.

There are ways in which the division between drivers and non-drivers, and the all-or-nothing choice between using walkable and car-oriented shops might be made more subtle. We could, for instance, have the price difference and the travel cost affect the distribution of purchases by each consumer across walkable and car-oriented shops, and the frequency of trips to car-oriented shops; in such a model, purchases at walkable shops might take the role played by inventories in McCann (1995). We could also endogenize car ownership, making it a function of the price difference between walkable and car-oriented shops. While such refinements might shed light on some additional issues, the simpler model presented here serves to establish some basic results.

Assuming linear demand, each consumer's demand is given by the relation:

$$Q_j = a - bP \qquad (1)$$

Let Q^W be the total demand faced by a representative walkable shop. The shop's demand curve consists of four segments. Where $P^W - P^C > f + g$, all consumer go to car-oriented shops, and there is no demand for walkable shops. Where $f + g > P^W – P^C > f$, the proportion of non-drivers who buy locally varies with P^L, so the walkable shop's demand curve is:

$$Q^W = \left[\left\{\frac{\left(P^C + (f+g)\right) - P^W}{g}\right\}\alpha(a - bP^W)\right](N/M). \tag{2.1}$$

Where $f > P^W – P^C > d + e$, all non-drivers go to walkable shops and all drivers go to car-oriented shops:

$$Q^W = \alpha(a - bP^W)(N/M). \tag{2.2}$$

Where $d + e > P^W – P^C > d$, the proportion of drivers who buy locally varies with P^L, so the walkable shop's demand curve is

$$Q^W = \left[\alpha(a - bP^W) + \left\{\frac{\left(P^C + (d+e)\right) - P^W}{e}\right\}(1-\alpha)(a - bP^W)\right](N/M). \tag{2.3}$$

Finally, where $d > P^W – P^C$ and all purchases are done in walkable shops, and the representative walkable shop's demand curve is

$$Q^W = (a - bP^W)(N/M). \tag{2.4}$$

Details of the derivation of 2.1 and 2.3 are given in Appendix 1. Now, differentiating 2.1-2.4 with respect to P^W, the slopes of the four segments are:

$$\frac{\mathrm{d}Q^W}{\mathrm{d}P^W} = \left\{\frac{1}{g}\left[2bP^W - [b\left(P^C + f + g\right) + a\right]\right\}(N/M). \tag{3.1}$$

$$\frac{\mathrm{d}Q^W}{\mathrm{d}P^W} = -\alpha b(N/M). \tag{3.2}$$

$$\frac{\mathrm{d}Q^W}{\mathrm{d}P^W} = \left\{\frac{1-\alpha}{e}\left[2bP^W - [b\left(P^C + d + e\right) + a\right] - \alpha b\right\}(N/M). \tag{3.3}$$

$$\frac{\mathrm{d}\, Q^W}{\mathrm{d}\, P^W} = -b(N/M) \tag{3.4}$$

The second and fourth segments are both are linear and, since α < 1, the second (where all non-drivers, and only non-drivers, use walkable shops) is steeper than the fourth (where all local consumers use walkable shops). The first and third segments are convex to the origin, with concave kinks where they join the linear segments to their right; the third segment has a convex kink where it joins the second segment, to its left (see Appendix)[1].

[Figure 1 about here]

Assuming free entry and exit by local shops with u-shaped long-run average cost curves, the monopolistic competition equilibrium may lie on any segment of the curve.

Since a walkable shop has some fixed costs, the average cost explodes when Q becomes small; if the demand curve shifts far enough to the left there will be no (P^W,Q^W) combination at which even a single (M=1) walkable shop can meet its costs, and the neighborhood will support no walkable shops (Figure 1). In the limiting case – a single isolated house in the countryside – this is obvious.

[1] The convex (inward) kink in this model contrasts with the concave (outward) kink of Salop (1979). Salop's kink occurs at a point where two firms on the circle (analogous to the walkable shops here) are close enough together that their markets overlap. In Salop's model, the flatter demand curve to the left of the kink is a "monopoly" zone (where the only competition is the outside option), while the steeper demand curve to the right is a "competitive" zone, where firms on the circle compete for customers. The firm's demand curve less elastic in the competitive zone – something Salop (1979, p. 144) calls an "unusual result" - because the assumptions of the model make this a transition from monopoly at the margin to Bertrand competition at the margin. Salop's concave kink – following those of Lerner and Singer (1937) and Sweezy (1939) – produces a zone of sticky prices - where cost changes have little or no influence on price.

The convex kink in the present model comes from differences in marginal travel costs for drivers and non-drivers. With a Sweezy-Salop concave kink, the interesting feature is a set of equilibria which are stuck on the kink – prices non-responsive to changes in cost. With the present model's convex kink, the average cost curve, far from getting stuck in a tangency at the kink, is *never* tangent at the kink; rather than the possibility of getting stuck, we have the possibility of discontinuous adjustment, with a small change in travel costs for drivers (or, equivalently, a small change the price of the outside option) producing a discontinuous, and disproportionately large, change in local prices. The walkable shops are assumed always to be in monopolistic competition equilibrium of the Chamberlain type (Chamberlain 1933; Spence 1976). As with Salop's model, the outside option is in perfect competition and the outside price is treated as exogenous.

I will refer to an equilibrium on the third or fourth segments of the curve as a *low price equilibrium,* and one on the first or second segments as a *high price equilibrium.* Notice, however, that prices in the high price zone will decline as the population density of non-drivers rises. This is a straightforward result of increased demand in the Chamberlain model.

Differentiation of any segment of the demand curve confirms the intuition that demand faced by walkable shops increases both with residential density, and with the proportion of consumers who are not drivers. One implication of this is that for sufficiently large αN – which is to say, a sufficiently high density of non-drivers – walkable shops will be viable even if all drivers shop elsewhere.

Now consider equilibria falling on either the second or the third segement of the demand curve. Start with one on the second segment – that is, one in which all non-drivers, and only non-drivers, shop in a representative walkable shop [Figure 2].

[Figure 2 about here]

What might lead drivers to choose the walkable shop? Here we study the comparative statics of changes in either *d* (the minimum of the travel cost distribution) or P^C (the price level in car-oriented shops). By the assumptions of the model, an increase in *d* shifts the entire travel cost distribution up, and increases in *d* and P^C are equivalent. Here we use an increase in *d*, which is to say a positive shock to the travel costs for drivers. Differentiating 2.3 with respect to d gives us:

$$\frac{\mathrm{d}Q^W}{\mathrm{d}d} = \frac{(1-\alpha)(a-bP^W)}{e}(N/M) > 0\,. \qquad (4)$$

So, an increase in travel costs raises demand in walkable shops; the second derivative is zero - under the assumptions of the model, the change in local demand is linear in travel costs.

To see the effect of a change in drivers' travel costs on the slope of the demand curve, we differentiate (3.3) with respect to d, obtaining:

$$\frac{\partial Q^W}{\partial d \partial P^W} = -b\frac{1-\alpha}{e}(N/M) < 0. \qquad (5)$$

Thus, a positive shock to d not only shifts the curve out, but also reduces the slope. The shift in the walkable shop's demand curve following a positive shock to d is shown in Figure 3 as the shift from DD' to DD".

When the initial equilibrium is on the second segment of the demand curve, as shown in Figure 2, an outward shift and flattening of the third segment of the demand curve will affect this equilibrium only if it raises the third segment far enough that it crosses the walkable shop's average cost curve. When this happens, however, the change is discontinuous, with the equilibrium tipping from high prices and low volumes to low prices and high volumes in walkable shops. A less technical way of expressing this is that the difference between the walkable and car-oriented shops in price-plus-travel-costs has become small enough that walkable shops can compete on price for the custom of drivers. The dynamics of the tipping process are illustrated in Figures 3 and 4. The outward shift of the demand curve makes positive profits available to walkable shops charging lower prices (Figure 3). New walkable shops then enter. The new entry divides local trade among more shops, shifting the demand curve for the representative walkable shop to the left, until a new equilibrium is reached: this is the shift, shown in Figure 4, from DD" to D*D**. The entry of additional walkable shops will, of course, raise the price elasticity of demand, further flattening all segments of the demand curve.

[Figure 3 about here]

[Figure 4 about here]

The new equilibrium must be at a lower price level, and closer to the representative shop's minimum average cost, due to the shape of the long-run average cost curve; moreover, entry has given us more walkable shops.

Within the range $d + e > P^W - P^C > d$, further rises in the cost of out-of-town shopping would lead to further reductions in local prices. Unlike the step-change illustrated above, however, in this range we see incremental price reductions in response to incremental cost increases. However, this is a model of prices in a single local area, or neighborhood. Any metropolitan area or large town has multiple local market areas, with differing densities, proportions of drivers and non-drivers, and costs of travel to car-oriented retail. A positive shock to driving costs across an entire metropolitan area might tip walkable shops in some local areas from a high-price to a low-price equilibrium, while leaving others unaffected; an additional positive shock could tip the prices in another set of local areas. Thus, while rising travel costs will at some point produce a discontinuous price drop in a given neighborhood's walkable shops, aggregated over a large metropolitan area the decline in walkable shop prices should appear continuous.

3. Implications of the model

When it becomes cheaper for consumers who have cars to drive to buy, walkable shops can be relegated abruptly to serving only non-drivers; among walkable shops, the number of competitors, price level, and capacity utilization then become crucially dependent on the density of non-drivers. If car ownership is an increasing function of income, then holding residential density constant, the price gap between walkable- and car-oriented shops will, *ceteris paribus,* grow with household income.

Although this result is couched in terms of price, we should not lose sight of the fact that it is a clear implication of the model that reduced product variety, reduced local competition, and increased distances between walkable shops, are all implied by the model as accompanying increased local price. In short, the high priced equilibrium in this model is one of degraded local retail services.

The result has implications for inequality, through the distribution of purchasing power between drivers and non-drivers; for static efficiency; for the creation of urban land use and transport patterns which are consistent with sustainable patterns of resource use – particularly of greenhouse gas (GHG) production; and in general, for understanding the efficacious mix of planning and pricing on the shaping of the built environment. Let us consider each of these in turn.

3.1 The distribution of purchasing power, and food deserts

The distributional implication of the model comes from the finding that when driving costs are sufficiently low that drivers go to car-oriented shops, those who depend on walkable shops pay more. If a neighborhood is heterogeneous with respect to income and car ownership is positively correlated with income, this means that the poor tend to pay more; similarly, independent of income, people unable to use cars pay more. Local income heterogeneity is of course at odds with models of the Alonso (1964) type, in which a city's residents are sorted and segregated spatially into internally homogeneous wealth or income groups. No neighborhood, however, is actually uniform with regard either to the income of its residents, or to their owning and being able to drive cars. The importance of the present model's distributional implications depends on the degree of deviation from the pure Alonso case. This deviation may typically be greater in European, East Asian and Australasian cities than in North American ones. Even within a poor neighborhood in the US, however, use of a car will presumably be correlated with income.

This finding enriches our understanding of "food deserts". Research on the distribution of retail – particularly, food – stores in relation to household income and to racial or other social categories, has found that people in poor and minority neighborhoods are on average located further from supermarkets (Zenk, Schulz, Israel, et al. 2005, in a study of Detroit), pay more for their food (Hall 1983, studying both New York boroughs and two counties in upstate New York), and have access to a reduced variety – particularly, of fresh healthy food (Zenk, Schulz, Hollis-Neely, et al. 2005, Detroit again); the arrival of a supermarket in a former food desert can have a substantial positive impact for both household budgets and nutrition (Wrigley et al. 2003, Leeds). Larsen and Gilliland (2008), in a study of London, Ontario, find that this inequality has grown worse over the decades, as supermarkets have moved to more suburban locations; they also find that poor neighborhoods tend to have inferior access to supermarkets even when access is assumed to be by bus. Whelen et al (2002) show, again in the case of Leeds, poor, disabled or elderly consumers do reach supermarkets in a variety of ways, ways which are often costly in terms of time, comfort, the need for planning, or simple dignity.

The focus, in this literature, on access to supermarkets, follows from the fact that smaller stores tend to have higher prices and less variety (e.g. Alwitt and Donley 1997, studying Minneapolis/St Paul and Chicago, respectively; Chung and Myers 1999). Yet the smaller stores do exist, and in some cases offer a good selection of fresh foods; Raja et al (2008) find, in their study of Erie County (Buffalo and environs), New York, that residents of predominantly black or mixed race neighborhoods who are not driving face substantially longer trips to supermarkets than non-driving residents of predominantly white neighborhoods, but are actually closer to small grocery stores, greengrocers, and butchers. While, whatever the neighborhood's ethnic composition, few of Erie County residents are within easy walking distance of either a supermarket or smaller retail food stores, Raja et al argue that improved access to food in under-served areas might better come from promoting small shops than from adding supermarkets.

The model presented in this paper does not tell us why residents of poor and minority neighborhoods have inferior access to supermarkets, but it does help us understand the implications of being without one: not only does competition from low-cost (and, generally, car-oriented) supermarkets drive many walkable shops out of business, but it can actually raise prices and reduce the capacity utilization in the remaining walkable shops. Note that in food retailing, one implication of reduced capacity utilization is a rising relative cost of handling perishables, in particular the fresh foods said to be scarce in food deserts.

3.2. Allocative Efficiency and Environmental Sustainability

Even ignoring the distributional effects, we note that when drivers use car-oriented shops, the allocation of resources is likely to be inefficient. There are two reasons for this. One is that, in monopolistic competition equilibrium, higher prices are associated with greater excess capacity in each walkable shop[2]. The other is that there are numerous external costs to car use.

Walkable shops and car-oriented shops are elements of two distinct logistical approaches to the delivery of retail goods and services. The car-oriented version requires more road traffic, which in turn produces external costs. Assessments of the external costs of road traffic are often restricted to direct costs in the existing built environment with the existing transport system, in many cases dealing exclusively with traffic congestion (e.g. Calthrop et al. 2000; Mun et al. 2005; Arnott and Rowse 2009); studies with this narrow focus treat the control of road traffic as a collective action problem among drivers, largely ignoring costs imposed on those who are, or would prefer to be, non-drivers. Some analysts attempt also to address such externalities as air pollution, both local (smog, small particulates) and global (CO_2); the value of rural open space; and the cost of subsidizing suburban infrastructure (e.g. Brueckner 2000). Even this list, however, fails to exhaust the external costs of car use: road traffic makes walking and cycling less safe, and thus creates a serious restriction of transportation choice, a curtailment of social space and, through reduced exercise, a significant public health problem (Centers for Disease Control and Prevention 2002); as shown in this paper, one consumer's driving can raise the prices in walkable retail for others; moreover, parking spaces have external costs independent of the driving they are associated with – impermeable surface lots, which cover substantial portions of car-oriented shopping districts (Akbari et al. 2003), and are significant contributors to groundwater depletion, water pollution, flooding, and urban heat islands (Arnold and Gibbons 1996).

For many of these effects, we must reckon not only a direct external cost, but also both immediate and long-term secondary effects from induced driving (Cervero and Hansen 2002; Cervero 2003). The

[2] This is the case, at any rate, in the simple Chamberlain-type model used here; it also accords with casual observation several measures of capacity utilization in UK high streets and US town centers: vacancy rates; the shifting of shop spaces to less intensive (second-hand stories, bookies, offices) or even residential use; and the evidently slow pace of business in many remaining shops. That said, in different formal models, the capacity utilization result is not straightforward: see Gu and Wenzel (2009).

conditions created by driving – unsafe or unpleasant pedestrian or cycling environments, high local prices - raise the cost of *not* driving; acts of driving also tend to induce further driving by the driver, since the fixed costs of keeping a car – or of taking it out of a scarce on-street parking space (Weinberger 2012) – mean that the marginal private cost of car use is below average cost. To the extent that the built environment is rebuilt in response to uncoordinated demand rather than resource conserving planning, driving induces reduced density and, per the model here, undermines walkable retail. The external costs of such changes in the built environment are not small. The public fiscal costs of low density development are very high (Ewing 1997; Blais 2010), for instance. In the critical area of GHGs, Norman et al (2006) find that when a range of inputs are taken into account – construction materials, building operations, and transport – find that car-friendly low density parts of Toronto produce between 2 and 2.5 times the CO2 equivalents, per capita, of higher density parts of the same city; see also Wegener's (1996) study of Dortmund.

Estimating this collection of costs is no simple task. Overall external costs of car use are higher, per distance travelled, in towns than they are in rural areas. GHG emissions are a linear function of fuel use, and close to linear in the distance travelled by a particular vehicle; all of the other costs mentioned are much greater, per distance travelled in a particular vehicle, when the travel is in and around towns and cities; some of the costs are the same for an electric car and an old gas guzzler. Litman (2009) estimates that the external costs of urban driving in North America are from 160% (off peak) to 250% (peak) of those rural driving. On average, he finds the monetized private costs of driving greater than private variable costs, but how much greater is difficult to say: his range of "plausible" estimates for the external costs of a weighted average of rural, urban peak, & urban off-peak driving runs from around \$0.15 to over \$0.90 per mile. If we consider that the range for urban driving will be higher than this (40% of driving, in Litman's formula, is rural), then internalizing these costs in the case of shopping trips could have a noticeable impact on effective prices in car-oriented shops; this, in turn, would have the effect of shifting prices in some walkable shops downwards.

(Litman's estimates do not appear to include increased non-transport GHG emissions among the costs of induced low density.)

3.3 Policy Implications

Our ability to draw precise policy conclusions recommendations from the model presented here, is limited by the facts that available estimates of the overall level of externalities from automobile use are not very precise, and that we do not know what magnitude of increases private travel cost (or, equivalently, prices in car-oriented shops) would be required to tip walkable shops in some local areas into a low-price equilibrium. The model does, however, have clear qualitative policy implications in the areas of land use planning, road pricing, and the pricing of parking.

Where pricing of externalities is incomplete, land use planning can provide a second best means of internalizing costs (Pines and Sadka 1985; Ruth 2006). Higher residential density, for instance, favors walkable shops, other things equal. Yet, high density may be insufficient to maintain a low-price equilibrium in walkable shops if most consumers have cars, driving is underpriced, and car-oriented retail is available. This helps explain why the US Transportation Research Board (2009) finds that increasing residential density in US cities would have only a small effect on energy use and CO_2 emissions: giving Atlanta the residential and transit patterns of Boston (the USTRB's most extreme and optimistic thought experiment) still yields an urban area in which most people drive cars to buy groceries. Brownstone and Golub's (2009) findings point in the same direction.

With adequate residential densities, walkable retail might be kept in a low-price equilibrium by severe and thorough planning restrictions on car-oriented retail. Kristensen and Tkocz (1994) find that, in Copenhagen, consumers with cars travel no further for shopping than those without; in smaller Danish towns, where prices are higher, drivers travel further than non-drivers. Knowles (2012) describes the impact of more recent transit-oriented development in the Copenhagen area in ways consistent with this account. This speaks to the power of planning (though, from the research cited, we do not know the respective effects of planning for residential density and planning for retail location), and it is consistent with the model presented here; it says little about what to do with towns and cities where planning is (or, in the past, has been) less exacting than in Denmark, or for that matter what to do in the smaller Danish cities and towns in Kristensen and Tkocz's study. Where significant car-oriented retail capacity already exists, restrictions on new car-oriented retail development may simply secure rents for incumbent car-oriented retailers while doing little for walkability. And, where whole cities have been built (or re-built) around automobile transport, the problem is not so much one of planning new development, as "retrofitting" of places that are now car-oriented (Dunham-Jones and Williamson 2011); in such cases, the existing stock of car-oriented shopping could forestall the emergence of low-price walkable retail.

Consider, next, the pricing of road use, and of parking. As noted above, Litman finds that aggregate externalities from urban driving are far higher than those for rural driving. Hence, a tax on motor fuel, or CO_2 equivalents, if it does not overprice rural and long-distance driving, will under-price driving for shopping, most of which occurs in or around towns. More focused road pricing measures usually take one of two forms: cordon pricing measures aimed at reducing automobile trips into city centers (Albalate and Bel 2009), or tolls on congested inter-urban roads or selected commuting bottlenecks. Inter-urban tolls, other things equal, simply aggravate the relative under-pricing of urban driving. Restricting traffic into city centers may create a better environment for walkable retail in the center, but it leaves a large ring – a donut of town, suburb, and ex-urb, within which most driving-to-shop actually occurs - in which traffic is under-priced. Moreover, since such schemes typically have exemptions for people who live in the restricted areas, outward mobility to car-oriented shops is protected, potentially leaving city-center shops with very limited markets and relegating them to the high-priced convenience store role depicted above.

In short, fuel taxes and inter-urban tolls under-price driving in towns, while existing congestion charges under-price driving outside of the CBD: in combination, this amounts to a subsidy for driving in urban areas outside of congestion-priced zones, and throughout smaller towns and suburbia. In the absence of more fine-grained road pricing, prices for parking offer a potential solution. The price of parking is whatever is charged to drivers for using a parking space; taxes on parking may be incorporated into parking prices, or may – if, say, levied on a retailer's private parking spaces – be absorbed into the cost base of some other activity. For the purposes of this paper, we assume that a parking tax levied on the retailer will be passed on to consumers in prices, and has a behavioral effect similar to that of a direct tax.

As with road pricing, much analysis of parking prices has been framed as a solution to collective action problems among drivers (Roth 1965; Shoup 2005; Arnott and Rowse 2009): on-street parking prices are too low for these authors if drivers need to cruise for parking too long. As with road pricing, this again lead to a focus on congested town centers; while Shoup rightly lambastes excessive, formula-driven parking minima, it is not clear that relaxing or even eliminating these requirements would do anything to reduce the amount of parking voluntarily chosen by the proprietors of car-oriented supermarkets and shopping malls. More generally, if implemented with the objective of reducing the time needed to find a parking space, rationing parking by price would not fully internalize the costs of driving, and could in some settings have the perverse effect of encouraging driving if not coupled with strict *maxima* on parking spaces. And, in focusing on the problem of underpriced on-street parking and over-provided off-street parking, these studies ignore the fact that in many old shopping districts, the specter of underpriced on-street parking has long since been banished: in the author's neighborhood in north London, about 5km from the congestion pricing zone, scarce non-resident on-street spaces in a thriving walkable shopping district are full even though priced at £3 (about $4.80) per hour, 9.5 hours per day, 6 days per week. Allowing for holidays, and assuming full occupancy but ignoring additional charges (fines) for over-staying, this gives us a price of £8,607 ($13,771) per year. The main roads are congested with cars driving to and from nearby supermarkets, which have made ample and voluntary private provision of parking for their customers, avoiding any such tax. This offers us a nice thought experiment: what would be the behavioral implications – for the consumer in the short run, and the supermarket operator as it plans future development of its properties – of taxing all retail parking spaces at the same high level?

Clearly, the pricing of parking can be used not simply to reduce cruising for spaces, but with the aim of internalizing a wide range of the external costs discussed above (Barter 2010). Feitelson and Rotem (2004) argue for a flat tax on surface parking, on the grounds both that surface parking entails particular externalities, as noted above, and that such a tax is easily administered; more complex alternatives, which address the total parking space used and/or the number of parking acts, have been widely considered (Marsden 2006).

4. Conclusion

Low-priced car-oriented retail can raise prices in walkable shops. When consumers include both drivers and non-drivers, a walkable shop's demand curve has a concave kink - opposite of the kink in Sweezy-Salop models. The model has distributional implications because it shows a mechanism by which non-drivers, who tend to have lower incomes, are burdened with higher costs. The finding that a small cost advantage for car-oriented retailers can lead to a disproportionately large price advantage also has important implications for environmental and urban policy: internalizing environmental and social costs of driving could lower prices in walkable shops, at least in neighborhoods with higher population densities; planning tools on their own are unlikely to be adequate for this task, while the most common pricing tools (taxes on fuel, on congestion, and public parking) perversely under-price much driving-to-shop. A tax on parking – including, at least, all retail parking – could fill this gap. How widely this approach would actually raise car-oriented costs enough to produce low-price equilibria for walkable shops, and the euthanasia of the strip mall, remains to be seen.

Appendix 1: Equations 2.1 and 2.3

The following is framed with reference to equation 2.3, but with appropriate substitutions of *f* and *g* for *d* and *e*, it applies to equation 2.1 as well.

In equation 2.3, the term

$$\frac{P^C + (d+e) - P^W}{e} \tag{A.1}$$

represents the proportion of drivers who use walkable shops, a proportion which changes as P^L changes. When $P^L = P^O + (d+e)$, the lowest local price at which *all* drivers use car-oriented shpos, the numerator and the proportion both equal zero. When $P^L = P^O + d$, the walkable shop price below which all drivers use walkable shops, the proportion is 1; we can see this by substituting $P^O + d$ for P^L in the numerator. Under the assumption that the distribution of costs is uniform within the $[d,d+e]$ range, the proportion of those shopping locally is, within the relevant range, a linear function of P^L. However, under the assumption that demand from those consumers who shop in a given area is linear, the demand curve faced by the representative local shop is *not* linear in this range, because a change in price causes both a linear change in the proportion shopping locally, and a linear change in the quantity purchased by each consumer; the interaction of these gives us a quadratic in P^L.

The second derivative of 2.2 is

$$\frac{\mathrm{d}^2 Q^L}{(\mathrm{d} P^L)^2} = \frac{1-\alpha}{e} 2b(N/M) > 0 \tag{A.2}$$

so the central segment is convex to the origin. At the left-hand (upper) end of the middle segment, where $P^O + d + e - P^L$ approaches zero, its slope approaches

$$-\left\{\alpha b + \frac{1-\alpha}{e}\left[a - bP^L\right]\right\}(N/M), \tag{A.3}$$

which is flatter than the first segment's $-\alpha b(N/M)$: the curve is kinked where these two segments join, and remains convex to the origin. At the other end of the middle segment, where $P^O + d + e - P^L$ approaches *e*, the slope approaches

$$-\left\{b + \frac{(1-\alpha)\left(a - bP^L\right)}{e}\right\}(N/M), \qquad \text{(A.4)}$$

which is flatter than the third segment's slope of $-b(N/M)$. Thus the curve is kinked here, too, but this time the kink is concave to the origin.

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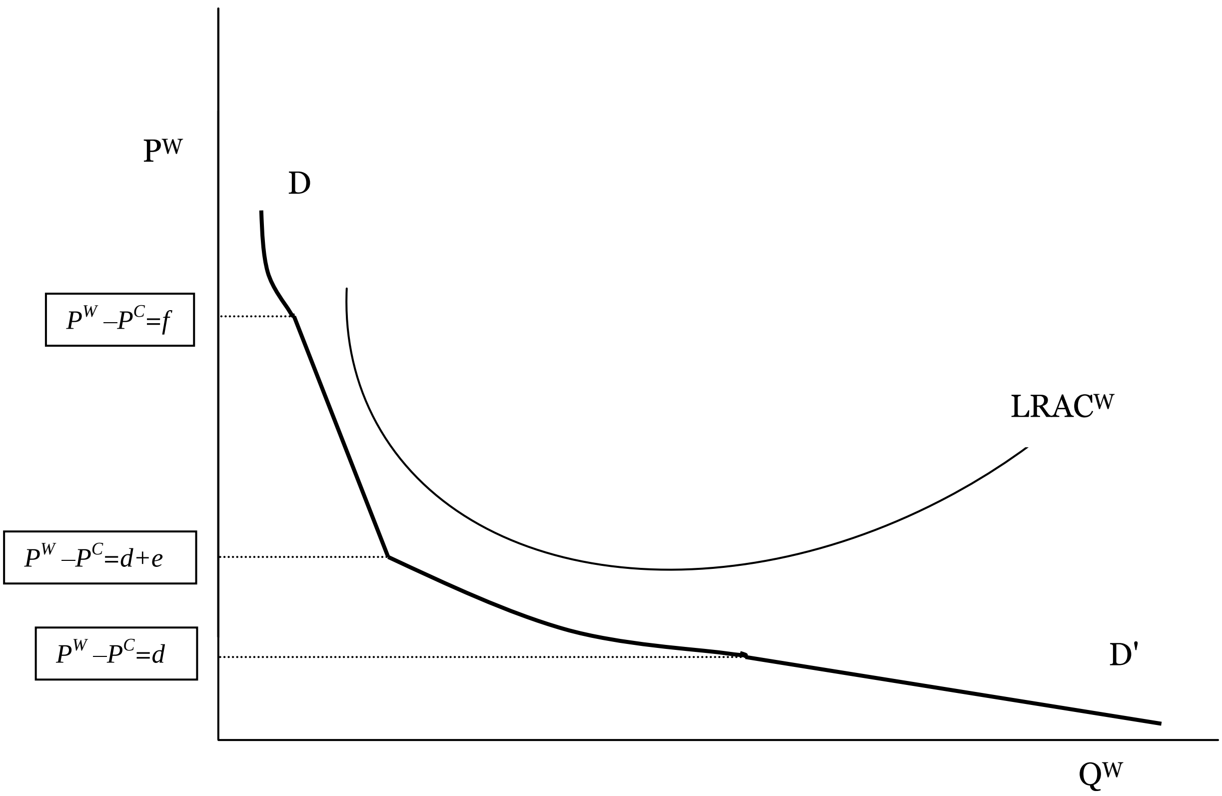

Figure 1
Insufficient local market to support any walkable shops.

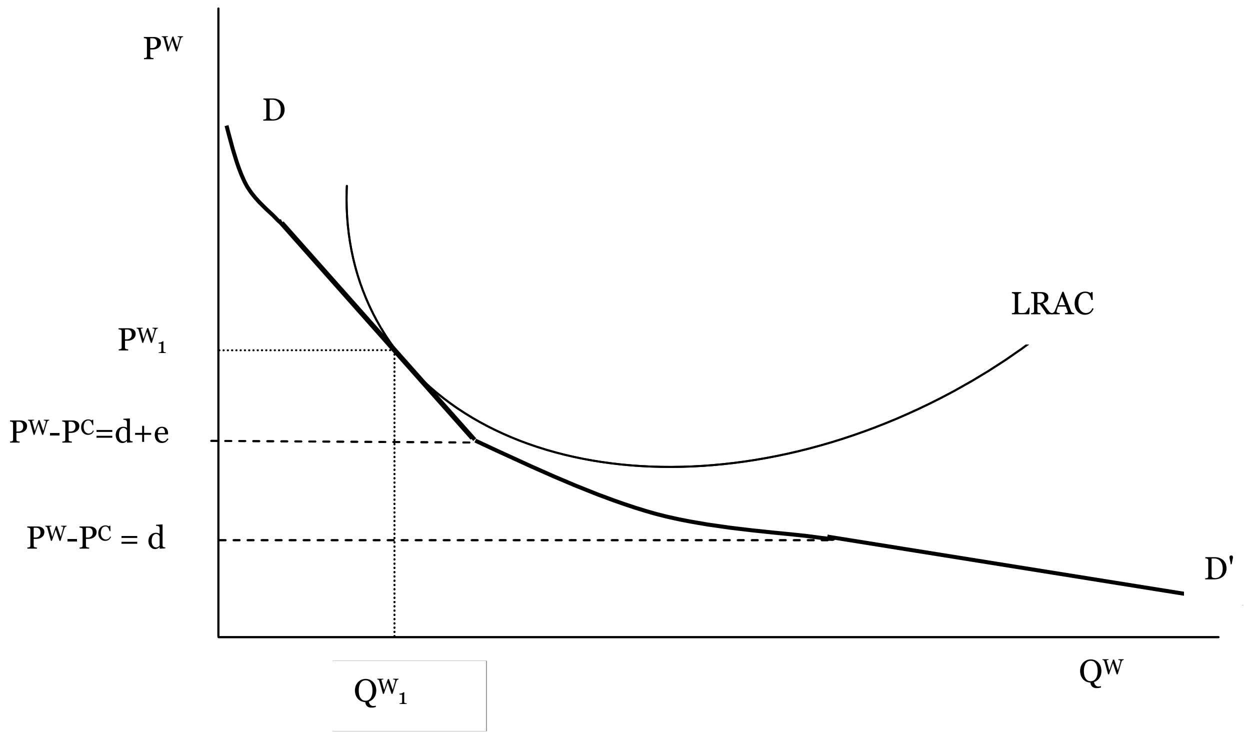

Figure 2
Monopolistic competition equilibrium with only non-drivers using walkable shops.

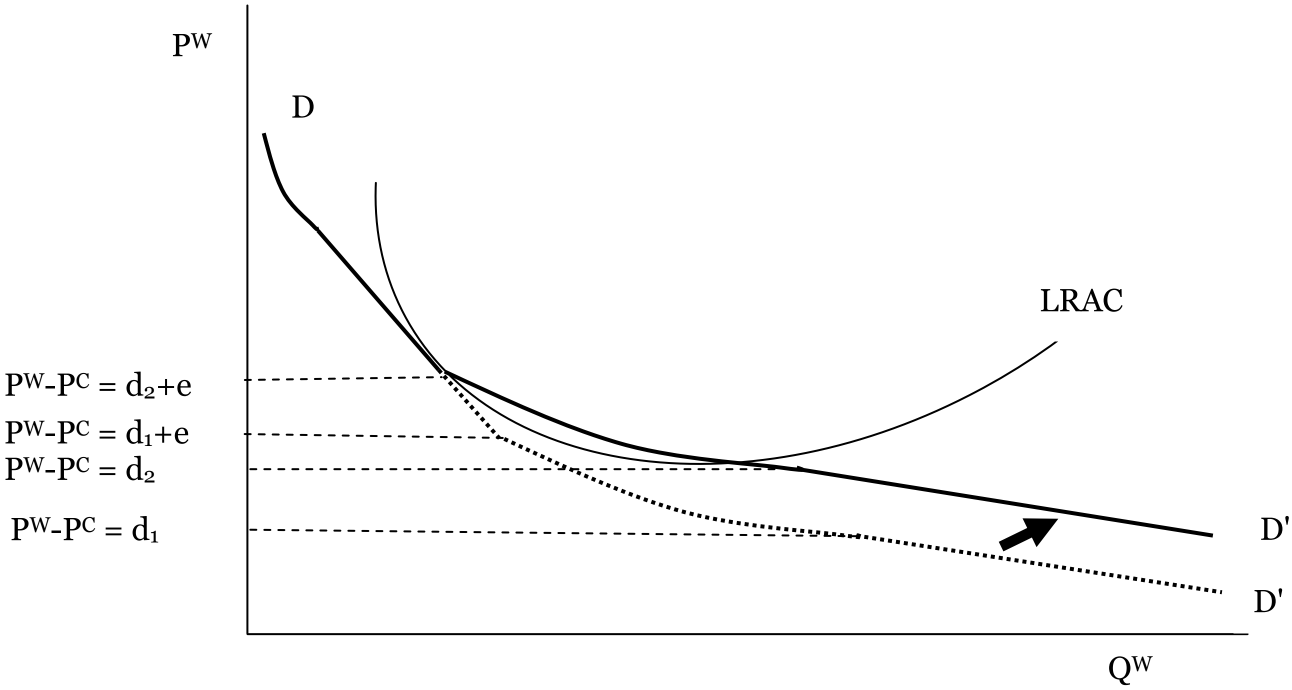

Figure 3
Minimum travel cost for drivers rises from d_1 to d_2, shifting demand curve for walkable shops, and creating profit opportunities for walkable shops at lower price levels.

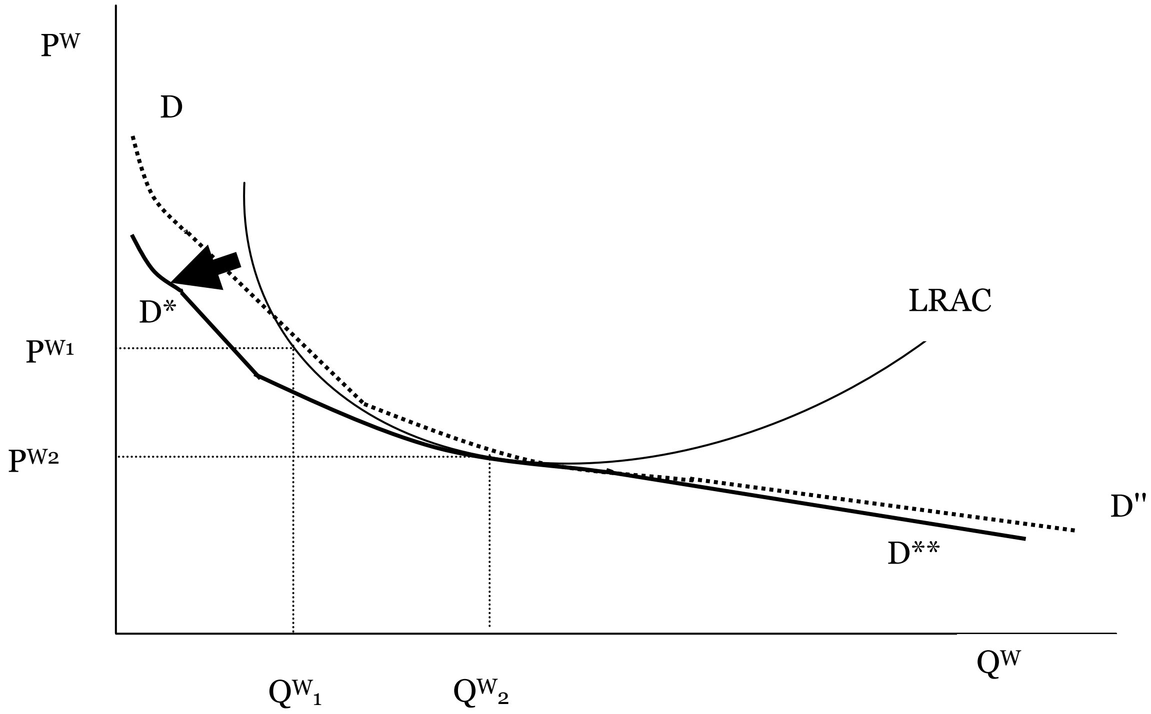

Figure 4
Entry of new walkable shops shifts demand curve for representative walkable shop to the left. New monopolistic competition equilibrium at lower price (P^{W}_{2}) and higher capacity utilization (Q^{W}_{2}).