EXCESS COMMUTING[1]: TOWARDS ESTIMATING THE COST OF RESTRICTING "WASTEFUL[2]" TRAVEL

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ABSTRACT

Transportation is major contributor to green house gas emissions. It is also a major consumer of energy, especially fossil fuels. Conferences such as those in Kyoto (1997/2005) and Copenhagen (2009) are aimed at multi-national pledges to reduce emissions. But underlying the proclamations, resolutions and negotiations, there appears to be an unwillingness of countries to implement potentially unpopular policies requiring their citizens to significantly change their commuting lifestyles. This is evidenced by major initiatives such as those to reduce vehicle weight, improve engine efficiency and develop alternative fuels to power motor cars.

Countries seem to avoid asking why we are commuting so far using motorised transport, what would it cost if we did not / could not commute so much, and finally what interventions should they implement to reduce excess motorised commuting. There is a significant body of literature that has shown that excess commuting can be as much as 70% of current commuting. While the minimum value of commuting is a function of development density and the location of land uses to satisfy trip purposes; the value of excess commuting can only be reduced if the "friction" of distance is increased. Such an intervention will result in a reduction in the number of locations at which trip purposes can be satisfied. A reduction in choice will carry a "cost". The topic of the "cost" of restricting the number of locations that can be reasonably chosen as trip ends is not clearly articulated in the literature.

The paper is aimed at beginning a discussion on how to estimate these "costs". The paper introduces the topic with summaries of the literature on the peak oil debate and excess commuting.

INTRODUCTION

It is estimated that oil provides 35% of the global energy (Robinson & Mayo,2008,8;Gupta, 2008, 1195) and 88-95% (Robinson and Mayo, 2008,8; Masson,2008,16) of energy used for transportation. (As well as contributing between 20 and 25% of carbon emissions (Bello, 2008). The value of oil lies in its efficiency as a store of energy, which can be easily stored and transported, is ideal as transport energy source and has many other industrial uses (e.g. chemical fertilizers, plastics).

It is generally accepted that the current world economy and globalisation is anchored in the availability of 'cheap' oil. Oil has "*boosted food production, permitted large scale and long distance*

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[1] "….excess commuting is the non optimal or surplus work travel occurring in cities because people do not minimize their journeys to work…."Horner MW, 2002, ``Extensions to the concept of excess commuting'' Environment and Planning A 34 543 ^ 566

[2] Hamilton B, 1982, ``Wasteful commuting'' The Journal of Political Economy 90 1035 ^ 1053

distribution of food and manufactured products,...... fueled massive urbanisation,...... powered the ever growing transport needs of these growing cities.......permitted suburbia" (Masson, 2008, 1).

The volatility of oil prices in recent years may be considered to be either a series of shocks or a change to sustained high prices[3]. If it is the latter, it could be reflecting the impact of Peak Oil.

The concept of Peak Oil is based on work done by Dr M. King Hubbert in the 1950's which predicts the increase in oil prices when more than half the known reserves have been depleted. While everyone appreciates that there is a limited amount of oil on the planet, there are two schools of thought of when Peak Oil will occur. One group believes that, based on known oil reserves and decreasing potential of discovering significantly more, it has either already occurred or will occur in the next few years. The second group believes that the extent of oil has been underestimated and that Peak Oil lies more than 30 years in the future.

The possibility that oil will become scarce and more expensive in the medium, if not in the short term, raises the concern of its impact on the residents of cities (more specifically the poor in cities of the south) and a need to identify mitigating measures.

The obvious mitigating strategy is to coerce a reduction in motorised travel distance at a faster rate than the increasing price of oil will induce. This raises four questions for research; namely:
a)   How can the 'cost' of coercing reduced motorised travel distance be estimated?
b)   What interventions will coerce commuters to reduce motorised travel distance?
c)   How effective will the interventions be?
d)   Under what conditions will authorities be willing to implement these interventions?

This paper serves as a preface to the research by briefly summarising the debate on Peak Oil and the consequences, as well as the literature on excess travel. It the very briefly examines the potential for reducing motorised travel in cities of the south, using Cape Town as a case study. The paper ends by asking how we can measure the effects of interventions to reduce motorised travel.

THE DEBATE ON PEAK OIL

The quantum of oil reserves

As mentioned earlier the concept of Peak Oil was developed by Dr M. King Hubbert in 1955 and can be reflected by the graph shown in Figure 1. This depends on the assumption that no more significant oil reserves will be discovered in the future. Proponents of Peak Oil argue that the peak has been or will be reached in the next few years. Figure 2 shows the non-OPEC countries; and those countries that have passed their peak in terms of annual oil production.

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[3] ...... oil shocks and sustained high prices. A spike is defined as a large transient increase in price which subsequently subsides. Sustained high prices are, by contrast, a large and persistent increase in price. These two events differ in terms of what responses people are prepared to take and also in terms of what responses government agencies are able to provide (Sessa et al, 2009,130)
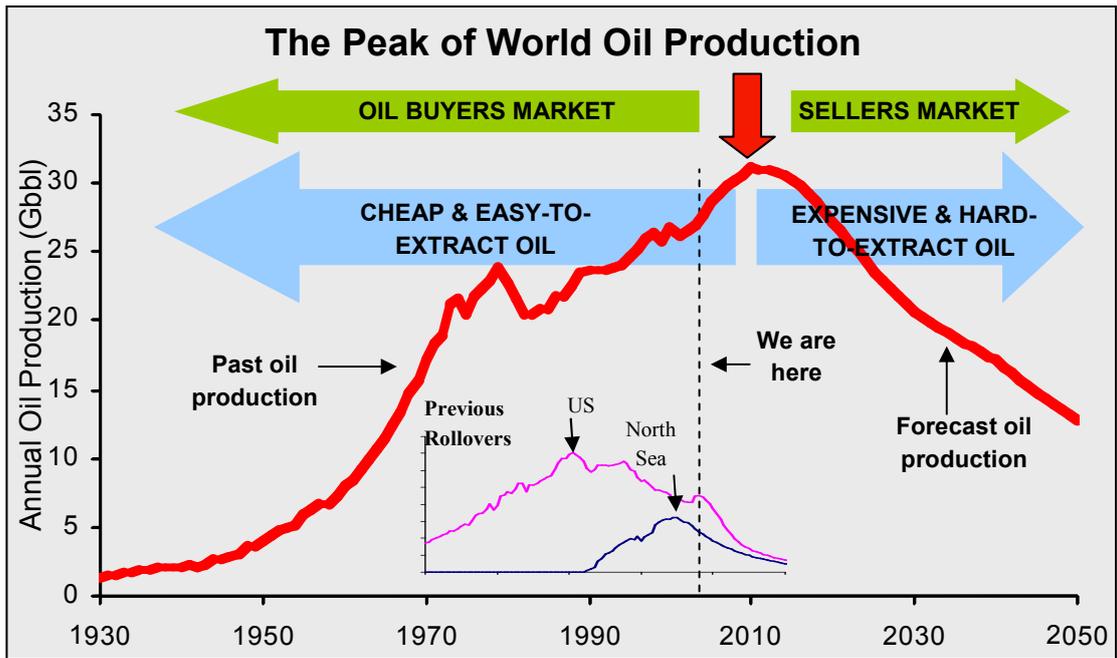
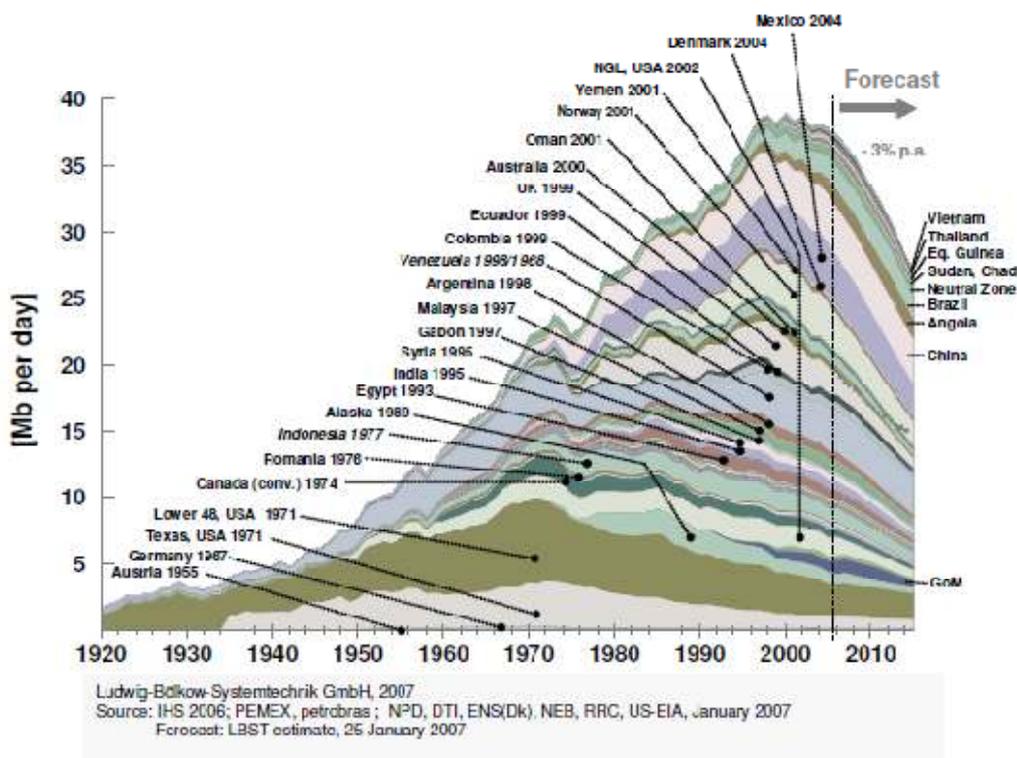FIGURE 1. PEAK OIL (after Fishman & Robinson,2006)

FIGURE 2: OIL PRODUCTION AND PEAKED RESERVES (EWG,2007,11)

However the concept of Peak Oil in this regard is based on the assumption that no further significant oil fields will be discovered. Estimates of oil reserve sometimes include reserves 'still to be discovered'. Table 1 shows that estimated oil reserves range between 1 000 and 2 300 billion barrels of oil. Laherrere (2000,14) argues that the USG2000 overestimates the extent of reserve growth and

undiscovered oil in that it greatly exceeds the rate of recent discovery that has been possible using the most advanced prospecting technology.

TABLE 1: ESTIMATED OIL RESERVES (Billion barrels) (After Kovarik, 2009)

	DOE / OGJ (1)	DOE/ GULF(2)	USGS (3)	USGS (4)
	Proven reserves (oil industry)		Identified reserves	Recoverable reserves
Total Mid East	675.6	629.2	597.2	899.2
All Mid East. as % world	*66.4*	*64.1*	*54.1*	*39.6*
North America	55.1	55.6	112.1	397.9
South America	89.5	69.2	77.6	185.5
Europe & Frmr USSR	77.6	82.3	166.2	423.8
All Europe & Frmr USSR as % world	*7.6*	*8.3*	*15*	*18.6*
Africa	74.9	86.5	76.5	170.7
Asia	44	58.7	71.2	170.6
Total world estimate	**1016.8**	**981.4**	**1103.2**	**2272.5**

(1) and (2) US Department of Energy of "proven" reserve estimates

(3) US Geological Survey estimates of identified reserves

(4) US Geological Survey 2000 estimate of identified reserves ultimately recoverable reserves

Kovarik (2009) argues that the equivalent of an additional 700 billion barrels (*equal to the Identified Reserves of conventional crude oil accredited to the Middle East*) should be added to the total to account for 'Unconventional Resources' (i.e. extra heavy oils, tar sands, gas in tight sands, and coal bed methane)*.* Figure 3 shows the economic price for unconventional resources to be less than $80/barrel in 2006. Many other writers also reflect the view that new discoveries and revised estimates of existing discoveries prove that there is no shortage of oil in the future; e.g. "*In truth, the combination of new discoveries and revisions to size estimates of older fields has been keeping pace with production for many years*" (Lynch, 2009,1). However, others (e.g. Deffeyes, 2001; Lynas, 2009) argue that they should not be included because of the difficulty of extracting these reserves and the financial and environmental costs.
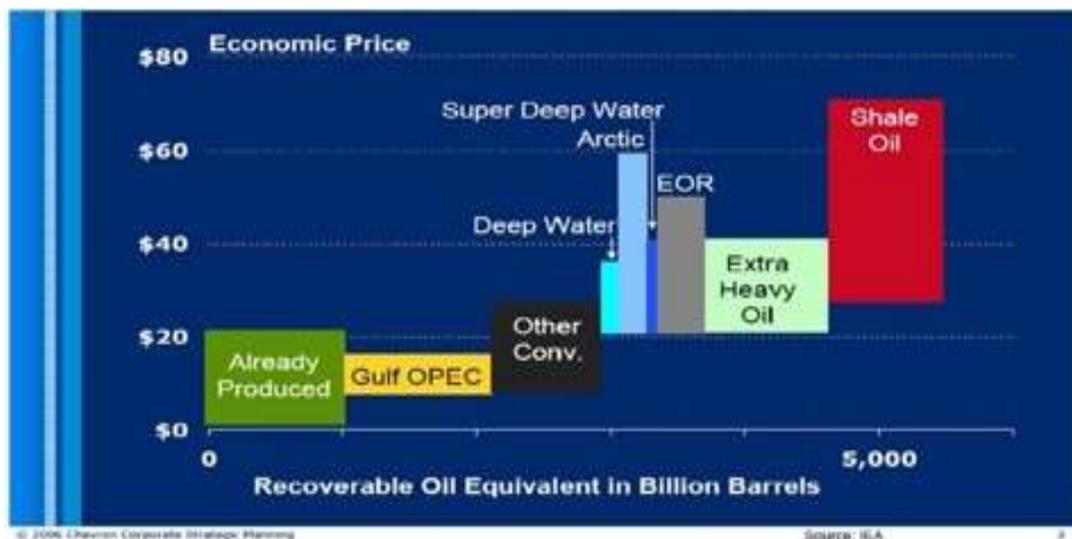

FIGURE3: ECONOMIC PRICE OF ALTERNATIVE OIL RESOURCES (Energy insights 2008)

The end of oil?

The current consumption of oil is approximately 90 million barrels/day (i.e. 30 billion barrels/year). One could deduce that the world will run out of oil in 30 year. This is not the case, because as oil becomes scarcer the price will increase and this can be expected to reduce demand and increase the extent of reserves because oil reserves that were previously unviable to extract from become viable, and because there is a greater incentive to prospect for new oilfields and for technological innovation. Nevertheless, demand is expected to increase. China and India, with their large populations, economic growth rates and current low car ownership levels will significantly increase the demand for oil in the near future. What this implies is that Peak Oil indicates is not the end of oil but the end of "cheap oil" on which the economic system is currently based.

Access to oil

Cheap oil has permitted globalisation and it remains to be seen if globalisation is sustainable in the face of ever increasing energy costs (Bowles, 2005; Masson 2008, 25).

Experience has shown that political activity in oil producing countries has had serious impacts on the supply and price of oil. These might be considered to be short term impacts and that oil markets soon readjust. However, if conflicts continue for a long period then the flow of oil into the market could be severely disrupted. This is a strong aspect supporting the Peak Oil concern since estimates suggest that two-thirds of oil reserves are located in the Middle East (see columns 1, 2, and 3 in Table 1). However, Kovorik (2008) argues that if unconventional resources are added to the USGS2000 estimate (Column 4 of Table 1) the proportion of oil resources in the Middle East would be far less; i.e. between 30% and 35%.

The estimate of oil reserve that is accepted will affect government policy on diplomacy, oil dependency, energy use and transport. A number of studies (e.g. Abosedra & Ghosh 2007, Bacon & Kojima 2008, Bacon & Mattar 2005, Gupta 2008) have been done to determine the vulnerability of countries. It can be expected that oil importing countries and especially developing countries are the most vulnerable.

The Peak Oil debate is actually a political debate. Estimates and revisions of oil reserves might not always have been done on a scientific basis as they have political implications. "Reserves" is not a physical notion, but a political-technico-economical notion. As a result, the definition of "reserves" varies by country (Energy Insights,2009) . Badal (2009) writes that "*Oil is a strategic resource; therefore having oil is a key political and economical advantage for a state. This is why politics interfere in the evaluation of oil reserves, especially in countries with poor accountability records; that is, the majority of OPEC countries. In fact, OPEC oil reserves have dramatically increased during the 1980s and 1990s. However, they have not discovered major oil fields after the 1970s*".

Implications of Peak Oil

Badal (2009) writes that "*I think we are facing an oil price shock, 100 or 200 dollars a barrel, an economic recession that cuts demand, and I will not be at all surprised if a fall in demand would*

make the price collapse again. So we might be back to 20 or 30 dollars a barrel next year perhaps. And so you have a price shock, a recession, a recovery, hits again the falling capacity limit, another price shock. And so I think that in the next few years, we have a sequence of vicious circles and gradually the reality of the situation will filtered through. We are in for a very volatile few years with enormous economic consequences". This concern is echoed by the UK Industry Taskforce on Peak Oil and Energy Security (ITPOES) (2010) which finds that *"oil shortages, insecurity of supply and price volatility will destabilise economic, political and social activity potentially by 2015"*.

It is obvious that the impact of Peak Oil must be an increase in the price of oil as the market responds to a scarce commodity. This will cause the cost of transport to increase. The affluent will probably be able to absorb the increases in fuel cost. The less affluent might be able to switch to car pooling and public transport which is less energy consuming. But they might still be faced with long travel distances as they have often traded off location closer to work for lower cost housing on the outskirts of the city. The poor might not be able to afford to ravel.

Dodson & Sipe (2005), in studies of Brisbane, Melbourne and Sydney, estimated the vulnerability of Collector Districts (±200 households each) as the weighted sum of three variables; namely the average socio-economic index (SEIFA), the percentage of households having 2 or more motor vehicles and the proportion of work trips made using cars. Scores between 0 and 5 were allocated on the basis of percentile value. The SEIFA score was doubled and added to the other two scores to obtain a vulnerability index out of 20. They displayed their findings in colour coded maps which highlight the vulnerability of the less affluent on the outskirts of the city. In summary they conclude that:

"Within each of Brisbane, Sydney and Melbourne, it is invariably those households that are located in socio-economically disadvantaged outer-suburban locations that will be most vulnerable to current high and potential future rising petrol prices…..because

a)   *socio-economic vulnerability already places these households at greater risk of adverse impacts from any economic change, such as industrial restructuring, rising interest rates, increasing unemployment or workplace deregulation.*

b)   *……., the specifically greater dependence on automobiles for urban travel is the critical factor that places these households at much greater risk from rising fuel prices. …….. This impact may be compounded by the relative lack of provision in such areas for alternative modes, such as public transport, walking and cycling, and by the wide dispersion of employment and services that necessitates long journeys for work and other activities*
        (Dodson & Snipe, 2005, 23).

In less affluent countries, the problem would be exacerbated because incomes are lower and the national budget less able to increase transport subsidies. The paper returns later to consider the case of Cape Town.

Unfortunately, higher commuting costs will not be the only consequence of higher oil prices.

Higher transport costs will increase the costs of all products. The concern arises of the extent to which this will make goods and services less accessible; especially to the poor. For example Roth (2006) writes that he expects that high oil price will lead to the rationing of many items in Australia;

including health care. He envisages that this will bring with it the need to relook at the values that are applied by medical practitioners.

The need for a change in society's values is also the conclusion drawn by Atkinson (2008,81). He sees that it is inevitable that oil prices and energy costs will rise and lead to a chaotic economic collapse unless *effective organisational and institutional structures will come into being to plan a realistic, low-energy future*. He hopes that before this, attention will be focused *on planning a set of measured steps to an energy-parsimonious society"*. He notes that economic and political commentators "*are attempting to defend a reduced version of current 'modern' lifestyles implying continued mass car ownership and use, as well as the complex global system of production and distribution.* He is pessimistic that this will happen because "*northern countries continue to assume it can indulge itself in its car-based suburban and consumerist lifestyle in an unfettered way".* Government will be required to show leadership in planning and regulation. If this does not occur he sees a collapse of urban systems as we know them and an urban rural migration to more manual and basic activities.

Even if chaotic economic collapse does not occur, the increased oil and energy prices will require an operational and physical restructuring of our cities, more specifically of suburbia and the car lifestyle.

Strategies to mitigate the impact of higher oil prices

Contrary to Atkinson's review of the attitude of authorities (in the United States), there are examples where authorities have recognised that the current travel patterns are not economically sustainable in a world of high oil prices. Nor are they sustainable in a world attempting to mitigate global climate change. One example of such an initiative is *Individualised Marketing* to promote private car use. Figure 4 shows how successful the scheme has been on three continents. In the case of Perth, 250 000 people have reduced car travel by 140 million km per annum (Robinson & Mayo,2006,6)
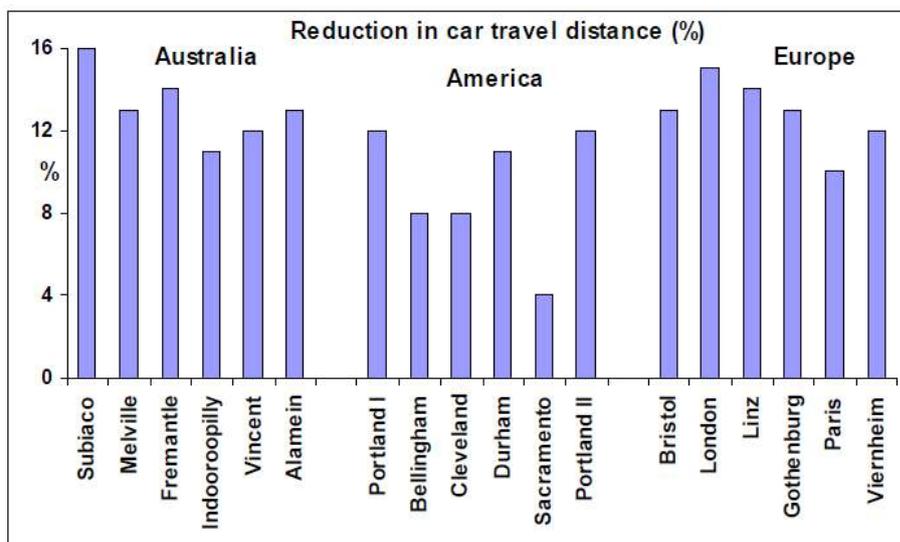

FIGURE 4: CAR TRAVEL SAVINGS FROM INDIVIDUAL TRAVEL DEMAND MANAGEMENT

New Zealand Transport Authority's 2008 study (Donovan et al, 2008) into managing the transport challenges of high oil prices lists 18 strategies grouped in five focus areas:

- *Land Use Management.*
- *Direct and Efficient Pricing*.
- *Infrastructure Investment.*
- *Behaviour Change and Education.*
- *Freight Management.*

Of particular interest to this paper are the strategies to:

- *Restructure urban areas* by encouraging mixed use development and development that is less dependent on oil such as urban renewal and Transit Oriented Development (TOD).
- *Reduce motorised travel* by reducing the number of parking bays in developments and taxing them, redressing taxation policies that favour the use of the car, encouraging the use of public transport and non-motorised modes through the provision of information and infrastructure.

Summary

Oil is a finite resource. As such it can be expected that shortages will occur and that prices will rise. This will have significant implications for the current lifestyle that is made possible by 'cheap oil' and the motor car. *The implications of Peak Oil are such that even if one remains unconvinced about it and when it might occur, the consequences may be so devastating that not to consider how our system might respond to such a crisis would be foolhardy.* (Roth, 2006).

This impact will be greater in developing oil importing countries; where oil vulnerability will make it difficult for the economies to bear the cost of increased energy costs and the low income population has very little space in which to adjust or compensate for increased transport costs and the resultant increases in goods and services.

EXCESS TRAVEL

Definition and Methodology

The first focus of any attempt to reduce motorized travel is to look for travel that is excessive within the existing land use pattern of a city. This

Excess commuting is the difference between actual travel (T_{act}) and the minimum travel (T_{min}) that would be required by individuals to travel to their closest possible work place; based on the measure of separation, be it time distance or a combination of the two.

Excess travel was referred to by Hamilton (1982) as wasteful. To calculate T_{min}, he assumed a mono-centric city with the residential density declining exponentially from the centre. The equation that he proposed for Excess Commuting was:

$$EC = (T_{act} - T_{min})/T_{act} * 100$$

In a study of 41 cities in Japan and the USA, he found that 90% of distance travelled was excess.

White (1988) proposed an alternative approach in which she used linear programming to determine the minimum travel distance for the existing trip generation. She found that excess travel amounted to about 11%.

Many studies followed (see Ma & Bannister, 2006 for a list) in which the two approaches were applied and produced such diverse estimates of EC.

Horner (2002) proposed an additional measure; namely the Maximum Travel possible (T_{max}). He argued that this would be a better basis on which to compare cities and it would also give a measure of the structure of the city.

A fourth approach has been proposed by O'Kelly & Niedzielski (2008) in which they argue that the "demand for movement" is inherent in the spatial structure of a city. Therefore, it is more useful to develop a measure of how much effort is required to reduce the amount of travel. The approach uses a doubly constrained spatial interaction model to estimate the entropy that remains from the distribution of trips produced by and attracted to each traffic zone and the β value; using the trip distribution model:

$T_{ij} = A_iO_iB_jD_j \exp(-\beta c_{ij})$[4]

Entropy is the measure of disorder or randomness which is highest when the trips are weakly structured; i.e. when $\beta=0$. As β changes from 0 the average trip length become shorter (or longer) and entropy decreases. The effort to reduce the average trip length is reflected in the difference between the entropy of the current travel pattern and the pattern that produces the "desired" shorter average trip length. This value can be normalised by dividing it by the value of the maximum entropy for the city.

Issues in Estimating Excess Commuting

The literature raises a number of issues that need to be considered when estimating excess commuting. The following are considered the most relevant to this paper:
- *The high variation in the estimates of Excess Commuting* raises questions about the validity of using this value as a measure of excessive commuting and or efficient city structure. The two approaches give different results because the first method compares existing travel against a theoretical land use (i.e. mono-centric CBD and an exponentially declining residential density), whereas the second compares existing travel against the minimum travel that could satisfy the same trip productions and attractions. Ma and Banister (2006,762) note that if all workplaces

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[4] Where:

A_i	is the balancing factor for origin zones
O_i	is the sum of the trips produced by zone i
B_j	is the balancing factor for the destination zones
D_j	Is eh sum of trips attracted to zone j
b	is the cost coefficient
c_{ij}	is the cost of travelling between zone I and zone j

are located at the centre of a city it would have an EC =0 because there would only be one trip distribution. Whereas a multi-centred city would produce a worse EC but more than likely less travel. As such the approach to estimate EC on the basis of existing trip end values appears to be more appropriate. Ma and Bannister (2006,764) report that industrialised cities have decentralised in recent years and that while average travel time has remained the same average travel distance has increased. This can be taken to indicate that the financial cost of travel is not considered to be a major factor in decisions of workplace relative to home.

- A number of *methodological issues* that affect the assessment of EC are raised in the literature. These include:
  - The number of zones to be included in the assessment. The smaller the number of travel zones, the smaller will be the estimated EC because of the number of trips do not end outside their zone. Horner & Murray (2002) found more than 75 zones are needed to would minimize this error.
  - Distance should be measured along the network; although it is common to measure it in Euclidian space as this is much easier.
  - Models need to be disaggregated to improve model accuracy. The model should be disaggregated by mode because studies have found that the EC is higher for private transport than for public transport. Models should also be disaggregated by job type because jobs are not interchangeable e.g. an academic cannot replace a clerical person. An alternative variable is income. Studies have found that low income commuters do not have the same level of accessibility as high income earners and as such demonstrate lower EC.
- Extensions to the model have included the density of public transport networks (Murphy, 2009) and the impact of multi-worker household (Buliung and Kanaroglou, 2002). In this regard, the choice of residential location to minimise travel of one worker might increase the travel of another.

Discussion

There are many factors that influence choice of work place and home location. Transport cost might not be as important as transport planners believe. Often households trade off between better value for money and distance from the CBD (Dodson and Sipe 2005). Other factors include amenities, life style, image and status and the non-work activities of the household. Often work-rich zones are also expensive and therefore households are forced to locate outside of these zones and commute to them.

EC might be seen as a useful measure to prompt intervention to reduce travel and energy consumption. However, one is cautioned when proposing land use or transportation policies that assume *'that minimising travel costs were the dominant consideration'* in home and work location choice (Giuliano & Small, 1993, 1499). Guiliano and Small (1993, 1498) highlight the following possible reasons for this:
- Commuting time is not considered to be excessive and as such does not influence decisions.
- High turnover of jobs and high cost of relocation delays moving house and entrenches long distance commuting.
- Job variety may prevent finding jobs for all the workers of a household close to home.

- Non-work activities and related travel are also factors in deciding where to live.
- Many factors might overshadow the intention to minimise travel distance.
- Racial discrimination might result in preferred home or work locations not being realised.

From the preceding discussion it can be concluded that the estimation of Excess Commuting is complex. It needs to be adjusted to suit the purpose for which it is being undertaken. The approach of using the existing land use pattern and trip generation is more appropriate than using an idealized structure to estimate excess commuting. When developing a new spatial pattern, which might be possible in developing countries where population growth rates are high, alternative land use-transport patterns can be compared. All models need to be disaggregated to improve the quality of the assessment. The use of the entropy approach has the advantage that it reflects the difficulty in achieving a desired reduction in average travel distance.

CAPE TOWN: AS CASE STUDY

In this section Cape Town is used as a case study. Demographic and trip making characteristics are described. This is followed by a discussion of the public transport trips and the effect increased oil price on affordability of public transport for the poor. Finally, the section describes the potential to reduce average trip lengths in Cape Town.

Demographics, growth and energy consumption

Cape Town had a population of 3,2 million and 845 000 households in 2007, with an unemployment rate of 25% (CoCT, 007,30). The annual population growth rate has exceeded 3% in recent years and is expected to continue to do so into the future (CoCT, 007,40). The growth rate was higher among the lower income population (CoCT, 007,30).

The city consumes 136 Million Gjoules of energy annually (CoCT, 007,23) of which electricity accounts for 28%, petrol 26%, diesel 17%, jet fuel 15% and coal 6% (CoCT,2007,25). It produces 20 million tonnes of CO_2 emissions; i.e. 6,4 tonnes/person (CoCT,2007,25).

Travel characteristics

The modal split for Cape Town morning peak period for private, public and non-motorised trips is 46%, 42% and 12 % respectively (CoCT,2007,40). The percentage using private transport range from 21 % among the lowest income group to 82 % among the highest income group (Tabane,2005).

Table 2 shows the trip length distribution for public transport trips. It equates to an average trip length of 27 km and 16 km for the low and high income earners respectively.

TABLE 2: PUBLIC TRANSPORT TRIP LENGTHS CAPE TOWN (NHTS, 2003)

Monthly Income	Trip length (km)									Total
	0-5	5-10	10-15	15-20	20-30	30-40	40-50	50-75	>75	
Low	2049	3119	27645	9190	49008	49047	8703	3927	0	152688
Med-Low	9284	5417	22069	19132	25944	6951	6755	264	0	95816
Med-High	18614	27670	79425	49529	60306	49169	16536	6104	0	307353
High	16845	13266	39176	22058	15125	8068	3645	641	0	118824
Total	46792	49472	168315	99909	150383	113235	35639	10936	0	674681

The equivalent income boundary values for 2009 are low<R1371>med-low <R2742> med high <R6169> high (i.e. Low<$183>med-low <$366> med high <$823> high.

The fare required to cover the cost of public transport is shown in Table 3. The table also shows which travel distances are affordable assuming that a commuter makes 44 trips per month and spends less than 20% of income on transport.

TABLE 3: APPLICABLE FARES AND AFFORDABILITY (Rands)

Distance (km)	Trip length (km)									Fare max (R/trip)
	0-5	5-10	10-15	15-20	20-30	30-40	40-50	50-75	>75	
Minibus	5.36	7.38	9.91	11.42	16.48	21.53	26.58	36.18	48.82	
Low	yes	no	no	no	no	no	no	no	no	6.23
Med-low	yes	yes	yes	yes	no	no	no	no	no	12.46
Med-high	yes	yes	yes	yes	yes	yes	yes	no	no	28.04
High	yes	yes	yes	yes	yes	yes	yes	yes	yes	100
Bus	6.26	8.03	10.24	11.57	16.00	20.42	24.85	33.25	44.31	
Low	no	no	no	no	no	no	no	no	no	6.23
Med-low	yes	yes	yes	yes	no	no	no	no	no	12.46
Med-high	yes	yes	yes	yes	yes	yes	yes	no	no	28.04
High	yes	yes	yes	yes	yes	yes	yes	yes	yes	100

Vulnerability to increased oil prices

Increased crude oil prices will affect the cost of public transport. The degree to which this will affect fares depends on the effect that the increase has on costs other than the fuel price and the ability of government to increase subsidies. Two scenarios assume that the increase in crude oil price only affects the price of petrol and diesel; and that the government either applies the current amount of subsidy or the current percentage of subsidy. Another two scenarios assume that the increased cost of crude oil affects all aspects of the economy, increasing the cost of all the components of transport proportionately; and that the government either applies the current amount of subsidy or the current percentage of subsidy.

The third scenario is probable when a government's resources are limited. The impact of this scenario is demonstrated in Table 4 for a 50 % increase in crude oil price; i.e. the equivalent of increasing crude oil from $80 to $120 a barrel. (This price was exceeded in July and August 2008. A price of $200 a barrel is not considered improbable in the medium term.)

TABLE 4: AFFORDABILITY OF PUBLIC TRANSPORT WITH 50% INCREASE IN CRUDE OIL PRICES

Distance (km)	Trip length (km)									Fare max (R/trip)
	0-5	5-10	10-15	15-20	20-30	30-40	40-50	50-75	>75	
Minibus	8.04	11.07	14.86	17.14	24.71	32.29	39.87	54.27	73.22	
Low	no	no	no	no	no	no	no	no	no	6.23
Med-low	yes	yes	no	no	no	no	no	no	no	12.46
Med-high	yes	yes	yes	yes	yes	no	no	no	no	28.04
High	yes	yes	yes	yes	yes	yes	yes	yes	yes	100
Bus	10.72	13.75	17.54	19.81	27.39	34.96	42.54	56.93	75.87	
Low	no	no	no	no	no	no	no	no	no	6.23
Med-low	yes	no	no	no	no	no	no	no	no	12.46
Med-high	yes	yes	yes	yes	yes	no	no	no	no	28.04
High	yes	yes	yes	yes	yes	yes	yes	yes	yes	100

Comparing Table 4 with Table 3 shows the change in the distance that is affordable to commuters resulting from the increase in crude oil price. The effect on the poor is immediately apparent.

The relative greater vulnerability of the poor

The poor do not have the possibility of reducing their transport costs by changing from private transport to public transport. Their ability to change work location is also limited. This was shown to be the case by Tabane (2005) developed trip distributions for the existing trip generation and modal split conditions in Cape Town for each of four income categories for both private and public transport. Having calibrated the trip distribution for each, he increased the β of the trip distribution models to reduce distance travelled. He found that the amount of travel could be reduced by between 6% and 14% for commuters in the low and high income groups respectively; with similar improvements being achievable to users of both private and public transport (Tabane,2005,33).

DISCUSSION

Public transport is promoted as the strategy to reduce the effect of Peak Oil. This is a practical option for commuters currently using private transport. However, for the poor, who might not be able to afford the increased public transport fares, the authorities will need to find ways to shorten distances between home and work and other urban activities.

It is possible to design a more "optimal" spatial system of home and work locations. It might also be possible to implement this plan if sufficient change occurs over a reasonable period of time. This will be the case for many cities in developing countries where population growth rates are high. For example, the population of Cape Town is expected to double over 25 years at a 3% growth per annum. This means that as much housing and jobs as currently exists in Cape Town will need to be created over this period. The opportunity exists that this growth can be directed to locations that result in reduced motorised travel.

One might believed that draconian regulation is required to coerce property developers to locate development in the interests of reducing motorised travel. Transit Oriented Development (TOD) is

evidence that developers are already willingly to develop in ways that contribute to less private transport travel. Less rigid regulation could be applied if authorities understood the factors that prompt and incentives that could be used instead of regulation. In a stated preference study of office location by property developers in Pretoria and Johannesburg, van de Weteren and Del Mistro (2003) found that factors within the ambit of the authority, such as providing the land, renting space for municipal purposes and fast tracking planning permission were significant factors that could be used to influence the location choices made by developers.

However, even if housing and workplaces are located in such a way that they facilitate shorter commutes, there is no guarantee that commuters will reduce their motorised travel. One way to encourage this behaviour is to increase the friction of distance by effectively increasing the "cost" (or the β) in the trip distribution model. The two main components of this friction are travel time and travel cost. In terms of commuting patterns, the consequences of such an intervention will be that the number of work places from which employees can source work will be reduced and the size of the catchment from which employers can source workers will also be reduced.

For an authority to prepare its city to reduce the impact of Peak Oil, it will need to provide implement interventions that would not be needed if the authority did not have his concern. The choice to promote public transport to reduce private vehicle use carries a cost, which can be considered a short term cost to avoid / mitigate long term consequences. Similarly, if the authority was to intervene by regulating or incentivising the location of future housing and workplaces or by increasing the friction of distance, it would also need to incur costs.

To convince the authorities that these interventions will be effective and viable, planners will not only need to convince them that they are necessary and that they will be beneficial, but also that the negative short term impacts will not be excessive. Authorities are already intervening for the public good. They will therefore also be willing to invest in other interventions; provided they understand the benefits and the short and long term costs of the interventions. Research is necessary to determine the implications and costs of any intervention.

The benefits, in terms of savings in fuel and energy consumption and reduction in air pollution can be modelled. This paper serves to motivate the need for research into the implications and costs of increasing the friction of distance. This is not considered to be an easy task. How does one ask a worker what the impact would be of not being able to travel to his or her place of work and finding employment within a specified distance from home? How does one ask an employer what the impact would be only employing workers that live within a specified distance from the workplace? The cost to the worker could be determined by asking him or her at what cost of commuting would he or she consider changing jobs; or even moving home. The cost to the employer could be determined by asking how much the employer would be prepared to supplement the cost of travel of a new recruit so that it did not exceed the legislated percentage of worker salary. Considerable work remains to be done to formulate the research method, survey technique and questionnaire to be used in the study

CONCLUSIONS

The purpose of this paper was to serve as a foundation for research into the implications of reducing commuting distance in cities and to solicit comment on survey approaches that could be used to estimate the cost to worker and employer of reduced commuting distance .

It has presented the case that despite opposing views on Peak Oil, oil price can be expected to increase significantly in the near future because oil is a limited resource, oil prices have been very volatile in recent years, there have been relatively few discoveries of major oil reserves, and the very high growth rates of the Chinese and Indian economies. The impacts of this price increase will be significant in all countries, but more so in oil importing developing countries and even worse for the less affluent in those countries. One consequence will be that commuters will not be able to afford to travel the distances that they currently travel. Authorities should be preparing for this eventuality by developing and implementing interventions that reduce the distance travelled before commuters are forced to do so by Peak Oil.

One such intervention is to restructure the distribution of homes and workplaces in the city so that opportunities are created for shorter travel distances. This is possible in cities of the south because of the expected medium term population growth rates. Interventions that increase the "cost" of travel will also be necessary so that commuters actually make shorter trips. Coercing commuters to make shorter trips will incur a cost. Research is necessary to estimate this cost among employers and workers.

At this stage the methodology to be used to determine these costs has not been finalised and comments and suggestions would be greatly appreciated.

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