Assessing Travel Efficiency at a Strategic Level

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ABSTRACT

Assessing travel efficiency at a micro level is usually undertaken using the outputs of widely accepted micro or meso transportation models that provide predicted changes in travel indicators such as journey times and delay at intersections. At a more broad scale though, measuring travel efficiency becomes more difficult to quantify.

Typical indicators such as road safety, the opportunity to use travel modes other than the private car including public transport accessibility can be useful measures of travel efficiency although often these indicators are only assessed qualitatively. In contrast it is the opinion of the author that quantitative measures are often weighted more highly by decision makers because of the inferred level of precision and absoluteness of the resulting conclusions. Consequently it is the small scale local effects that determine decisions rather than larger 'bigger picture' issues.

One of the more common quantitative measures for measuring travel efficiency over a larger area is vehicle kilometres travelled (VKT) although this indicator typically requires more complex models that are not available to all practitioners or local authorities. Also, even if these models do exist they often cannot be used to model proposed developments because of the 'noise' in these strategic models or that the model does not respond well to small isolated changes – these models are of course intended to be used for strategic decision making.

An alternative method to using traditional macro models to determine changes in travel efficiency over large areas is to combine data on existing shopping transactions that includes the origins and shopping destinations of consumers with predicted trade draw analysis provided by retail experts. Together it is possible to determine the predicted changes in travel efficiency and VKT associated with the expansion or introduction of retail opportunities to quantify larger scale travel efficiency effects.

This paper sets out a methodology used to assess VKT over a large area and provides an example of how use can be made of existing data to inform transport planners of changes in travel patterns and hence the overall travel efficiency of a proposal. This paper will be of particular interest to those tasked with assessing the wider transport impacts of proposals and assist to identify the other environmental effects a proposal may have, rather than just focusing on the vehicle level of service of the nearby intersection.

INTRODUCTION

The Greater Christchurch Urban Development Strategy (UDS) provides the primary strategic direction for the future growth of the Greater Christchurch area through to 2041. The UDS and Proposed Plan Change No.1 to the Regional Policy Statement (Change 1) identify areas to accommodate Christchurch's greenfield residential and industrial growth areas as well as identifying Key Activity Centres (KACs) that are designed to serve the retail and service needs of local communities. Including the central city, there are some 15 KACs in the UDS. The location of each KAC is shown in **Figure 4** of this paper. Each centre is envisaged to interact with other KACs and operate as a co-ordinated network. KACs are anticipated to bring transport benefits by generating self-sufficiency within communities and hence reduce the need for travel thus contributing to an efficient transport network. This paper explores what is meant by Transport Efficiency and provides an example of how transport efficiency in terms of non freight vehicle movements can be quantified where for a proposed regional shopping centre, located on the suburban fringe of Christchurch.

Travel Efficiency

Travel efficiency is not explicitly defined in New Zealand transport documents. However, from an environmental sustainability perspective there are numerous policy examples that establish the linkage between the efficient use of roads and the efficient use of fossil fuels for transport that links to reductions in vehicle kilometres travelled (VKT). References to achieving travel effectiveness through reducing VKT are set out in several national strategies including:

- New Zealand Transport Strategy 2008 (NZTS), page 31
- New Zealand Energy Efficiency and Conservation Strategy 2007, Chapter 4
- New Zealand Walking and Cycling Strategy 2005, pages 16 and 17

Assisting economic development and ensuring a sustainable land transport system are two of the Governments' five transport objectives as set out in the Land Transport Management Act. Methods to achieve the five transport objectives are set out on the NZTS. Table 1 of the NZTS sets a target to *"reduce the kilometres travelled by single occupancy vehicles, in major urban areas on weekdays, by ten percent per capita by 2015 compared to 2007",page 17.*.

As set out in section 3.1 of the NZTA, *"Currently levels of traffic, congestion and greenhouse gas emissions are increasing and the transport system remains highly dependant on fossil fuels. This indicates that a business as usual approach in the future will not lead to the achievement of the targets and that the balance of interventions will need to change. In particular, there will need to be a greater focus on the management of travel demand*." Three key travel demand objectives that are particularly relevant to this paper relate to (1) reducing the need to travel, (2) reducing travel distances and (3) promoting more efficient travel. The NZTS also recognises the need to break the cycle of dependence upon the car, recognising that *"Over the long term, New Zealand has to reduce its reliance on car-based mobility if access for all is to be improved in an affordable way", page 63.*

Policy directed at achieving an efficient transport system is also articulated at a regional level. For example, the Canterbury Regional Policy Statement (CRPS) seeks to achieve transport efficiency through the following policy extracts:

"resource management issues arise through transport's energy use, its adverse effects on the environment and the infrastructure it requires". Through Policy 3, the RPS seeks to *"promote changes in movement patterns, travel habits and the location of activities which*

achieve a safe, efficient and cost-effective use of the transport infrastructure and reduce the demand for transport". The explanation to this policy states that *"…the demand for transport can be reduced by promoting an urban layout that decreases distances between homes, sources of employment, shops and other frequent destinations, reducing energy demand and emissions."*

Policy 5 of the CRPS relates to Key Activity Centres (KACs) that are envisaged to support the development of principal public transport and cycling and pedestrian networks within these centres and reduce car travel, increase the efficient use of resources, and strengthen existing communities. The theme of reducing VKT is also highlighted in page 86 of the CRPS where seeks to encourage energy efficiency in transport by promoting urban consolidation which can assist in reducing the use of the private motor vehicle and minimising the length of journeys.

Transport Efficiency from an Economic Perspective

The transport network is seen as contributing to economic activity by enabling the distribution of goods and providing people with access to places of work. The accepted role of transport in economic development tends to focus on issues such as improvement in travel time reliability, and a reduction in transportation costs. Such indicators are clearly important in estimating the economic benefits of transport interventions. However these commonly-used indicators tend to measure the quantity of economic activity without taking on board the location and context of the intervention or less quantitative transport factors that can also assist in increasing 'travel efficiency'.

Some literature (Pozdena 2009) presents a case that there is a direct relationship between VKT and productivity, inferring that policies that increase motor vehicle travel such as subsidised roads and parking facilities, inexpensive fuel and vehicle-oriented land use developments support economic development, and demand management strategies that reduce VKT are economically harmful. As an example of this philosophy one need look no further than page 11 of the current GPS (May 2009), that states:

"…moving too quickly to modal shift will have a negative impact on environmental and economic efficiency"

There is evidence to support the position that increased vehicle travel in very poor countries has high productivity, whereas increased travel in more wealthy industrialized countries does not produce the same quantum of benefits. An review of economic impact research (SACRA 1999) concluded that the available evidence does not support the argument that new transport investment, in general, has a major impact on economic growth in a country with already well-developed infrastructure. The research established that the relationship between vehicle travel and economic development is actually very weak.

This is supported by other studies (Talukadar 1997, Kenworthy, et al. 1997) that reported that, *"there are no obvious gains in economic efficiency from developing car dependence in cities"* and, *"There are on the other hand significant losses in external costs due to car dependence".*

In New Zealand, concerns regarding the methods used to estimate the economic benefits of the Roads of National Significance (RoNS) are being voiced with some schemes, estimated on the basis of conventional methods of analysis, showing a benefit to cost ratio (BCR) of less than 1 (Oram 2010).

The conventional planning approach has recently been criticised for its focus on mobility and not accessibility. This is because the transport and economic models that are being used to justify transport schemes including the RoNS, evaluate transport system performance using measures such as vehicle traffic speeds, litres-per-kilometre, cents-per-passenger-kilometre and tonne-kilometres-per-dollar, which reflect the speed and affordability of vehicle travel, and so favour vehicle-oriented transportation improvements that enable increased reach and further encourage sprawled land use development. Such an approach tends to ignore efficiency benefits associated with the use of non-car modes of transport.

Whilst there is a link between economic growth and VKT, **Figure 1,** which is based on data sourced from data from the Ministry of Transport (MoT), shows the relationship between GDP per capita and VKT per capita for each New Zealand region.

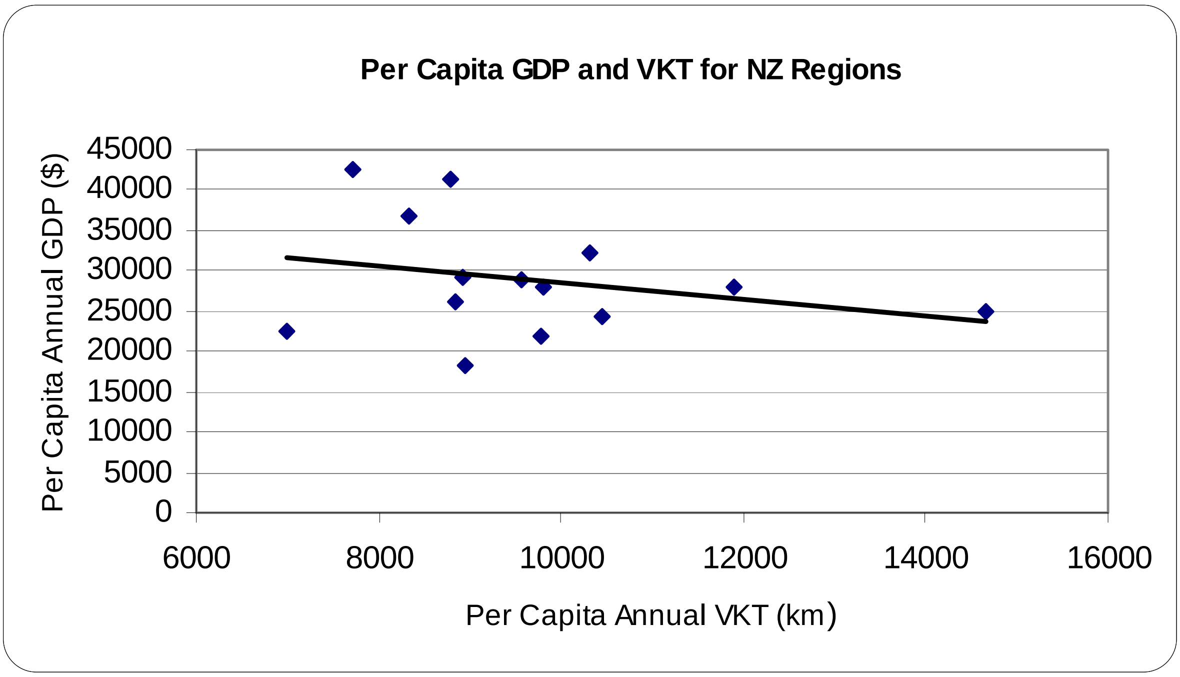

Figure 1: Per Capita GDP and VKT for NZ Regions (2003)

Figure 1 indicates that per capita economic productivity decreases as vehicle travel increases. Such a finding has important policy implications. It indicates that excessive automobile dependence can in certain locations reduce economic productivity. Conversely policy reforms that aim to reduce per capita VKT increase transport system efficiency. Therefore tools such as travel demand management initiatives probably support rather than hinder economic development.

Economic efficiency increases if transport resource costs such as time, land, risk and energy are reduced, or if the value provided by transport activity increases. For example, transport system efficiency can be increased if higher value trips are given priority over lower-value trips, such as if a freight or service vehicle with a $100 per hour opportunity cost is given priority over vehicles with only $10 per hour opportunity cost. This is why efficient road and parking pricing, which tests users willingness to pay for roads and parking, can increase transport system efficiency even if it reduces total vehicle traffic. Therefore directing investment towards assisting to provide a compact city that reduces the need to travel and VKT has economic benefits.

Canterbury's Transport Efficiency Issues

With a population of over 500,000 and 15 KACs that are characterised by the presence of retailing usually in the form of a mall or significant neighbourhood shopping centre, Greater Christchurch is well served with retail opportunities that are dispersed throughout the wider area. There is concern in Canterbury about the amount of urban sprawl that has occurred in recent years (LTNZ Regional Summary, 2007). These sentiments and the concern regarding the prospect of more out-of-centre retail development has been raised by the Mayor of Christchurch in an interview given to The Press in November 2010.

As reported by the Ministry for the Environment, in 2009, New Zealand has the highest VKT per unit of GDP in the OECD. From an environmental perspective Government would like to see the economy i.e. GDP grow at a faster rate than the rate of growth in VKT. This means that every dollar of productivity requires fewer vehicle kilometres of travel and therefore places less pressure on the environment. Within this context and whilst recognising that Canterbury is a major rural economy, **Figure 2** shows that Canterbury's transport efficiency in terms of GDP and VKT gearing.

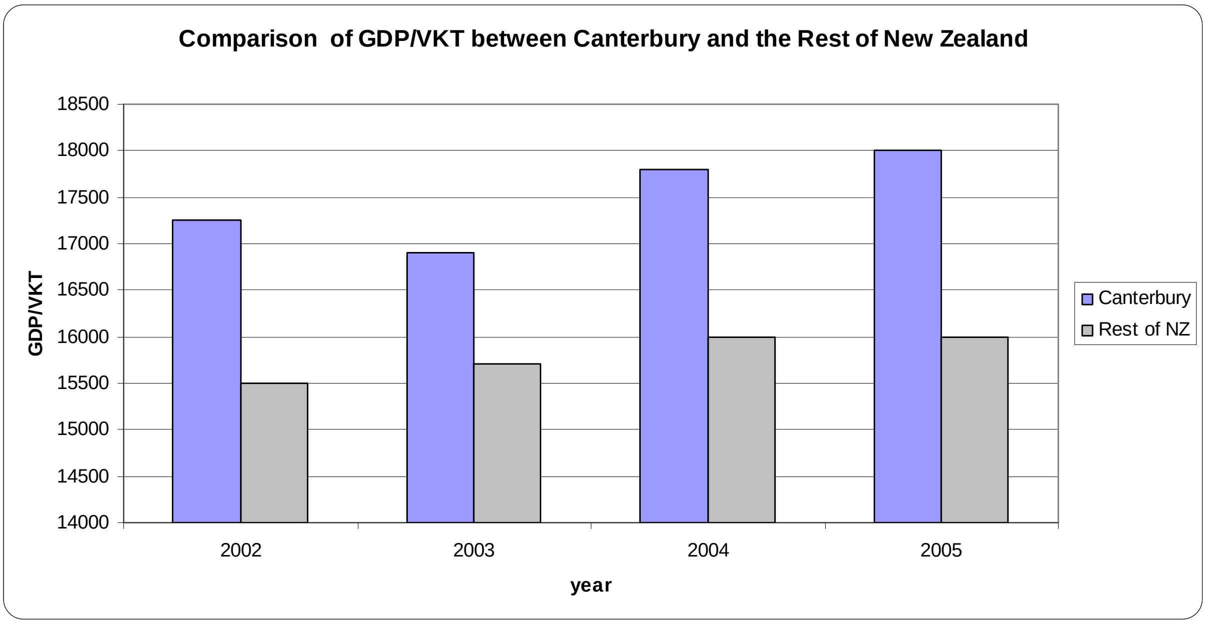

Figure 2: Comparison between Canterbury and Rest of New Zealand GDP/VKT

From Figure 2 is can be seen that the regional GDP to VKT ratio is higher in Canterbury than the New Zealand average indicating that Canterbury's regional economy is marginally more efficient from a transport perspective and that the trend is increasing at a higher rate than it is for the rest of New Zealand expressed as an average. **Figure 3** illustrates the comparison of mean trip distances between Canterbury and the rest of New Zealand.

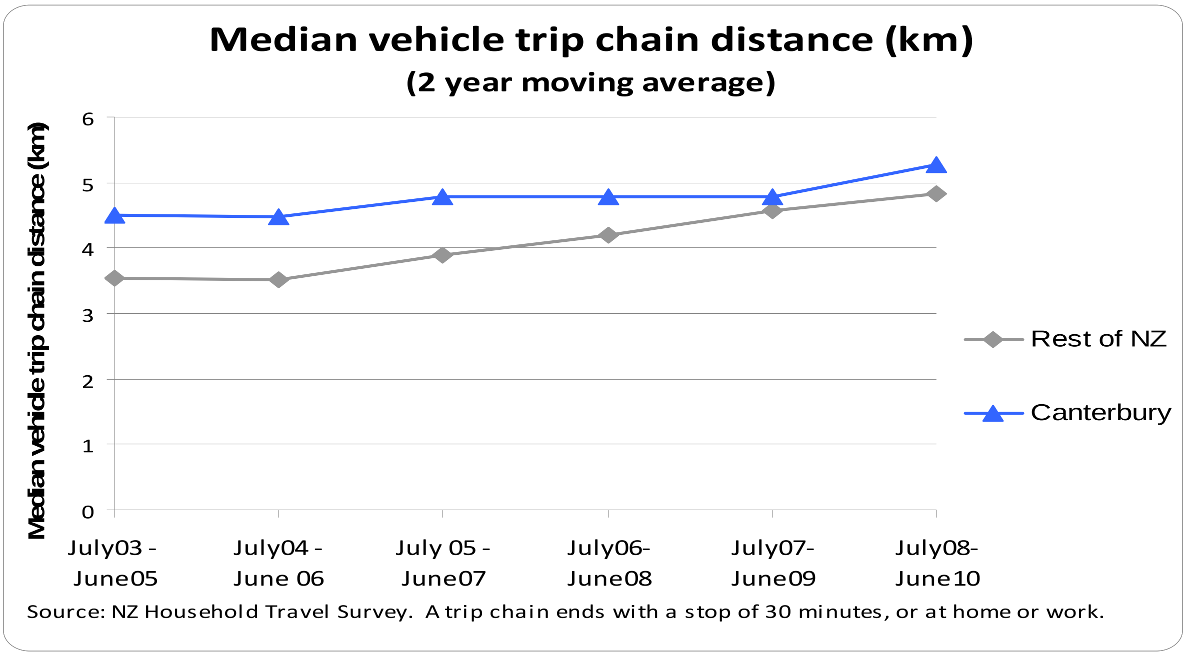

Figure 3: Comparison between Canterbury and Rest of New Zealand Vehicle trip chain

From figure 3 it can be seen that Canterbury trip distances have been consistently higher than the national median vehicle trip chain distances. In relation to Canterbury trends, whilst remaining unchanged between July 2004 and 2007, median vehicle trip lengths have increased since 2007 by around 10% which is a sharper increase than that which is occurring nationally. Whilst this trend could be effected by sharper growth in population in comparison to the rest of New Zealand, this trend could suggest that there is a greater need to improve Travel efficiency within the Canterbury Region than maybe elsewhere.

Measuring Travel Efficiency at a Strategic Level

Figure 4 sets out the locations of the 15 Key Activity Centres (KACs) as identified in the Canterbury Regional Policy Statement Change 1 decisions. KACs are designed to be efficiently located with regard to transport systems, promote proximity to residential housing, and meet their wider community social and economic needs. KACs are to operate as centres of service and business activity characterised by large shopping centres and act as public transport nodes. They are envisaged to operate in harmony with each other. Collectively the network of KACs generates a high demand for travel and as such present an ideal situation in which to test transport efficiency at a strategic level.

Because the KACs operate as a network, the travel patterns associated with an expansion of or addition to the network can have a profound effect on overall travel patterns and hence travel efficiency over a wide area. In seeking to achieve sustainable economic development the need to test the travel efficiency of any changes to the network is required in order to assist in any land use decisions regarding the development of KACs.

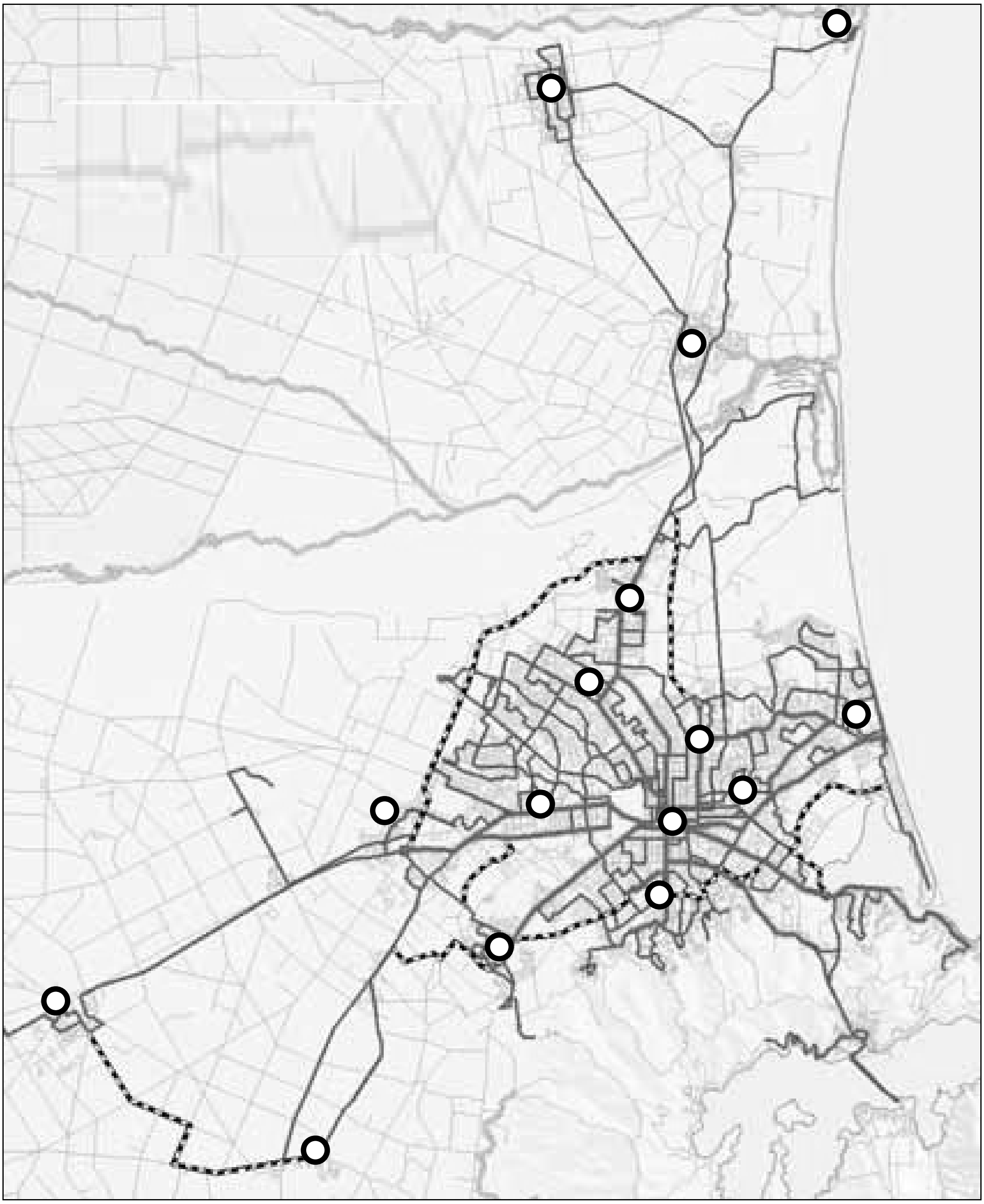

Figure 4: Locations of New and Proposed Key Activity Centres within Canterbury

A decision to expand or generate an additional KAC can in certain circumstances raise retail and traffic distribution effects that do not support sustainable economic growth or travel efficiency. Measurement of changes in travel patterns expressed as changes in VKT have, in the past, not found favour with the Environment Court.

A well known example is that of Auckland City Council v St Lukes Group Limited (Sylvia Park). On the issue of transport efficiency, Judge Sheppard framed his response on the basis that if within a region more shopping centres of equivalent scale and function are developed, then more people would live closer to one or more centres, and would have less distance to travel to the nearest. Judge Sheppard concluded that *"…it would be anomalous to conclude that a new centre within the region would cause additional travel...and it would represent the actions of people providing for their perceptions of their well-being" 2001Environment Court Auckland Decision number132/2001.*

Sylvia Park is now over 70,000 sqm GLA and as such is of a regional scale. The importance now placed on energy use and sustainable economic growth as set out at the national policy level, may suggest that the Sylvia Park decision was of its time and that the assessment of travel efficiency under current transport policy might be considered in a different light.

Table 1 and **Table 2** below are based on research of the travel characteristics of different types of shopping centres in Christchurch.

Table1: Relationship between Shopping Centre type and mean trip distance

Centre Type	n	Mean Size (sqm)	Mean Sales $m	Mean Trip Distance (km)
Regional	1	164,660	$779	11.2
Sub Regional	5	39,300	$192	10.7
Large Suburban	3	16,900	$98	7.7
Destinational Large Format Retail (LFR)	5	10,900	$76	14.2
Suburban	6	7,200	$43	6.0
Local	6	2,000	$13	6.9

Table 2: Relationship between Shopping Centre type and travel distance profiles

Shopping centre type	n	% Sales within 5km	% Sales between >5km and 8 km	% Sales >8km
Sub regional	1	48%	20%	32%
CBD (Regional)	5	52%	18%	30%
Large Suburban's	3	65%	14%	21%
Destinational Large Format Retail (LFR)	5	73%	14%	13%
Suburban Centres	6	83%	14%	3%
Local Centre	6	73%	14%	13%

Both tables reveal that, in general, larger centres generate higher mean trip distances and that the travel efficiency of larger retailing centres is therefore reduced as the size of the centre increases.

A Methodology to Calculate Travel Efficiency

To determine the travel efficiency effects of a theoretical expansion or addition to the KAC network, an analysis can be undertaken at several levels including, change in VKT and a comparison of VKT associated with other established Key Activity Centres and shopping destinations. A description of the methodology with respect to Christchurch is described below.

A first step in assessing any positive or negative changes in VKT associated with change can be done by setting up a travel distance matrix. This can be calculated from all Census Area Units within the Canterbury Region, to the existing network of KACs.

The proportions of spend for each origin at each of the selected KACs can then be calculated using information provided by the retail analysis experts which can then be applied to known Bank of New Zealand Marketview data for transactions in 2009. The Marketview data shows the actual retail destination of spend and the geodemographic data of where card holders reside.

Card transaction data can be useful but recognition of its limitations should be considered such as;

- It does not an provide an absolute measure of retail spend but rather a strong sample of spend patterns.
- The number of transitions per trip cannot be determined.
- The card data will not reveal the origin of the shopping trip, only the household

The strength of the data relates to its large sample size of transactions and the proportion and location of spend.

Clearly not all shopping trips are home-based and interrogation of the MOT Household travel Survey can be used to determine that primary trip proportions throughout the day and during evening peak times.

Of the remaining trips, half of these would be pass-by trips which have no VKT change associated with them as they are already travelling on the network and passing the development site. The remaining half of the non primary trip proportion would be associated with diverted tips. Diverted trips are normally treated as primary trips within Transport Impact Assessments, as they require knowledge of where such trips have diverted from. For simplicity, and without knowledge of where such trips would be diverted from, the assessment can assume that diverted trips would have no resultant increases in travel distance. This is a conservative approach as in reality; increases in travel distance would be expected from diverted trips.

The weighted average distance between origins and destinations can be calculated, based on transaction proportions for each of the customer catchment areas, identified in the BNZ Card transaction data. Applying the distance matrix to the predicted trip matrix can then enable the current VKT being generated by each shopping centre to be calculated.

The number of primary vehicle trips associated with an existing, new or expanded centre can then be derived from **Figure 5** which shows the relationship between pm peak hour trip rates and the size of New Zealand shopping centres. For this assessment these primary trips are treated as existing retailing trips that have simply transferred from existing centres. They are not new to the road network.

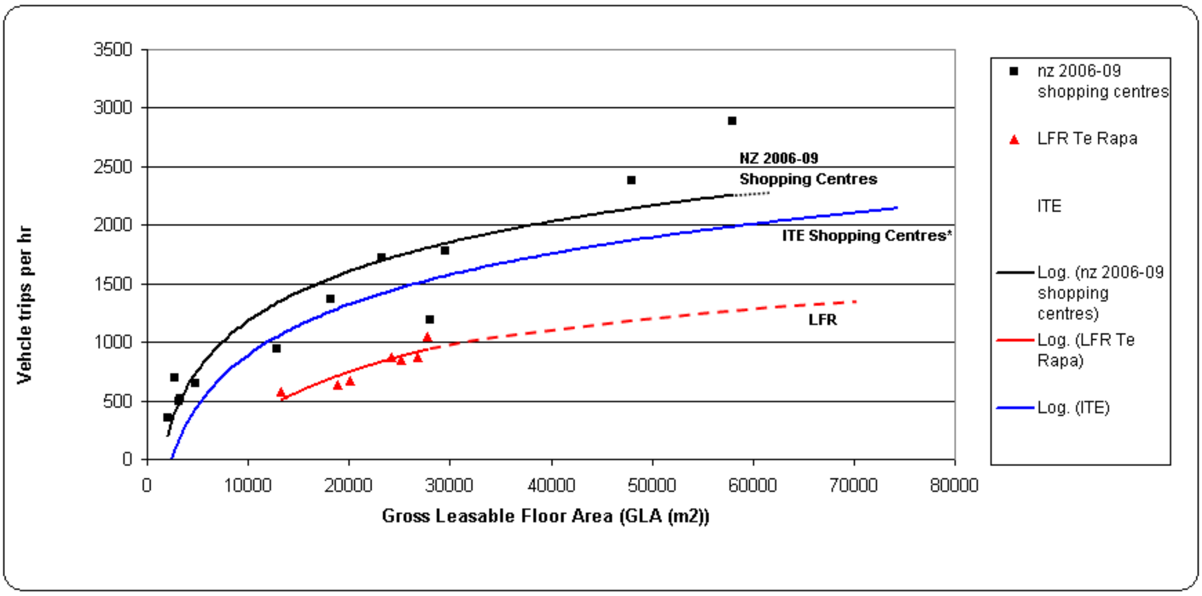

Figure 5: *Evening peak hour Vehicle Trip generation for Shopping Centres*

These primary trips can then be apportioned onto the road network in accordance with the estimated proportion of trade draw and customer catchment areas, as provided by the retail analysis. This results in an overall change to the shopping patterns associated with the existing centres as trips are transferred from these to a new or expanded shopping destination and thus a post development trip matrix can be established.

The post development trip matrix can then be applied to the distance matrix to determine a post development VKT. Comparing the amended VKT table to the original data set enables the overall percentage difference, as well as the overall change in VKT associated with retail trips within the model to be determined. **Figure 6** illustrates a theoretical example of a model output showing change in evening peak hour travel by catchment area.

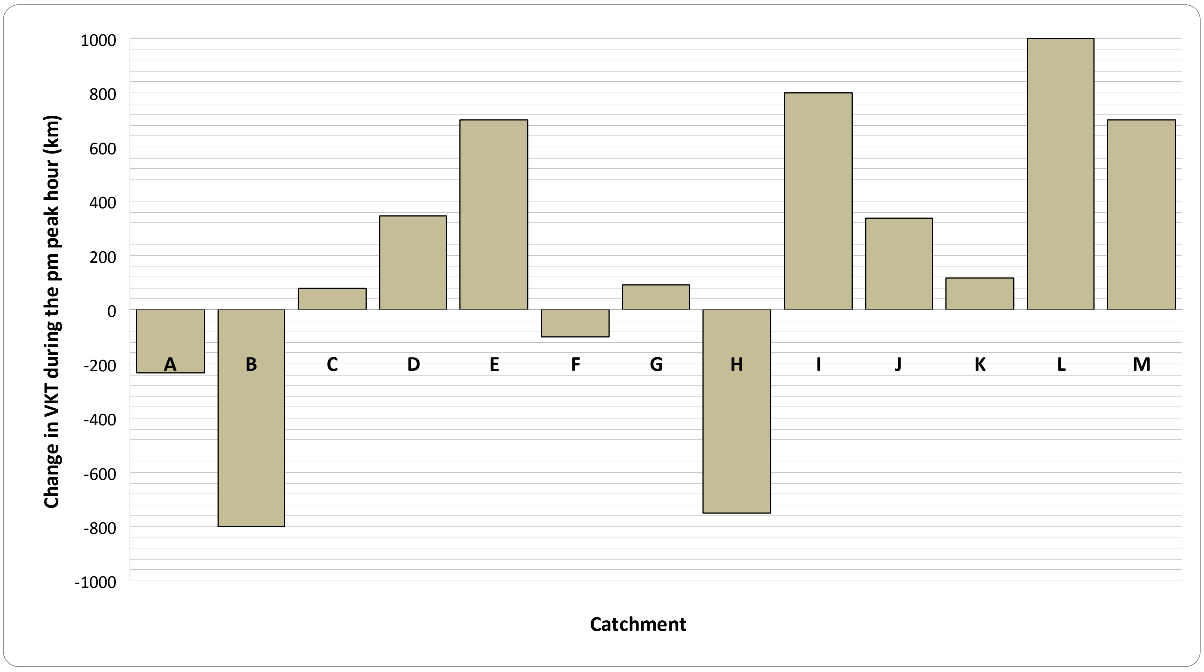

Figure 6: Change in Peak Hour VKT from customer catchment areas

Figure 6 illustrates how the introduction of a new or expanded activity centre would effect changes in travel patterns by way of increases and decreases in VKT throughout the modelled area. The net change in VKT is a key output from this assessment as this output can be used to compare a range of development scenarios that include variations in size and location of the centre to be tested in order to achieve an optimal development scenario that reflects the most travel efficient outcome.

A further interrogation of the Marketview transaction data can enable the proportion of customer catchments relative to each centre to be calculated. The customer/distance relationship associated with some theoretical existing activity centres is shown in **Figure 7**. The retail centres within the figure are arranged in order of size with increasing size shown from left to right.

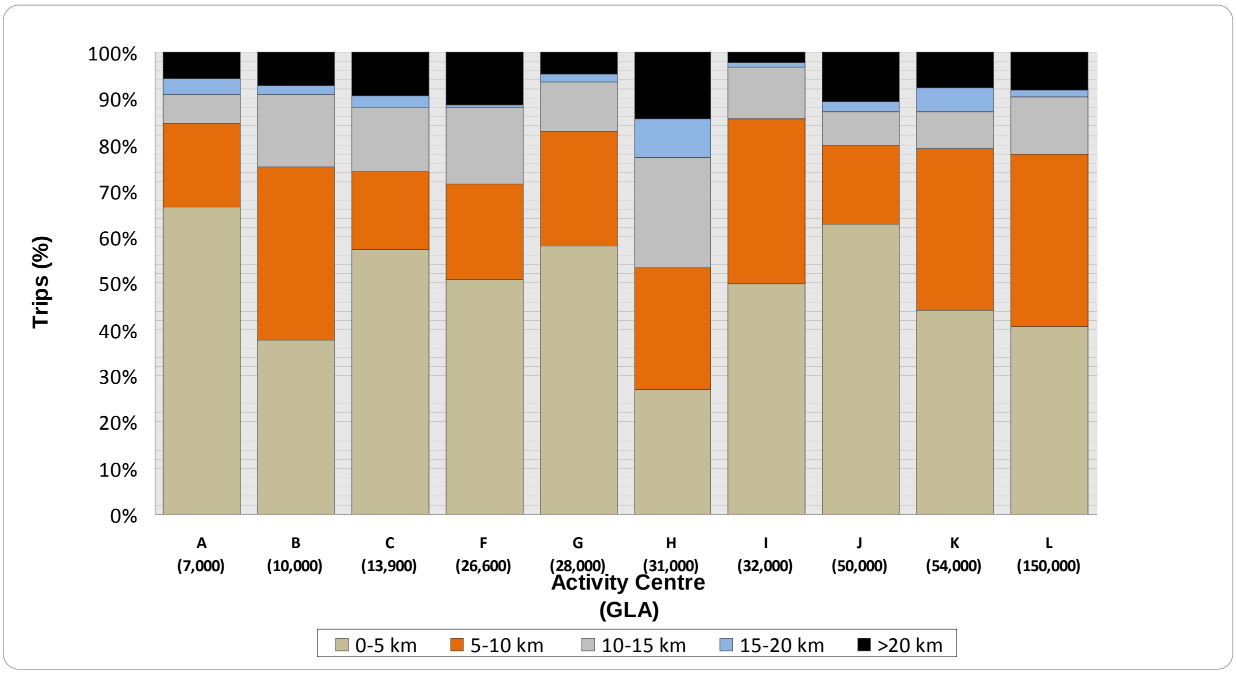

Figure 7: Relationship between Customer home locations and shopping Destinations

The travel patterns of an activity centre are unique to that centre and it is acknowledged that each plays a role in the travel efficiency of the whole network. However assessed on an individual basis, and as highlighted in Figure 7 activity centre A, attracts a high proportion of customers from a short distance and could be considered to be the most travel efficient. This can be an indicator of where further sustainable growth of the centre could occur.

Conversely where the growth of a centre results in a lower proportion of short distance visitors, as highlighted in Figure 7 activity centre H, then this would be an indicator that growth in such circumstances would be far less travel efficient. One reason why an activity centre shows reduced travel efficiency relates to the size and location of the centre in the context of its local catchment. Where the size of a centre exceeds the needs of the local catchment, then the centre is required to draw customers from more distant locations. This effect could be minimised where residential growth occurs within the customer catchments.

For activity centres that already show a low proportion of customers within short travel distances, such sites can be used as an indicator of where new residential development or residential intensification could be considered as a way of enhancing the travel efficiency of the centre and that associated with new residential growth.

Non Car Modes

The relationship between the size of a retail centre and the number of existing or future predicted households within walking distance of each centre can provide an additional indicator of travel efficiency of a particular site. For new proposed activity centres, this measure can assist in determining a centre size that maximises the opportunity for travel associated with the site to be undertaken by walking. **Figure 8** illustrates this approach for a hypothetical scenario where a comparison is being made of a proposed centre and existing centres of comparable scale. Various threshold times can be used based on the specific activity such as 'shopping' and the thresholds derived from measures such as average, eighty-fifth percentile or similar outputs from the Ministry of Transport Household Travel Survey data

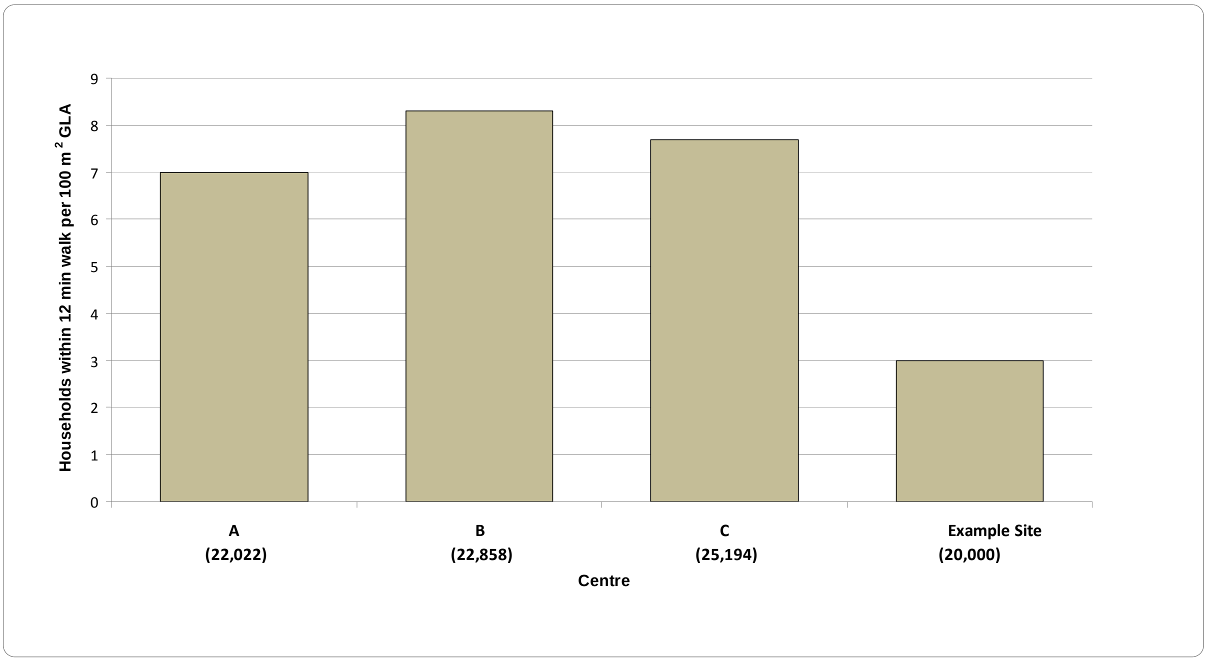

Figure 8: Walking catchment for Existing Shopping Centres and Proposed Shopping Centre

An analysis similar to the walking mode choice analysis can be undertaken for bus travel whereby the numbers of households within 30 minutes bus travel of a centre can be assessed and presented as a ratio of the centre size can provide an additional measure of travel efficiency.

CONCLUSION

Assisting economic development and ensuring a sustainable land transport system are two of the Government's five transport objectives as set out in the Land Transport Management Act. This paper has shown that to improve in transport efficiency, reducing vehicle kilometres travelled is a central theme in achieving the LTMA outcomes. There are several national and regional policies and strategy documents that seek to promote movement patterns that result in reducing the need to travel and therefore a reduction of VKT.

Conventional planning approaches has tended to overlook the efficiency benefits to be derived from use of non car modes and has focused economic benefits of transport schemes on indicators such as travel time reductions. Some commentators assert that economic growth and its' accompanying growth in travel demand are so strongly linked that policies to reduce VKT would be harmful to economic growth. Extensive research and examination of GDP/VKT relationship does not support this notion.

New Zealand and Canterbury, more so, are heavily reliant upon the use of the car and there is a sense of urgency around the need particularly in Canterbury, for the region's economy to grow at a faster rate than the growth rate of VKT. Within this context there is a need to undertake a process that assesses travel efficiency of travel intensive development proposals at a strategic level.

This paper highlights a method to measure the transport efficiency of a network of key activity centres. Real world economic transactions by cards can be used to determine the most travel efficient size and location of such developments to minimise VKT impacts and hence contribute to transport efficiency and economic growth. It has been shown that the use of card data can also assist in exploring the optimal size of a development proposal in terms of maximising the potential walk and public transport provisions against nearby residential catchments.

The strength of VKT modelling in this instance is its ability to ensure proper integrated transport and land use planning. This influences travel behaviour change primarily by promoting transport choice and therefore resilient communities.

No longer do practitioners need to be lead by simplistic congestion indicators and rather indicators regarding land use and transport integration are now able to be used in real world situations.

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