Parking organisation and sustainability

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Abstract

This paper starts by making case for relationship between sustainability, motorisation and private vehicle parking organisation. It will illustrate this relationship using Causal Loop Diagramming method. The second part will analyse the effect of minimum parking space requirement policy that often use to address rise demand for parking space result from rise in car ownership. The analysis will observe the impact such policy have toward parking space provided in the urban environment, drawing example from Bangkok and Hong Kong. The paper concludes by setting out the concept of Equi-distance Parking proposed by Knoflacher and demonstrates the essentialness of implementing a transport mitigation measure that influences behaviour change by addressing at the most fundamental level: the internal human body energy spending whilst travelling.

Keywords: Parking organisation, Minimum parking requirement policy, sustainability, Equi-distance parking, Asian cities

1. Introduction

One of the observable facts about Bangkok is its street vendors. Many of the streets in this city has street vendors selling an array of items such as clothes, curios, electronic items and a wide variety of cooked and raw food. The municipal authorities in Bangkok have demarcated sites where street vendors can operate. In fact, these areas do not cover all sections of the city and hence the customers are not catered to. This has led to street vendors operating in unauthorized areas[1].

Street vending is an important source of income for the urban poor. The number of street vendors in the city increased rapidly after the monetary crisis of 1998 that affected most of the Southeast Asian countries. Many of the workers who lost their jobs as a result of the crisis and others who could not find jobs, took street vending as a source of livelihood.

There is no evidence that street vendors cause vehicle traffic problems; they operate from pavements and not on the roads. In reality, the road space is not sufficient to accommodate the growing number of private vehicles and that is what causes traffic problems.

Although vendors activities do not cause vehicle traffic problem, their activities may influence pedestrian movements. Vendors occupy some spaces in one side or both sides of sidewalk that is provided for walking movement.

In some locations, street vendors may be interesting for the pedestrian who enjoy their walking activities, such as in commercial or shopping areas. But, vendor's activities are also disturbance for pedestrian commuters, because they obstruct pedestrian movement in the sidewalk.

This study tries to investigate the impact of vendors activities in the sidewalk based on pedestrian perceptions. The aim of this study is to increase knowledge regarding pedestrians' behavior relating to vendors activities in commercial areas. The differences among age group of young, middle age, and old pedestrians are studied. The differences between male and female, and the familiarity of pedestrian to the sidewalk are also observed.

2. Parking organisation and sustainability

Transport sector consumes large proportion of world energy. International Energy Outlook reports that transport sector consumes up

to 20% of the world energy (IEO, 2010) and in Thailand around 37% of the nation final energy is used in transport sector (DEDE, 2008). Nearly 100% of this energy is from a non-renewable source.

Transport sector is also a well-known major air pollution contributor. A study in 1998 shows that the contribution of vehicular emissions of PM10, HC, and CO in Delhi is 29%, 73% and 42% respectively (Xie, Shah, and Brandon 1998). These figures emphasise that Sustainability of transportation system must be addressed to achieve sustainability of urban

The rapid rise of motorisation rates observed in many Asian cities contributes toward an increase in the demand for the energy in transport sector (Doi, 2005). In additional, the increase in motorisation also given birth to various types of other problems such as air and noise pollution, traffic congestion, urban sprawling, and many more. Many Asian mega and small cities are currently facing such problems even though the intensity may vary.

The rapid increase in motorisation in urban area also means a rapid raise in parking spaces. Unlike street space, the increase of parking spaces is directly proportion to the increase of private vehicles with no time lag. Over the past 10 years the average increase rate in private vehicle ownership of Bangkok is approximately 6% per year. This can be equated to the lost of urban space to provide parking space of around 6 km^2 per year (equates to 750 full size soccer pitch). Figure 1 below shows the Bangkok motorisation trends.

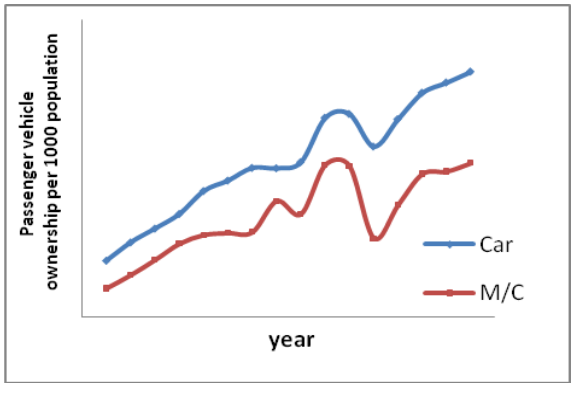

Fig. 1 Bangkok motorisation trends
Source: own calculation based on data from Traffic Statistic for Bangkok 2008

In their paper, Pfaffenbichler and Emberger show the space consumption for different types of transport modes. It can be seen from Figure 2 below, that a car user needs 60 times more space than a pedestrian, some 8 times more than a cyclist, approximately 50% more space than a motor scooter, and 3.5 to 5 times more space than a user of public transport. The figure in bracket show the percentage of occupancy or the number of person assumes to occupant the vehicles. The amount of area consume by each mode of transport has taken in account parking space and space occupies as vehicle move.

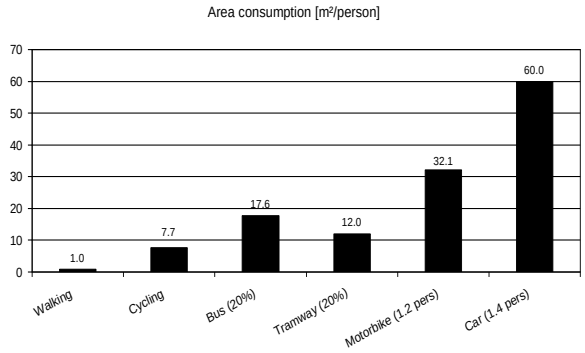

Figure 2: Area consumption per means of transport.[1]
Source: Pfaffenbichler, P. (2001). with additional calculation by G. Emberger

Figure 2 illustrates amount of space in urban environment that could be free up if modal shift away from private vehicle can be achieved and loss of space if the shift goes toward private vehicle.

It is perhaps true that in a high density city such as Bangkok the provision of parking space is often provided off-street within the residential, commercial, or work place as space is scarce and expensive. However, an increase in demand for parking space will produce the same effect whether it is provided on-street or off-street.

If parking space is provided on-street, it increases demand for kerbside parking. The kerbside parking in city is a limited supply, depends on length of kerb available and parking regulation, any surplus demand will have to be provided by off-street parking.

When the parking space is provided off-street, the cost of the providing parking space will be absorbed into the cost of accommodation unit or rent of office space. A study in 1996 in San Francisco, found that single family houses and condominiums were more than 10% more costly if they included off-street parking than if they did not

(Jia and Wachs, 1996). Litman estimates that housing cost is increased by 12.5% for the first parking provided and 25% for the provision of two parking spaces (Litman, 1995). The increase in land price will result in urban sprawling as people seek cheaper land around the peripheral of the city. This also increases the need for private vehicle and consequentially, level of motorization.

The relationship between the provision of parking space and the increase in motorisation rate are shows in Figure 3.

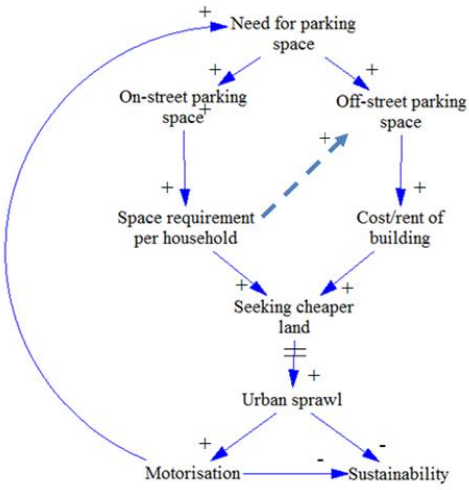

Figure 3: Causal Loop Diagramming (CLD[1]) shows Overall system relationships between provision of parking space, motorisation and sustainability of a city

[1] *CLD syntax*The syntax of the CLD-method is very simple - there exist just arrows and the signs "+" and "-". But it is crucial to understand the meaning of "+" and "-". The following table explains the used symbols:

→	The arrow is used to show causation. The item at the tail of the arrow causes a change in the item at the head of the arrow
+→	The "+" sign near the arrowhead indicates that the item at the tail of the arrow and the item at the head of the arrow change in the **same** direction. If the tail increases, the head increases; if the tail decreases, the head decreases.
-→	The "-" sign near the arrowhead indicates that the item at the tail of the arrow and the item at the head of the arrow change in the **opposite** direction. If the tail increases, the head decreases; if the tail decreases, the head increases.
//→	In causal loop diagrams, each arrow also represents time passing, or delays. Sometimes the delay is a matter of seconds; in other situations, delays could be centuries. Perceiving the length of delays is sometimes quite important in understanding the behavior of a system. The symbol in causal loop diagramming for displaying delays is "//". Its purpose is to highlight time lags, which are significantly longer than usual delays within the system.

3. Minimum parking space requirement and surplus parking space

In order to ensure that parking in the urban environment is sufficient, the government enforces a minimum off-street parking space requirement for each new building. This policy is a tool that traditionally uses to address the rise in demand for parking space resulted from the rise in vehicle ownership. In Bangkok this regulation is part of the Ministerial Order No. 7 issued in 1974, Table 1 below shows an extract from the Order. This requirement is given as space per unit office area and per household. There are 2 different requirements for area within and outside of Bangkok Metropolitan area.

Type of building	more than	Number of parking space require	
		within Bangkok area (1)	outside Bangkok area (2)
Apartment and small condominium	60 sq m	1 : 1 household	1 : 2 household
Large Condominium	all cases	1 : 120 sq m	1 : 240 sq m
Office	300 sq m	1: 60 sq m	1 : 120 sq m
Shopping mall	300 sq m	1 : 20 sq m	1 : 40 sq m

Note: 1. with in Bangkok metropolitan area define by notice number 25, 21 December 1971
2. within municipal area or the area that enforce by Royal decree to use Building Construction Control Act 1932

Table 1 Extract from the parking spaces requirement for development in Bangkok from the Ministerial order No. 7 (1974)
Source: Own translation

The rate of minimum parking space requirement is an estimated value which is based on type of activity, type of building and the location of buildings in the past using the peak period demand. This assumption create surplus parking spaces for all periods but the peak period because the number of parking spaces provided is derived from an inconsistent and non-area specific sources and is based on the peak period demand (Shoup,1997). The rate above was issued in 1974, and the boundary of the Bangkok Metropolitan that this regulation applies was defined in 1971, it is likely that this requirement is outdated as it has not taken into account the change in land use and the level of public transport service of Bangkok over the last 40 years. In additional the rate is generalised as it only divided into 2 categories:

area within and outside of Bangkok Metropolitan but the area of Bangkok Metropolitan is over 7,500m^2 with much diversity in land use

Off-street parking is created as part of the requirement for building both commercial and residential to provide minimum parking space that would be sufficient for the activity in that building. The costs of providing parking spaces normally absorbs into the price of flats or renting spaces. The parking spaces are then made available at very low cost or no cost. Barter's figure in his presentation "Bangkok Parking Policy Choices in International Perspective" which shows that only 10% of employees in Bangkok who drive to work pay for their parking space. This illustrates that the use of private parking spaces at work place is heavily subsidized in Bangkok. The cost of subsidising increases the purchase and rent price of accommodations and office spaces in the CBD area. The higher cost of development in the CBD will force the commercial and residential developments away from the CBD to seek for areas with cheaper land prices and hence influences the growth of motorisation and urban sprawl.

The parking space in Hong Kong is regulated under a minimum parking requirement system similar to Bangkok, although the requirement is much stricter, perhaps due to the more restrictive physical constraint. The 2nd Parking Demand study report (2002) reported that the city have an overall surplus of 82,000 parking spaces. It is difficult to conclude whether the surplus parking space is due to the oversupply of parking spaces resulting from the minimum parking space requirement policy or because the ownership of car in the city is far less attractive. Nevertheless it is interesting to observe that in a high density city with limited space like Hong Kong, large amounts of surplus parking space which equates to 100 full size soccer pitches is available (over 800,000 m^2).

Unfortunately, a similar level of information on parking spaces is not available for Bangkok. It is however, possible to observe the effect that the minimum parking requirement policy has toward the provision of the off-street parking space in office building. Table 3 below summarises the information of 21 buildings locate in the CBD area of Bangkok. The primary use of these buildings is for office purpose only.

Table 2 Parking spaces requirement for resident development in Hong Kong (2002)

Private Development	Zone 1	1 car space per 4 – 7 flats
	Zone 2	1 car space per flat or for every 100m2 of gross floor area, whichever is the fewer
	Zone 3 and 4	Minimum 1.5 car parking spaces for each dwelling
Public Rental Estates		1 car space per 13 – 16 flats
HOS/PSPS/HS		1 car space per 5 – 8 flats

Development in Hong Kong (2002)
Source: The second parking demand study, Final report, Department of Transport, Hong Kong (2002)

Table 3 shows the area of Bangkok where these buildings are located, the number of buildings located in that area, the number of buildings within the area which are located within 500m of a BTS or MRT station, the average parking spaces provided in space per floor area (sq. m.) units , and the number of excess parking space provided in each area.

The calculation result on Table 3 shows that within the study samples the rate of parking space provision per office area is 55 sq m per space, higher than the official requirement of 60 sq m per space. On average each building provides 58 parking space more than required which equates to +17% above the requirement.

Table 3 shows that in most cases the developments will provide more parking spaces than the minimal requirement dictate. It must be noted that the average value summarised on the Table 3 hides highly fluctuate values: the difference between the number of parking spaces provided and required could be as high as 114% and as low as -36% from the minimum requirement. It should also be noted that all of the building in this analysis located within a walking distance to a Sky Train or the MRT stop but only 4 out of 21 building were built after the commencement of the Sky Train (BTS) in 2003.

Leaving aside the question of how is it possible for those buildings with parking space provision lower than the requirement to receive planning permission and the small size of samples used, in conclusion this exercise suggest that the minimum parking space requirement policy results

in oversupply of parking space in an urban Environment.

4. Equi-parking

The principal of Equi-parking proposed by Prof. Hermann Knoflacher is based on concepts that human body energy consumption is the driving force in human mode choice decision making and that infrastructure influences the behaviour of human. In this section, these concepts and a comparison between the existing parking and Equi-distance parking will be described**.**

4.1 Human energy body consumption

The principal of Equi-distance parking is based on the concept that human body energy consumption is the driving force in the decision making in transport choice. Car is arguable one of the landmark invention of the development of human civilisation. It significantly increases the travelling speed and reduces the internal energy require for travelling (Knoflacher 2003). Table 3 illustrates the time and internal energy usage for using different modes of transport to undertake a 1.5 miles journey. Table 3, Fig. 5a and 5b below show that by using a car, a human can reduce the journey time by 85% and the internal energy use by 91% compared to walking. Therefore, human body perceived the use of car to be effortless and give huge benefits and therefore would prefer to use a car over other modes of transport.

Table 3: Provision of parking space in office building within CBD area of Bangkok
Source: Own calculation based on data from Investment Bureau

Area (1)	No. Of building survey (2)	No of building with access to BTS or MRT within 500m	Average parking space (space per sq m) (3)	No of parking space excess the requirement per building in each area (space) (5)
Upper Ratchadapisek Rd.	2	2	45	114
Middle Ratchadapisek	4	4	54	53
Lower Ratchadapisek Rd.	1	1	59.6	3
Sukhumvit	5	5	57	98
Witthayu	2	2	46	110
Rama 4	1	1	44	282
Upper Sathorn Rd.	3	3	62	18
Lower Sathorn Rd.	3	3	65	-91
Total number of buildings	21		Total surplus parking space	588
Global weighted average value for space per sq m*		**55**	Average surplus per building	**58 spaces (17% of the minimum space require)**

Activity	Time (minute / 1.5 miles)	compare with walking	Internal energy (MJ / 1.5 miles)	compare with walking
Driving 20 mph	4.5	-0.85	0.05	-0.91
Bicycling 10 mph	9	-0.70	0.28	-0.46
walking 3 mph	30	1.00	0.51	1.00

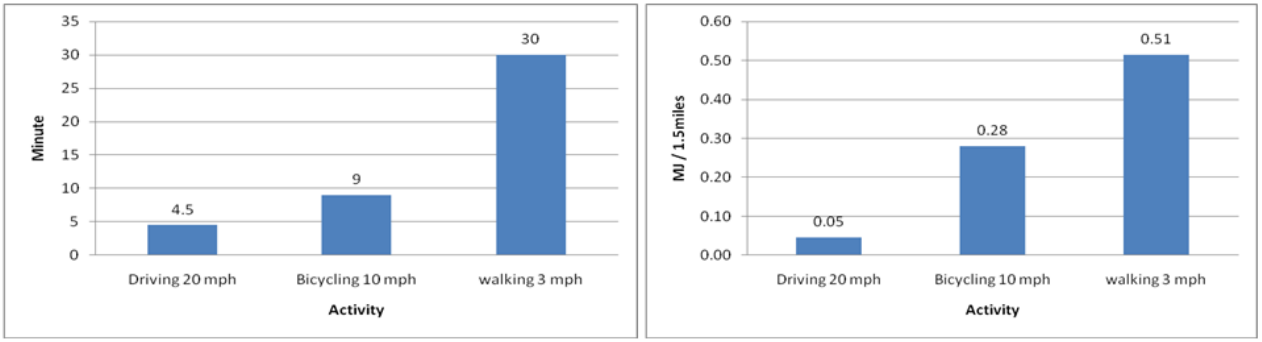

Fig. 5a Time and Fig. 5b internal energy usage for using different mode of transport (Source: Own calculation based on Cohen and Heberger (2008))

However, when taking in account of the usage of external energy required to undertake the same trip a different picture is revealed. Figure 6 below shows the external energy needs for the different mode of transport in both the vehicle production and the operation per trip. In this calculation the life time and the average number of trips was taken into consideration.

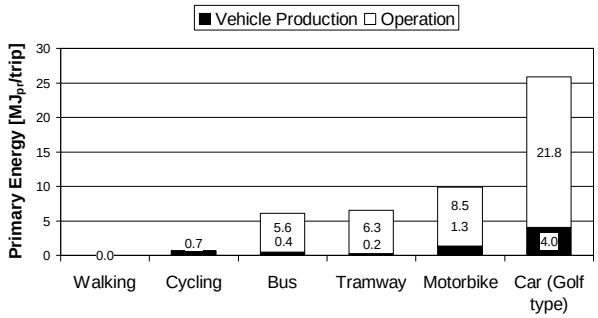

Fig. 6 External energy consumption per trip per means of transport
Source: (Pfaffenbichler 1998)

Figure 6 shows that no external energy is required for a walking trip. For a cycling trip only the energy for production is required. For a commuting by bus 0.4MJ and 5.6 MJ for production and operation is required. For tram 0.2MJ and 6.3MJ, motorbike 1.3 MJ and 8.5 MJ, and car trip 4.4 MJ and 21.8 MJ for production and operation consecutively. In short, Fig. 6 demonstrates that by undertaking the same trip with car it required 25MJ external energy more than walking and 25 times more than by cycling. It worth to mention that this calculation is a simplified one as it does not take in account the additionally environmental burden from noise pollution, air pollution, greenhouse gas emissions and accident costs incurred due to car journey.
The argument above illustrates that in order to influence human behaviour or decision in selecting mode of transport, it is necessary to design a measure that would affect the level of internal human energy (Knoflacher,2003).

4.2 Structure influence behaviour

There have been many literatures that emphasised the relationship between structure or environment and human behaviour. One of them is an experiment carried out by [Peperna 1982] at the Institute for Transport Planning and Transport Engineering, Vienna University of Technology to demonstrate the relationship between the quality of the walking environment and the share of pedestrians in the city of Vienna.

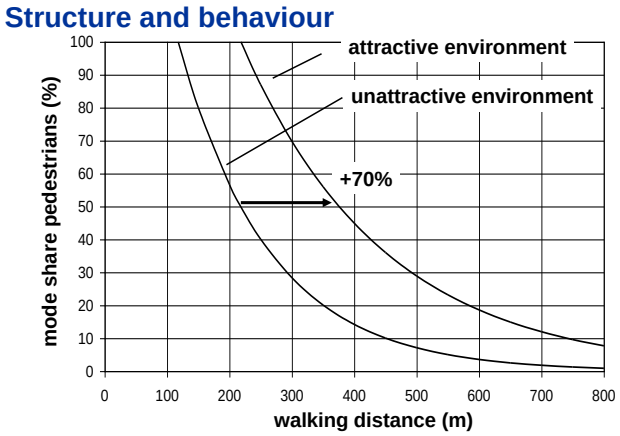

Figure 7: Relation between built structure and behaviour
Source: Peperna, O. (1982). "Die Einzugsbereiche von Haltestellen öffentlicher Nahverkehrsmittel im Straßenbahn- und Busverkehr," Master thesis, Technische Universität Wien.

On the y-axis Figure 7 shows the percentage of the pedestrian mode share and the x-axis is the walking distance to the destination point. If the destination point is less than 100m away nearly 100% of people will walk to the destination point. If the distance between the origin and destination is increased to 200m, around 50% of people will not walk anymore; they will use another mode of transport (car, cycle or public transport). If the destination point is more than 450m away, then the percentage of people walking drops to a mere of 10%. This demonstrates that the % of people walking depends on the distance, it is therefore important to maintain the density of the city if the percentage of people travel by foot is desired.

However, the position of the curve in Fig. 7 can be influenced through the quality of the walking environment. The curve on the right hand side shows the proportion of walking % in pedestrianisation streets (a more attractive environment) while the curve on the left hand side shows the proportion of walking % on a less pedestrian friendly street. Fig. 7 shows that an improvement in the walking environment will increase the acceptance for walking further; from 220m to 380m at the 50% mode share point, an correspond to an increase by 70%.

4.3 Car parking organisation

In his paper "Sustainable Transport – and how structure influences behaviour", Emberger argued that Parking space serve the same purpose as a public transport stop does – both are an interface or interchange between the slow mode (walking) and the motorised means of transport. However, the design approach and organisation of the two are treated in the traditional transport planning science completely different. This section will examine the existing parking organisation and present the concept of Equi-distance parking as proposed by Knoflacher.

4.3.1 Existing parking organisation

Under the existing parking organisation motorists are able to park at or adjacent to his/her home (origin) and trip destination (work /shopping /recreation). In the city where space is scarce such as Bangkok, parking normally is provided off-street within the building or located very close to the destination point. In contrast, the public transport stops are normally provided at street level at approximately 300-500m interval between the stops or more[2]. This type of arrangement of the infrastructure encourages the use of private cars as humans perceive that by using the private transport with parking places adjacent to the starting point of the trip less internal energy has to be used compared to walking 150-250m or more to the nearest public transport stop (as demonstrated in Section 4.1).

Under the existing arrangements of the existing infrastructures and parking organisation, it is difficult to change the behaviour of private vehicle user or induce any modal shift. It gives the public transport no chance in competing against the private transport

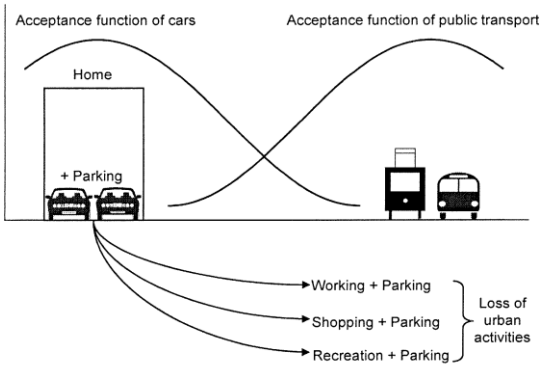

Figure 8: Existing parking organisation
Source:[Knoflacher 1993], page 145

Figures 8 illustrates the existing arrangement of the parking organisation, the distance from home or the starting point of the trip is on the X-axis and the level of acceptance function on the Y-axis. Fig. 8 shows that as the car is park at home or closer to home as the PT stop, the level of acceptance to use the car is much higher compared to the acceptance function of public transport. The level of acceptance of public transport increases as the distance towards the public transport stop decreases.

In addition, the provision of parking spaces close to the destination (work /shopping /recreation) will also reduce the urban activities such as shopping, working places or recreation that could be reached within walking distance as economic forces will provide clusters of facilities which are easily accessible by car (i.e. Megamalls, out of town shopping centres). This will create the vicious cycle that result in the raise of motorisation and the decrease in the quality of life in the city.

4.3.2 Equi-distance parking organisation

Equi-distance parking organisation was proposed by Professor Knoflacher in 1993. He argued that in order to break the vicious cycle of motorisation a reorganisation of the parking system is necessary.

The concept of Equi-distance parking organisation aims to balance the level of acceptance for car and public transport by storing cars in garages which are located the same distance as public transport stops. This will provide the same level of accessibility (i.e. equal distance) between origin and destination to parking space as to public transport stop. It will balance the internal energy perception and affect the mode choice decision making at the most fundamental level.

[2] Transport for London recommended a distance of 400m between each stop

Figure 9 shows that as private mode of transport are stored away from the origin and destination at the same distance as the nearest public transport stop it will share the same level of acceptance function as public transport. This will stimulate urban activity that could be reached by walking from origin such as work/shopping and recreation, reduce the rate of motorisation and provide modal shift away from car. Consequentially, as car use decrease reduces traffic congestion, air and noise pollution, and accident rates. Additionally, the space that will be freed up as the parking spaces are relocated into garages can be used to provide much needed public spaces and green areas to improve the quality of the urban environment

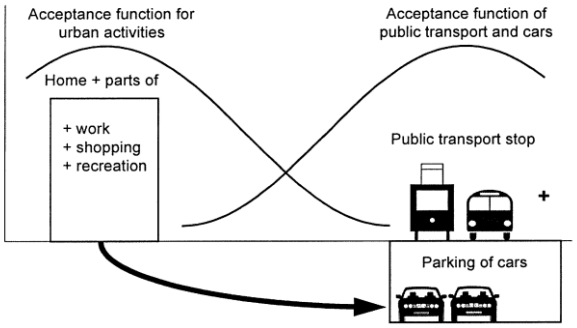

Figure 9: Equi-distance parking organisation
Source:[Knoflacher 1993], page 145

In order to achieve this parking reorganisation, Prof. Knoflacher proposed that a major shift in transport policy is required. Financial measures that have been implemented to encourage private vehicles use, such as minimum parking requirement in commercial and residential building and free kerb side parking have to be abolished. A similar proposal was made by Shoup. In his paper, "The High Cost of Free Parking" he argued that minimum parking requirements increase the cost of urban development, degrade urban design, burden enterprise, promote automobile dependency and encourage urban sprawl (Shoup, 1997).

It is necessary that the infrastructure of the urban environment is reshaped to encourage the use of public and non-motorised transport.

4. Conclusion

Transport sector consume over 20% of the world energy, most of which is non-renewable energy. It is also the main contributor toward air pollution. This emphasises the need for Sustainability transport system in order to achieve sustainability in urban environment. The relationship between parking space and sustainability in urban environment suggested in this paper will contribute toward and supporting a case for the necessity of the parking organisation to be implement alongside other transport mitigation measures.

The study of minimum parking space requirement policy and its impact that draw example from Bangkok and Hong Kong identified that Bangkok's policy is out of date and in urgent need for a review. Although having stricter policy, Hong Kong still saw over 82,000 surplus parking. However, it is unclear whether this resulted solely from the policy or also a contribution of other factors. Nevertheless, this study shows that such policy contribute toward surplus parking space that waste valuable urban space. A study of parking space provided in 21 office buildings in Bangkok further emphasised this point as it shows parking space is provided on average 17% more than the minimum requirement.

In order to influence behaviour and effectively 'push' people away from their private vehicle, it is necessary to provide an infrastructure that would encourage such change. The existing parking organisation and infrastructure favours and encourages the use of private transport and therefore gives public and non-mortorised transport no chance in competing against it. The concept of Equi-distance parking proposed by Knoflacher will reduce the advantage that private vehicle have over other modes of transport by balance the internal energy perception. This affect the mode choice decision making at the most fundamental level.

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